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ANNUAL REPORT

OF THE

SUPERINTENDENT, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1919

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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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DRAFTING ROOM IN NEW CHART, ARCHIVES, AND INSTRUMENT BUILDING.

On the recent completion of this building the Coast and Geodetic Survey has taken its first step in obtaining relief from the insanitary, unwholesome, and inefficient building which 75 per cent of the office force is still compelled to occupy.

REPORT

OF THE

SUPERINTENDENT, U. S. COAST AND GEODETIC SURVEY.

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 4, 1919.

SIR: There is submitted herewith my fifth annual report as Superintendent of the United States Coast and Geodetic Survey for the fiscal year ended June 30, 1919. This is the eighty-eighth annual report of this Bureau.

PART I.

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Chapter II: Work of the Washington office of the Bureau during the fiscal year, pages 23 to 32.

PART II.

Chapter I: Statement of the needs of the Bureau better to accomplish its field work, pages 33 to 42.
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PART III.

Chapter I: War work of the Bureau, pages 72 to 76.

PART IV.

Résumé of the work accomplished in the field and office during the year, pages 77 to 143.

INTRODUCTION.

Charts, as produced by the United States Coast and Geodetic Survey, are the direct means of protecting from loss the vessels of our Navy, Coast Guard, and merchant marine, thereby also protecting human lives and commerce. The charts are produced only by this Bureau and reach their high degree of value to the navigator only when they give *accurate* as well as the fullest information.

The honest and candid statement which the public should have put before it at this time is that these charts, which should now be expedited in their production and carry accurate and vital knowledge to all who need it, are in a measure losing the value they should

have. This may seem a startling statement, and it is a deplorable one to have to make, but there is a reason for it. It is a workable problem with but the one answer. To keep these necessary charts in the hands of all who demand them, both field and office forces of the Bureau must be kept in the highest form. The work is absolutely necessary; it can not be accomplished without sufficient funds, which are not now provided; therefore, an adequate appropriation is the only remedy.

The present condition is caused entirely by *lack* of funds—funds sufficient for modern surveying vessels, and funds to operate same; also funds to enable us to secure able officers and crews, with salaries adequate to hold them. This is for the field work, which is but the beginning of the labor. Again, funds are needed for the office work. Highly trained men are necessary properly to care for the data which are to go on the charts, and those we have are so much underpaid, besides lacking in sufficient numbers, that they are leaving the Bureau for better salaried positions.

Indeed, the condition in the Coast and Geodetic Survey is so serious that it threatens to jeopardize the public welfare.

The large number of recent resignations from the commissioned personnel and from the other scientific arms of the Bureau, in fact from all classes of the service, will continue more rapidly unless checked by meeting the situation *very soon* face to face.

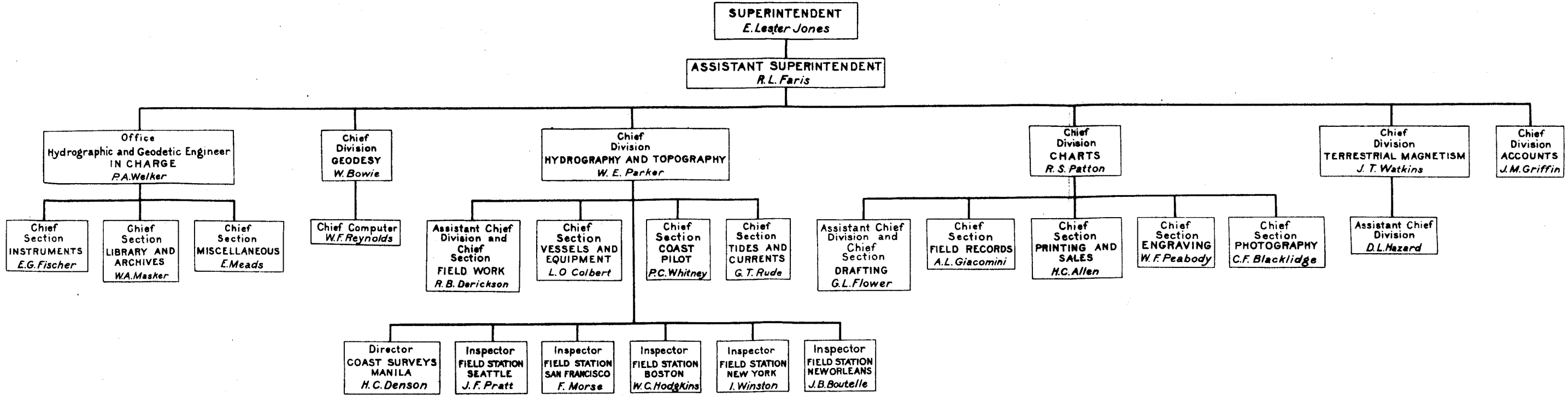
The commissioned officers are the lowest paid men of their training in the Federal service. Their salaries, compared to those paid in the Army and the Navy for similar qualifications, are from 30 to 50 per cent less. Much of their work is more hazardous, requires special training, and takes them into all our country's possessions as the pioneer workers or the navigators—surveyors who "blaze the trail" on land and sea—and no Army or Navy officer has greater qualifications, nor do they sacrifice more than the officer of the Coast and Geodetic Survey; yet the latter works for much the lowest salary, gets no longevity pay, no emoluments, and after he has given his best years in the service of his country he must retire *without* pay.

Many of the Bureau's officers are just waiting, believing that Congress will properly recognize this harmful and unjust condition.

In the chapters to follow, under separate headings, I have endeavored to try again, by further emphasis and explanation, to show what has caused this certain disintegration, with the hope that relief will be immediately forthcoming, and thereby save further inroads on the proper functioning of this important Bureau.

Effective Oct. 15, 1915
Revised to Oct. 5, 1919

CHART SHOWING ORGANIZATION OF THE U.S. COAST AND GEODETIC SURVEY 1919



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Part I.—CONDITION AND WORK OF THE WASHINGTON OFFICE.

CHAPTER I.

CONDITION OF THE WASHINGTON OFFICE.

Too few persons realize the sacrifices a man of ability is making at the present time by remaining in the Coast and Geodetic Survey. Before this country entered the war conditions had grown to a serious stage, but since the signing of the armistice steady disintegration has gone on, and the situation has reached a point where the quality of the Survey's employees is declining principally under the stress of present economic conditions. Unless proper relief is forthcoming *at once*, and the present salaries are materially advanced, this important branch of the Federal Government, which has so much to do with the protecting of human lives, will, in a measure at least, be stripped of its best brains.

There are three definite and logical reasons for this situation:

1. The sorrowful tradition that Federal employees should not expect to be paid even nearly as much as though they were working for some private corporation or firm.
2. The high cost of living, and that in the more than 100 years of existence of this Bureau during which some salaries have not been increased.
3. The unfortunate and unbusinesslike method of submitting lump-sum appropriations to be used to pay salaries far in advance of those received by men and women doing similar, and in many cases, higher-grade work, and who are paid from statutory salaries which are antiquated and unjust, because they were made for conditions a decade or more ago.

Out of these conditions has arisen the state of affairs with respect to each of the different classes of employees of this Bureau mentioned below:

DRAFTSMEN.

The salaries of hydrographic and topographic draftsmen (cartographers) in the Coast and Geodetic Survey range from $1,000 to $2,400 per annum. In various Government bureaus where employees are paid from lump-sum appropriations the salaries are often double those given above. For example, in the Navy Department, the Bureaus of Steam Engineering, Construction and Repair, and Yards and Docks have adopted the Macy award for draftsmen, which award is also in effect in all shipyards in the United States. A comparison of the salaries established under this award with those

paid in the Coast and Geodetic Survey for work of *equal importance*, and requiring equivalent technical qualifications indicates the following:

MACY AWARD.		COAST AND GEODETIC SURVEY SALARY FOR CORRESPONDING POSITION.	
Chief draftsman	$5,634	Chief draftsman	$2,400
Assistant chief draftsman	4,945	Assistant chiefs of sections	2,200–2,400
Supervising draftsman	4,006–4,257	Expert cartographers	2,000–2,200
Chargeman	3,130–3,756	Cartographers and cartographic draftsmen	1,000–2,000
Draftsman, grade A	2,504–3,005	Copyist draftsmen	1,000
Draftsman, grade B	1,878–2,254		
Draftsman, grade C	1,627		
First-class copyist	1,252–1,502		
Second-class copyist	1,001		

For the entrance grade of topographic draftsman, for which this Bureau pays $1,000 per annum, the War Department offers $2,100 per annum. The qualifications for the two positions are identical. Salaries paid outside the Government service are comparable with those established by the Macy award given above.

As this report is being written, I have before me for acceptance the resignation of one of our draftsmen who has been with us more than nine years, whose basic pay is now but $1,400 per annum, and who is going to a position that pays him $2,600 per annum. Another draftsman recently left this Bureau who had not the basic education to reach the higher grades in our technical work. His basic pay here was $1,400. He immediately accepted a position as a draftsman in another branch of the Government service at $1,800 per annum.

The result of this situation is that our trained cartographers are resigning to obtain elsewhere the adequate compensation which is denied them in this Bureau. At this present time we have 28 positions for draftsmen, 11 of which are vacant or filled by temporary employees (persons who have not the qualifications for permanent appointment, but whose services are used with the hope of some advancement in utilizing the bulk of data that have accumulated in the office). In other words, only about two-thirds of our drafting force of only 28 are capable of any independent effort in digesting the mass of accumulated data that we have before us. In spite of the fact that the requirements have recently been so amended as to permit of our accepting high-school graduates, we are unable to obtain candidates to fill the vacancies thus created. This force, without which charts can not be produced, is at present actively disintegrating. Such disintegration can be checked only by a material increase in all grades of pay. Unless it is checked it will reach the point where the Bureau will be unable to produce the corrected charts on which the safety of navigation directly depends.

This deplorable situation, which is definitely affecting the highest efficiency of our charts, has been repeatedly emphasized, both publicly and in my annual reports, but without receiving the slightest relief. These men deserve much credit for remaining in their positions so long, and their loyalty, in the face of underpay and miserable quarters to work in, is highly creditable.

COMPUTERS.

We have need for many more computers than are authorized in the present appropriation bill, and the entrance and lower-grade salaries should be made higher. I shall mention only the salient points, and not go into lengthy details. The geodetic surveys of this Bureau are broad and comprehensive. Our schemes of triangulation extend all over continental United States, and are the framework on which are based, and which furnish the controlling positions for, operations (Government, State, and county) of less extensive character. Necessarily, over such a broad and comprehensive scheme the arcs of triangulation extended over great areas and the stations marking the points of triangulation were widely separated. Likewise, lines of precise levels stretch far across the continent. The outcome of this was that the publications that have been issued by this Bureau giving the geographic positions and descriptions of triangulation stations and the descriptions and elevations of precise-leveling stations have contained, and now contain, the data for many States in the Union. That is to say, that our triangulation publications have been issued so that each contains a particular arc of triangulation without reference to the political boundaries of the area covered, and these arcs sometimes extend through two or three States of the Union, and the publication containing our precise levels has data for all of the States of the Union. Heretofore the inducement for issuing these publications in this form has been that the scheme for triangulation and levels has been so large that the points contained in any one political division were so small in number that in but few instances would there have been justification for issuing a publication containing these data for any one State in the Union. These observations have now progressed to such a point that each class of publication contains a very great number of positions, elevations, and descriptions of triangulation and precise-leveling stations in most of the States of the Union, so that it is now wasteful to distribute them in the form in which they have been issued heretofore, because the recipient is interested only in data for his particular locality. A marked economy would be effected by issuing a single publication for each State in the Union, in which would be assembled all geodetic data that have resulted from observations to date of issue. Such a publication would concentrate much information that is of great and valuable service to local surveyors, and the information would be in such form that it would be readily accessible.

To do this on a practical and satisfactory basis would require that each publication thus issued for each State in the Union should contain, not only the essential geographic positions that have been computed for the large arcs of triangulation that extend over the whole country, but the geographic positions and descriptions of every minor point of triangulation that has been determined in conjunction with the larger basic observations; and here is where we are hopelessly swamped with our present computing force. There are portfolios of field observations containing thousands of such stations in the archives of this Bureau that have never been computed. Indeed, so inadequate is our computing force to meet the

present needs that we have adopted the expedient of putting into print the results from the latest field work, and gradually working backward into the old material. This is believed to be a very much better method than to go back to the old work first, for if this were done the most recent work would be very many years old before it could be put into print. As it is, the public is deprived of the benefits of this information that has cost many years of effort to obtain, as well as many thousands of dollars. The cost of the computation and printing would be but a fractional part of the expenditures that have already been made.

The entrance salary for computers should be $1,600 per annum rather than $1,200, and the number of positions in the higher grades should be increased. The entrance salary of $1,200 per annum is too low to command the interest of men capable of doing this work. Those who come to us at this salary and learn of the meager prospects of advancement stay but a short while. The men who lingered but a short while were 31 during the past fiscal year, and of the 11 positions at $1,200 per annum 9 are now filled by temporary employees.

ENGRAVERS.

In no section of the Bureau is the antiquity and inadequacy of the existing salary scale more strikingly exemplified than in the engraving section. The sundry civil act for 1920 increased two $1,000 positions to $1,200; with this exception there has been for years no increase either in compensation or in the number of employees. The salaries range from $1,000 to $2,400; in a total force of 19 men the average salary is $1,621.

Two of these men have been appointed recently. The remainder have served in the Bureau for periods ranging from 9 to 60 years. The average length of service is 22 years. The man who has served only 9 years receives $1,000 per annum. He is a skilled engraver, thoroughly competent, who during all that period has never been denied a promotion to an existing vacancy. He has gone ahead, in his regular order, from an entrance salary of $504 per annum to his present salary of $1,000.

Why, it will be asked, do men stay in positions which pay such inadequate salaries? The answer is that copperplate map engraving is a distinct profession practically limited in this country to this and one or two other Government bureaus. If they resign here, they must start in at the bottom in some other department where advancement is also slow, and where they lose the credit for their previous years of service. There is no field for them in commercial life, so if they seek work outside it must be along other lines, and this does not appeal to them. Engraving is an art, not a trade, and the man who becomes a skilled engraver must have something of the temperament which compensates the artist for the sacrifices he often endures while he is painting his masterpiece.

Yet the very fact that this work is so highly specialized affords the strongest argument for according the men such justice that they will not be tempted to resign. If one of these men should go, it would take years to replace him. There is no outside source of supply of men having the required skill. They must be trained within the Bureau, and it requires a period of years before the apprentice be-

comes sufficiently skilled in all details to be intrusted with the production of a new chart.

In contrast with this salary scale it is interesting to note that in effect in the Bureau of Engraving and Printing. That bureau employs 32 engravers, whose salaries range from $1,500 to $7,500 per annum. The average salary of the 32 positions is $3,003, or almost double that of the engravers in this Bureau. The calibers of the men required by the two bureaus are fairly comparable, since any possible difference in artistic qualities of the work is fully compensated for by the mathematical accuracy required of the map engravers.

Not only should the salaries of the engravers be raised, but the number of employees in the section should be increased. The work which the section is called upon to do has increased materially in recent years. In 1901 the number of charts issued to the public was 64,496; in the fiscal year 1919 it was 290,537. During the same period the amount of original data received by the Bureau to be utilized in the production of new charts or the correction of existing ones increased over 150 per cent. Yet during that same period the force of engravers increased only from 17 in 1901 to 19 in 1919. This ever-growing discrepancy between public demand and available data on the one hand, and available force on the other, has been one of the factors responsible for the long delays in furnishing to the public the results of new surveys in the form of modern and correct charts, and even, in some cases, for the inability of the Bureau to utilize at all the data received.

This increase in force need not be proportional to the increased demand upon the Bureau, as indicated by the above comparison. Increases in a much smaller ratio will be entirely adequate. Also, the increase should be made gradually, as the section can not afford to reduce the time devoted to chart production as would be necessary if it attempted to train any considerable number of inexperienced men at one time. Next year the force should be increased by at least three men, and further increases should be postponed until the training of these three is well under way.

CLERKS.

The salaries paid clerks in the Coast and Geodetic Survey are below the average in the Government service. During the fiscal year for which this report is made, the average pay for clerks in the Coast and Geodetic Survey was lower than the average pay for clerks in the Department of Commerce or any bureau thereof. The average pay for clerks in the Department of Commerce as a whole for the fiscal year 1919 was $1,211.60, and the average pay in the Coast and Geodetic Survey for clerks was $1,130.24. During the fiscal year for which this report is made, the entrance salary for clerks in this Bureau has been $720 per annum. The lower House of Congress has recognized the necessity of a general increase in all the lower paid positions in the Federal service, so that no employee above 18 years of age, whether laborer, messenger, watchman, or charwoman, will receive less than $1,080 per annum. These are the provisions of the Nolan bill, which has passed the lower House. If, then, em-

ployees such as messengers, laborers, etc., performing duties that require no training or education to establish their fitness for the position held are to receive $1,080 per annum, surely it is proper that the entrance salary of a clerk who must spend time and money to fit himself to perform his duties should be more than $1,080 per annum.

The Coast and Geodetic Survey is a technical bureau, and the scientific nature of the work of the Bureau permeates all its branches. It requires a much higher grade of intelligence, and closer application for a clerk to perform his duties satisfactorily where the duties of the branch to which he is assigned are different from those of any other branch of the Bureau, and where he is thrown on his own initiative, than where the work is largely routine, and where a number are performing the same duties, and the clerical personnel is readily interchangeable, as is the case in many other branches of the Government service. In those branches, numbers of clerks are performing the same class of work and under the immediate supervision of directors, but in the Coast and Geodetic Survey the clerk must be put on his own resources as to his accomplishment. In proof of the statement that the clerical employees of the Coast and Geodetic Survey have average, or higher than average, ability the statement needs only to be made that, during the fiscal year, 66 clerks left the Coast and Geodetic Survey, many to higher-paid positions in other branches of the Government service, while it *never* occurs that a clerk comes to the Coast and Geodetic Survey at a higher salary than he received in another branch of the Government service. Instance after instance can be cited where clerks leave the Coast and Geodetic Survey for higher salaries. One employee served as a clerk in this Bureau at $720 per annum from February 26 to May 22, 1918, and was replaced by another employee at $720 per annum because she had not the requisite training to handle the work in this Bureau. Immediately afterwards she obtained employment as a clerk in the Treasury Department, and is now employed in that capacity in that department permanently at a salary between $1,300 and $1,400 per annum. Here is a case of a clerk who had not the ability to perform the duties required in this Bureau, and yet she went to another department and was paid a salary that could be gained only after years of service in the Coast and Geodetic Survey.

Another clerk entered the Coast and Geodetic Survey December 18, 1912, and served until January 5, 1918, by which time he had been promoted to $1,200 per annum. He was then drafted into the Army. On his discharge from the Army he sought reinstatement in the Coast and Geodetic Survey, but the only vacancy then existing was one at $900 per annum. This he refused to accept, and sought employment elsewhere. He is now employed as a clerk in the Bureau of War Risk Insurance at a salary of $1,400 per annum. Here is an instance of a clerk *entering* another branch of the Government service as a clerk at a much higher salary than he had attained in the Coast and Geodetic Survey after nearly six years of service. The clerks now receiving salaries of $1,200 per annum in the Coast and Geodetic Survey have served an average of 12 years.

Many other parallel cases could be cited, as there has been instance after instance of transfers from the Coast and Geodetic Survey cleri-

cal roll to higher-paid positions in other branches of the Government service. Long before the end of the war and before the demand for clerical help had become acute, there had been many tempting offers to clerks in this Bureau to transfer to other positions and other branches of the Government service at much increase in salary, and during the press of the war the opportunities were without number.

A clerical employee in the Coast and Geodetic Survey is under some disadvantage. It is a specialized class of work. In nearly every instance, no matter how proficient the clerk becomes in performing his duties in the Coast and Geodetic Survey, he does not acquire skill and knowledge that he can use in other walks in life. He is taken out of the channels of ordinary activity, and his acquirements in the Coast and Geodetic Survey generally are marketable nowhere else. For example, no matter how proficient a clerk may become in the tidal or magnetic divisions, the knowledge and skill required are of use in only the respective branches of this one service. Even the correction of our nautical charts requires extreme accuracy and considerable dexterity, and yet there are very, very few places outside of the Coast and Geodetic Survey where knowledge and skill thus gained can be put to account. Even the auditing of the accounts of our field parties requires special knowledge of the methods of this Bureau, and a very specific knowledge of the Comptroller's decisions respecting the expenditure of Government funds. In whatever division or section of the Coast and Geodetic Survey a clerk is employed he is useful largely because of his knowledge of the procedure in carrying out the technical work of the Bureau. It, therefore, follows that the longer a clerk of average intelligence is employed in the Bureau the more value he is to the Bureau, and the less able to use this knowledge elsewhere. The results of the work of the Coast and Geodetic Survey are necessary for the welfare of the Nation. Somebody must carry on the work of the Bureau, and it is only proper and just that those who do it should be properly rewarded for their services. If they are not, the achievements of the Bureau suffer, either through the incompetence of those who are willing to remain at the inadequate salary, or through the continual turnover of clerical employees through a succession of persons being appointed to the same position, and leaving either because better opportunities are offered elsewhere, or because they have not the ability to perform the technical duties of the position they seek to fill.

INSTRUMENT MAKERS.

In my 1918 annual report I summed up the situation in this Bureau with respect to the low entrance salary for instrument makers. The salaries that we were able to offer in normal times were not sufficient to attract men of the proper qualifications to make and repair our delicate and intricate surveying instruments. The men that do this work must be of a much higher class of attainment than are usually found in a quality-production instrument shop of even manufacturers of surveying instruments. Men in shops are generally skilled in only the production in numbers of special parts of a given instrument. Our instrument makers must

be able to make parts and repairs to any of the delicate surveying instruments that we use, and with the highest degree of precision, because an inaccuracy in an instrument would bring inaccuracy in results from surveys made with it.

While the range of salaries that we were able to offer instrument makers in this Bureau during normal times was below the average, under present conditions, when wages and salaries have advanced so materially, the salaries in our lower grades have no attraction whatsoever for men who are in the least qualified to adjust, repair, and make our delicate instruments.

What we should have is a range of salaries that would not only invite men of the proper technical qualifications to come to us, but which would hold out prospects of advancement that would assure their remaining with the Bureau. We never get men of these qualifications. They are attracted to other shops, where the pay and opportunity are on a parity with their training and ability. And, yet, these are the men that we need. With a corps of such men instruments would be perfected that would far more than offset the additional wage scale that would be required to accomplish it. To attract men of this caliber would require an entrance salary of $1,600 or $1,800 per annum. I am reliably informed that these are the entrance salaries prevailing to-day in many branches of the Government service and many of the more technical industrial plants. In our relatively very low entrance salary of $1,200 per annum the positions are usually vacant because we can not induce suitable men to accept them or they are filled by temporary employees who can under no circumstances qualify for permanent appointment, but whose services can be used to some purpose, though sometimes they are of questionable advantage. Some of these authorized positions have been vacant for months at a time.

The chief of this important section is a mechanical engineer of rare skill and ability who receives the low salary of $2,750. I doubt if anyone near his caliber could be secured for more than twice what is provided by law. Regardless of the individual, the position justifies a salary of $3,600.

NEED OF MODERN BUILDING.

The quarters occupied by this Bureau are a disgrace pure and simple. Insanitary and responsible for a clear loss of efficiency, I doubt if any other arm of the Government has to put up with such quarters. Easily remedied at a comparatively small cost, yet year after year appeals go for naught, while other bureaus enjoy modern and expensive buildings.

Year after year I have called attention to the need of a modern and adequate building to house this Bureau in place of the present makeshifts. We never can do efficient work in a building or buildings so unsuitable for our needs. It is physically impossible to bring together under proper supervision the different units of our organization. Where artisans, laborers, and employees of all kinds are scattered here and there in small rooms, under insanitary conditions, without proper light and proper ventilation, the best of results can not and ought not to be expected. So acute did this become during

the war, and so essential was the product of this Bureau to the successful prosecution of the war, that on your presentation of our needs to the President, he authorized the use of funds placed at his disposal by Congress for the construction of a comparatively small building adjoining our present building to relieve the existing congestion. This building is now completed, and the facilities that it affords only emphasize the great drawback and handicap under which we are operating in our present old quarters. I think it proper for future reference to record here the kind of buildings we are now occupying and the history of their requirement.

This Bureau occupies a red brick building on New Jersey Avenue, southeast of the Capitol Building; two adjoining granite buildings, with three small brick buildings in the rear; and a new, hollow-tile, fireproof building to the south, all of which are connected by bridges.

The main or brick building was erected in 1871 by A. and T. A. Richards and in that year was rented for the use of the Coast and Geodetic Survey. Previously, from August 2, 1832, the service had been quartered in a building on New Jersey Avenue, south of the present site, erected by Thomas Law about the year 1800, and a house adjoining to the north. The latter was used as quarters by the Superintendent, as was afterwards a portion of the main building, from 1871 until 1873. A small brick structure, with iron doors and windows, near the corner of New Jersey Avenue and C Street SE., was used for storage of engraved plates and other valuable records and property of the service until 1874.

The Richards Building, together with a small brick structure for the use of the electrotype section and carpenter shop, and the land adjoining, was purchased by the Government for the Treasury Department, September 21, 1891, for the sum of $155,000, the site fronting east 199 feet 6 inches on New Jersey Avenue, west 199 feet on South Capitol Street, and being about 200 feet deep. The legislation authorizing the purchase of this property is contained in an act of Congress approved March 3, 1891. Since 1871 the buildings have been continuously occupied by the Coast and Geodetic Survey. They are provided with steam heat from two horizontal boilers, and are equipped with an electric freight elevator.

The three granite buildings, of which two are occupied by the Coast and Geodetic Survey, were erected by Gen. Benjamin F. Butler in 1873–74 and were constructed of granite from Cape Ann, Mass. The fireproof building adjoining the main building occupied by the Service, and which has been especially designed for its use, was used for the storage of valuable records, original maps, engraved plates, and documents from June 8, 1874.

This whole property, including the middle building and that fronting on B Street, was purchased by the Government for the use of the Treasury Department, April 10, 1891, from Benjamin F. Butler for the sum of $275,000, in pursuance of an act of Congress approved March 3, 1891. The land has a frontage of 119 feet 3 inches on B Street SE., 80 feet east on New Jersey Avenue, and 97 feet west on South Capitol Street. That portion fronting on B Street is now used by the United States Public Health Service, to which it was assigned by the Secretary of the Treasury in 1891. The two buildings to the south are used by the Coast and Geodetic Survey. The

entire group of buildings is heated by steam from two horizontal boilers in the portion used by the Public Health Service. A brick structure to the rear, formerly a barn and annex, was also included with the property, and used by the Coast and Geodetic Survey to house its chart-printing presses.

In 1903 all of the above-described buildings then occupied by the Coast and Geodetic Survey were transferred with that Bureau to the then Department of Commerce and Labor, now Department of Commerce, in accordance with the act approved February 14, 1903, and with a provision contained in the deficiency act approved March 3, 1903.

In the sundry civil act of August 1, 1914, was appropriated $12,500 for an extension and rebuilding of the old brick building in the rear of the Butler Building for the use of the printing section of the Bureau, which had greatly overgrown the available space. By April 7, 1915, a one-story annex and a new three-story building had been erected in the space between the Richards and Butler Buildings. This filled a long-felt want, and greatly added to the facilities for printing charts.

Under dates of March 8 and June 17, 1918, the approval and authorization of the President were contained in allotments of $75,000 and $30,000, respectively, a total sum of $105,000, for providing the needed facilities for work of preparing charts, military maps, and other special work for the Army and Navy by the construction of a suitable building for this purpose.

On September 18, 1918, an additional allotment of $29,250 was made for the purpose of equipping the new building.

The allotments were made from the funds appropriated by Congress, and placed at the disposal of the President for national security and defense during the period of the war with Germany and Austria.

On June 28, the date of the approval of the bond incident to the construction of this building, the contract was awarded to Wills, Egelhof & Co., 161 Park Avenue, New York City, for the total amount of $94,860, and work was commenced upon the same date. The contract time for the completion of the work was six months from the date of acceptance, which expired on December 28, 1918, but at the close of the fiscal year ended June 30, 1919, the building was not ready for occupation. It was so nearly completed, however, that it was available soon after that date.

The building was erected upon the vacant lot to the south of the Richards Building, and occupied practically the entire lot with sufficient space all around for securing suitable light. It is of hollow-tile construction two stories in height, the upper for the use of the drafting section, and the lower for the instrument section, including machine and carpenter shops.

DESCRIPTIONS OF BUILDINGS.

Richards Building.—The Richards Building consists of two parts, known as the front and back buildings, and these are connected by comparatively narrow passageways on each floor. The front building consists of six floors which, reckoning from the bottom, are occupied, respectively, by (1) part of the instrument section; (2) the

section of tides and currents; (3) the office of the engineer in charge, disbursing agent, and mail clerks; (4) the division of geodesy; (5) the engraving section; and (6) the photograph gallery.

The back Richards Building consists of five floors and a basement, but on the eastern end of the roof a structure has been built to provide a room for photographic printing. The floors of this building are occupied, respectively, by (1) boiler room and storage rooms in the basement; (2) instrument machine shop and instrument storeroom; (3) the sales section; (4) the office of the chief of the division of charts and the main part of the drawing section; (5) the office of the Superintendent and the main part of the division of hydrography and topography; (6) parts of the drawing and engraving sections; and (7) photographic printing room.

Each floor of the back building is a half floor lower than the corresponding floor of the front building.

Butler Building.—The Butler Building was originally three separate and distinct buildings. The corner one is now occupied by the Public Health Service, and the other two by the Coast and Geodetic Survey. Those occupied by the Coast and Geodetic Survey are designated for convenience as the archives building and the library building, and they have communicating bridges on the first and third floors only. The Butler and Richards Buildings are also connected by bridges on the first and third floors. The first floors are on the same level, but the third floor of the Butler Building is about 2 feet higher than the corresponding floor of the Richards Building.

The archives building, with the exception of the third floor and basement, is used for the archives, the third floor being occupied by part of the engraving section, and the basement for the storing of proper engraving plates, and other miscellaneous material. The library building is occupied as follows: The basement, which is in two levels about 2½ feet apart, is used for the storage of aluminum plates and general storage; the first story is occupied by the library and reading room; the front of the second floor is used by field officers when on duty in Washington, and the rear by the miscellaneous section; the third floor by the division of terrestrial magnetism; and the fourth floor by field officers while temporarily assigned for duty at Washington.

Printing buildings.—These buildings are in the rear of the Butler Building, and partially between the Richards and Butler Buildings. The old three-story part directly in the rear of the Butler Building is occupied as follows: The lower floor or basement is used for dressing, toilet, or miscellaneous working rooms and storage; the second floor is used for the hydraulic paper press and the storing of paper used in chart printing; and the third floor is a lithographic drafting room. The new brick building between the old brick and the Richards and Butler Buildings is occupied as follows: First floor is the printing-press room; the second floor is used as an office, a transfer room, and a process-printing dark room.

Carpenter shop.—This old brick building, a part of the Richards property, and located to the south of the main building, is two stories in height, and since 1851 one-half of the lower floor has been used by the electrotype section, while the other half of this floor and the whole of the upper floor have been used as a carpenter shop.

Chart, instrument, and archives building.—At the close of the fiscal year 1919 this building was not ready for occupation. The lower floor is intended for the use of the instrument section, including the instrument and carpenter shops, while the upper floor is to be occupied by the drafting section of the division of charts.

Levels in buildings:	
Richards Building	16
Butler Building	10
Printing building	7
Carpenter shop	3
Chart, instrument, and archives building	2
Area of floor space of buildings:	
Total area of rooms	52,863
Eliminate areas not fit for office work—	
Cellar	3,362
Carpenter shop	2,926
Old printing building, basement	2,200
Butler Building, basement	3,204
	11,692
Total available area	41,171
Area of chart, instrument, and archives building	15,200
Total office space	56,371
Area of halls, stairways, etc	12,678
Total area, including halls, etc	69,049

HEAT AND LIGHT.

As has been mentioned in this report heretofore, the buildings occupied by this Bureau are heated by steam heat from four horizontal boilers, two of these boilers being located in the basement of the buildings occupied by the Public Health Service and two in the basement of the Richards Building. While one set of these boilers is located in the basement of the building occupied by the Public Health Service and provides heat for the building occupied by that bureau and part of the building occupied by this Bureau, firemen and stokers sufficient to operate both the boilers located in the basement of the building occupied by the Public Health Service and those in the basement of the building occupied by this Bureau are supplied and their services are paid for out of the appropriations for this Bureau. The coal consumed in the boilers in the basement of the building occupied by the Public Health Service is provided by that bureau and the coal consumed by the boilers in the basement of the building occupied by this Bureau is provided out of our appropriations.

As an emergency measure during the Spanish-American War a copper cable line for supplying electric current was run between the Capitol and the building occupied by this Bureau. This line supplied direct current. In view of the fact that a considerable amount of photographic work was done by this Bureau for the office of the Superintendent of the Capitol Building and Grounds during the Spanish-American War, and after that war terminated, a certain amount of electric current continued to be supplied from the Capitol over the lines that had been installed during the war. Out of this

grew the fact that machinery and equipment were installed and operated by electric generators provided with motors for direct current. Electric current not used for operating machinery, but for electric lights, etc., was obtained by purchase from the Potomac Electric Light & Power Co. After the Spanish-American War had ceased, and the activities of this Bureau had so broadened that the amount of direct current that we were consuming and which was supplied from the Capitol Building was out of proportion to the photographic work and blue printing we were doing for the Superintendent of the Capitol Building and Grounds, and there was strictly no authority for supplying the current except as an emergency war measure, steps were taken to discontinue its use from that source and purchase all of the current needed by this Bureau from the Potomac Electric Light & Power Co. Inasmuch as it has thus come about that our electric equipment was suited for operation by direct current, and the Potomac Electric Light & Power Co. had theretofore been supplying the alternating current, negotiations were taken up with that company with the end in view of having the direct current supplied to this Bureau. The outcome of these negotiations was that the Potomac Electric Light & Power Co. was not able to run mains for supplying the direct current to this Bureau, and the only alternative was that either the machinery that was in operation in this Bureau to be run by direct current should be discarded and replaced by machinery to be run by the alternating current, or that a converter should be installed in the basement of this Bureau. After a thorough investigation it was determined that it would be more economical to install a dynamo for converting the alternating current supplied by the commercial power company into direct current than to discard the machinery operated by motors for direct current which were then in use. Such a dynamo was installed and is now in operation.

I have given this matter much thought, and it is obvious that there is no legal authority as the law now stands for supplying either heat or light by any other means than those employed at present. The fact remains, however, that a supply main for steam from the Capitol power plant passes directly through the buildings occupied by this Bureau, and that a dynamo for alternating current supplied from the central power plant is in operation in the basement of the House Office Building directly across New Jersey Avenue from this Bureau.

To the casual observer who is unacquainted with the legal limitations which prohibit our utilizing these sources of supply it is an apparent extravagance for us to purchase out of our appropriations from a commercial electric company, which purchase necessarily includes a profit to that company, the electric current used by this Bureau and to employ a force of dynamo tenders throughout a 24-hour day (three shifts of 8 hours each), to purchase coal, and hire firemen and stokers for operating our heating plant, when both light and heat can be supplied and are immediately available from a central power and heat plant maintained by the Government. While statistics are not available for determining the exact cost by a unit of measure of electric light and heat by the Capitol power and heating plant, based on the best available sources of information, I believe it is fair to say that the actual saving to the Government, if it

were supplied from the Capitol power and heating plant, would be approximately $4,000 per annum. The most practical solution of the legal difficulty of supplying light and heat from this plant for the Coast and Geodetic Survey appears to me to be to have legislation effected authorizing that heat and light shall be supplied this Bureau from the Capitol power and heating plant, the amount to be determined as supplied by a unit of measure and paid for out of the appropriations for this Bureau. Practical experience has demonstrated the economy of supplying heat and light from a central producing plant rather than from many small units, and certainly very considerable economy would result from such a procedure if authorized.

ROTATION OF FUNDS RECEIVED FROM THE SALE OF NAUTICAL CHARTS.

The present law provides that the charts published by this Bureau shall be sold at the cost of paper and printing as nearly as practicable. The funds that are expended in the purchase of chart paper, printer's ink, etc., are contained in the annual appropriations for this Bureau in the sundry civil bill under the subheading of "Office expenses." The appropriation under this subheading for the fiscal year for which this report is written was $80,000. Besides chart paper and printer's ink, out of this appropriation must be paid every expenditure incident to the maintenance of the headquarters of this Bureau at Washington, D. C., including the purchase of instruments for field work. Because of the varying costs of materials, etc., it is extremely difficult to make estimates with any degree of accuracy from year to year to meet the expenditures under this subitem in our appropriations. If prices advance materially, as they have in the past few years, the appropriation is entirely exhausted some months before the close of the fiscal year for which it is made. This results in a material deduction in our output. To overcome this difficulty in a measure I have this recommendation to make: That as our charts are sold the funds received from the sale thereof shall be placed to the credit of this Bureau in the Treasury to be again drawn upon for the purchase of chart paper, ink, etc. The advantage that would result would be that, if the sale of our charts is fluctuating, the receipts will fluctuate accordingly, and a fund will always be maintained for the production of charts, and we will not need to curtail our output because the appropriation has not been sufficient to meet our need for a given fiscal year. Heretofore we have frequently been compelled to submit deficiency estimates on this account, and the delay incident to placing funds at our disposal through a deficiency estimate has at times prevented our printing charts that are needed by the public.

CHAPTER II.

WORK OF THE WASHINGTON OFFICE.

The organization of the Washington office throughout the year by divisions and sections was, as in the previous year, with the exception that on April 1 the section of field records was transferred from the division of hydrography to the division of charts, and on May 1 the section of printing and sales was transferred from the division of hydrographic and geodetic engineer in charge of the office to the division of charts. Therefore the organization at the end of the fiscal year was as follows:

Division of hydrographic and geodetic engineer in charge of the office: Section of instruments, section of library and archives, and section of miscellaneous.

Division of geodesy.

Division of hydrography and topography: Section of field work, section of vessels and equipment, section of coast pilot, and section of tides and currents.

Division of charts: Section of field records, section of drafting, section of engraving, section of printing and sales, and section of photography.

Division of terrestrial magnetism.

Division of accounts.

The work done by the Washington office during the fiscal year, by divisions of the office, was as follows:

DIVISION OF HYDROGRAPHIC AND GEODETIC ENGINEER IN CHARGE OF THE OFFICE.

The general duties of this division are: The care and upkeep of the buildings occupied by the Bureau; the designing and repairing of surveying instruments and equipment, and packing and shipping them to the field parties; the purchase of supplies for the office, for chart printing work, and for the field; the care and custody of the original records of field surveys as well as the library of printed publications kept for the use of the Bureau; the keeping of the records of leave of absence taken by the personnel of the Bureau; the custody and accounting for the receipts from the sales of charts and publications sold by the Bureau.

It would be tedious and serve no good purpose for me to give the minute details in carrying out the duties of the division of the hydrographic and geodetic engineer in charge of the office generally outlined above. It is sufficient for me to say that the work was done efficiently and satisfactorily, and I shall make mention only of some of the more important items and accomplishments.

The most important of these toward establishing facilities for the work of the Bureau during the year was the erection of the new building known as the chart, instrument, and archives building. This has supplied a long-felt want in furnishing a modern, thoroughly equipped machine shop, carpenter shop, and drafting room. The emergency requirements of the war threw a great burden upon the Coast and Geodetic Survey. Demands were made upon us for charts in unprecedented numbers by the Navy Department and by the Shipping Board. The war had not been long in progress before the demand for delicate instruments both on vessels of the Navy and for use in the Army became acute. In conjunction with the Bureau of Standards some of the most delicate navigational instruments used on board our vessels were designed. This brought about the need of more room for draftsmen and for instrument makers in this Bureau. On my presentation of these facts to you, you in turn brought them to the attention of the President, and under date of March 8 and June 17, 1918, he authorized allotments of $75,000 and $30,000, respectively, a total sum of $105,000, for providing needed facilities for the work of preparing charts, military maps, and other special work for the Army and Navy by the erection of a suitable building for that purpose. On September 18, 1918, an additional allotment of $29,250 was made for the purpose of equipping the building. These allotments were made from funds appropriated by Congress and placed at the disposal of the President for the national security and defense during the period of the war with Germany and Austria.

Another great improvement was the installation of a Harris offset automatic printing press, with a capacity of printing charts 34 by 48 inches at the rate of 3,500 per hour. This press, too, was purchased through an allotment of $14,000 made for the purpose by the President from the funds placed at his disposal by Congress for national security and defense during the war with Germany and Austria. At the time the allotment was made the Bureau was largely engaged in the printing of navigational charts absolutely necessary for the use of the Army and Navy, and realizing the resulting disaster in case of a breakdown of one of the other presses the purchase of this additional press was authorized.

On our representation to Congress of the great necessity funds were appropriated to the extent of $1,500 in the sundry civil act approved July 1, 1918, for the purchase of two motor-driven lathes for the instrument section of this Bureau. These have been purchased and installed, and by their use the work will be greatly facilitated.

A hot-water-storage system was installed in the boiler room of the Richards Building. This has made it possible to dispense with the two small, inefficient water heaters, one in the hallway of the Richards Building and one in the printing building, which had formerly been in use. The result is that we have an economical hot-water system which supplies hot water throughout all of the buildings. The cost was $1,625.

A new concrete floor was put into the dressing room of the printing building at a cost of $545. The floors in rooms 343, 347, 462, and 406, and a portion of the pressroom floor in the printing building, were covered with linoleum at a cost of $438.75.

A vestibule door was installed at the main entrance to the Richards Building at a cost of $230.

The official records kept by the hydrographic and geodetic engineer in charge of the office show that the total number of permanent and temporary employees in the office and field, which included all employees appointed through civil-service certification, were as follows:

Office force	218
Field force	229
Total	427

The above is in reference to classified employees. Persons employed in rodding, as chainmen, recorders, and heliotropers in the field parties, and enlisted men on vessels in the service are not enumerated, as the number is variable, depending upon the extent of activities in the field.

The statistics in regard to leaves of absence during the calendar year 1918 are as follows:

	Days.
Annual leave	6,927
Sick leave	2,429
Leave without pay	1,178
Accrued leave	1,062

While the number of employees naturally varies on account of resignations and vacancies, calculated on the number actually in the service on June 30, 1919, as a basis of computation, the average annual leave taken during the year by each employee was 19 days and the sick leave 5½ days.

Based on the official day of seven hours, the overtime performed by the employees of the office during the fiscal year amounted to 1,021 days or approximately 5 days for each employee.

The receipts from the sale of charts, publications, old property, etc., amounted to $25,466.65.

DIVISION OF GEODESY.

The most important pieces of work which were completed during the past fiscal year or which were in progress during that time are the following:

Computation and adjustment of the following pieces of triangulation:

1. Primary triangulation, Atlanta–Griffin.
2. Rio Grande arc of primary triangulation.
3. In Rhode Island.
4. In Maryland.
5. In Massachusetts.
6. Vicinity of Macon, Ga.
7. Coast of New Jersey.
8. In Louisiana.
9. Mobile Bay, Ala.
10. Aberdeen Proving Grounds, Md.
11. Newport, Calif.
12. Eastern oblique arc to Sanford, N. C.
13. In New York.

The computation of the following lines of primary traverse:

1. Macon–Griffin, Ga.
2. Macon–Savannah, Ga.
3. Norfolk, Va.–Savannah, Ga.
4. Albany, Ga.–Callahan, Fla.
5. Brunswick–Columbus, Ga.
6. Savannah–Everett, Ga.
7. Jacksonville, Fla.–Columbus, Ga.
8. Wilmington–Sanford, N. C.

The computation and adjustment of the following lines of precise levels:

1. Biloxi, Miss.–River Junction, Fla.
2. Sinton, Tex.–New Orleans, La.
3. Memphis, Tenn.–Little Rock, Ark.
4. Harlingen–Eagle Pass, Tex.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The division of hydrography and topography has supervision of all hydrographic and topographic surveys executed by the Coast and Geodetic Survey, which supervision includes the determination of where surveys or resurveys are required, how they shall be conducted, the preparation of instructions for the surveying parties, the organization of the parties, and the inspection of the field work and examination of the field records that result from these surveys. This division is also charged with the construction, maintenance, and repairs of vessels and other field equipment, except instruments; the compilation of the coast pilot in the field and office; the observations of tides and currents; and compilation of tide tables. For administrative purposes the division is divided into four sections, known as the section of field work, section of vessels and equipment, section of coast pilot, and section of tides and currents. This division is also charged with the supervision of the five field stations of the Bureau. These stations are located at the following cities: Boston, Mass.; New York, N. Y.; New Orleans, La.; Seattle, Wash.; and San Francisco, Calif. Under the direction of this division there is also an office at Manila, P. I. The Manila office performs all of the functions of a field station and, in addition, has direct charge of all surveys in the Philippine Islands and much of the office work incident to these surveys.

Data were collected and itemized memoranda prepared for 23 sets of instructions for field work. This embraced a careful study of existing surveys. Original field sheets covering areas where changes frequently occur, and where preliminary surveys only have been made were reviewed in order to formulate plans for performing the necessary field work to bring the charts up to date. Completed field sheets were reviewed, as time permitted, preparatory to recommending them for the approval of the Superintendent.

During the year a coast pilot of the Philippine Islands was prepared. Also, reprints were obtained of coast pilots as well as for three volumes of coast pilots for California, Oregon, Washington, and one volume for Alaska.

The manuscript for the tide tables for 1920 was prepared and submitted for printing in three separate parts, namely, the Atlantic Coast Tide Tables, the Pacific Coast Tide Tables, and that part of the General Tide Tables which is not included in either of the two reprints. These tables are similar to those issued by the Bureau for the past two or three years.

DIVISION OF CHARTS.

A fairly large proportion of the time of the chart division during approximately the first half of the fiscal year was devoted to war work. Charts, photographic enlargement, and reductions of charts

and original surveys were furnished, projections made for laying out ranges, etc., drawing and photographic work for compass roses were made for the Navy, and a drawing water-colored and photographed for an aircraft flag for the Signal Corps. In addition to the above war work mentioned in general terms, the regular duties of the division accomplished were as follows:

Drawings were finished for 7 new and 7 old charts, making 14 complete chart drawings.

Ninety-one drawings of extensive chart corrections and 438 drawings for minor chart corrections were made.

One thousand five hundred and eighteen changes to the aids to navigation, including dangers, were charted and inserted in the standards filed for the printing and sales section for hand correction.

Two thousand four hundred and fifty-six proofs of charts were verified that were received for correction before reprinting.

Drawings for new charts or extensive corrections of Philippine Island charts, received from Manila, were prepared for printing.

Forty-two hydrographic sheets were completed in this section before this work was taken over by the field record section.

In cooperation with the Bureau of Lighthouses weekly Notices to Mariners were prepared and published. A large number of miscellaneous drawings, including illustrations for the annual report of the Bureau, publications of this and other bureaus of the Government, projections for field parties, etc., were made.

Approximately 50 plates in addition to new editions and bassos were corrected so that a transfer could be made for the new offset press. These corrections not only involved the necessary changes from recent data, but also included the corrections made by the lithographers on all new prints subsequent to the time of the last transfer. Sometimes these corrections for a single plate were scattered through a formidable amount of proof. It is evident that a printing plate brought up to date in this manner without error required close cooperation of the different sections and expert proof reading.

In view of the reduced drafting force, every effort has been made by the engraving section to relieve the draftsmen of some particular portion of the work heretofore done by them. At the present time a plate for Marsh, from which the symbol will be applied direct to the printing plate, is being engraved as an experiment and for eliminating handwork on drawings.

Several new charts which have been finished during the year or are still in hand, instead of being engraved from a drawing compiled by the draftsmen, have been engraved from transfer of negatives of reduced photographs of larger scale charts or transferred from a printing plate of the same scale. Also proofs which were formerly verified in the drafting section have been verified by engravers, so that only the final proofs have been verified by the draftsmen.

Barring 1917, when the then new lithographs were printed for the most part in black and white only, the number of charts printed was the largest in the history of the Bureau. Issue and condemnation has passed the 300,000 mark. The increase over 1918 was 28 per cent. It was 136 per cent greater than for the year 1915. The United States Shipping Board is becoming a real factor, having used 21,707 charts in 1919, as compared with 10,657 in 1918.

The graphic diagrams opposite show the issue of charts from 1888 to 1919, inclusive, and the issue of coast pilots for the same period.

DIVISION OF TERRESTRIAL MAGNETISM.

The war work of the division was confined to the supplying of magnetic data to various Army camps and organizations, and to persons engaged on investigation of the submarine problem.

The results of the field work executed during 1918 were computed and prepared for publication.

The reduction of the work of the five magnetic observatories for 1917 was practically completed, and that for 1918 was well advanced. Further progress was made in the reduction of the work of the San Antonio Observatory, 1890–1895.

The earthquakes recorded at the five magnetic observatories have been tabulated monthly, and the results have been published in the Monthly Weather Bureau Review, and transmitted to the International Seismological Association and others engaged in a comparative study of earthquake data.

The results of magnetic observations in Alaska to the end of 1918 were tabulated, the secular change data were collected, and tables prepared for reducing the results to 1920; this reduction was made, and preliminary isogonic lines were drawn for that epoch.

The results of observations made at the time of the solar eclipse of June 8, 1918, were prepared for publication in the Journal of Terrestrial Magnetism.

Data concerning preliminary impulses of 17 selected magnetic storms were prepared for De Moidrey, including tracings of portions of the magnetograms from the Cheltenham, Tucson, Honolulu, and Sitka observatories.

A paper on the relation between seismic and magnetic disturbances was prepared for publication in the Bulletin of the Seismological Society of America at the request of the editor.

A table giving the values of the magnetic declination at numerous places in the United States for 1920 was prepared for insertion in the World Almanac.

A new edition of Principal Facts of the Earth's Magnetism was submitted for publication, the supply of the last edition being very nearly exhausted.

Compass data were supplied for 126 charts.

PUBLICATIONS ISSUED DURING THE YEAR.

Serial No. 74. Triangulation in Maine. By Walter F. Reynolds, chief computer, division of geodesy. U. S. Coast and Geodetic Survey. Special Publication No. 46, 286 pp. 22 figs. Octavo.

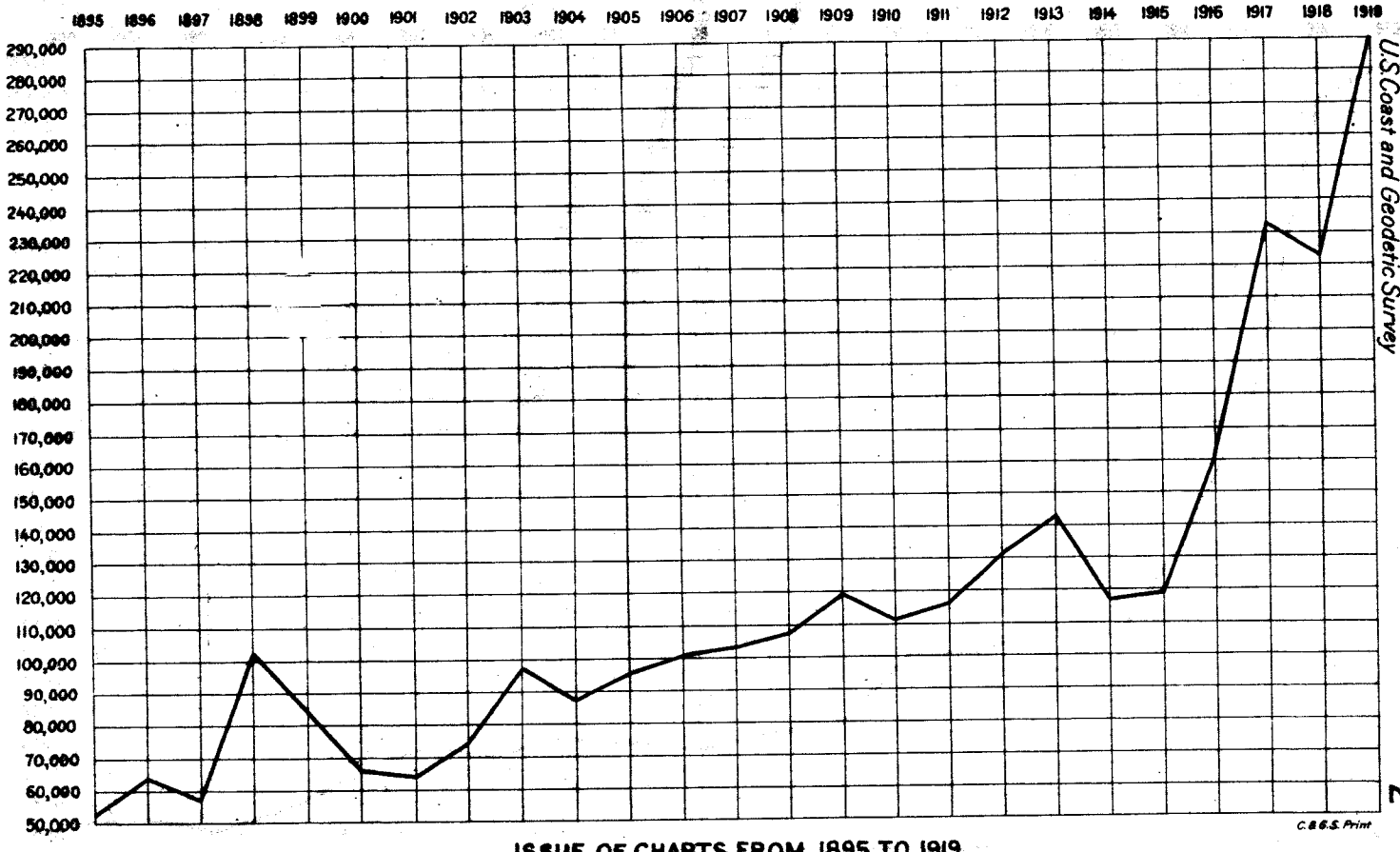
Gives results of triangulation in Maine by the U. S. Coast and Geodetic Survey.

Serial No. 80. Atlantic Coast Tide Tables from Eastern North America for the year 1919. 222 pp. 13 figs. Octavo.

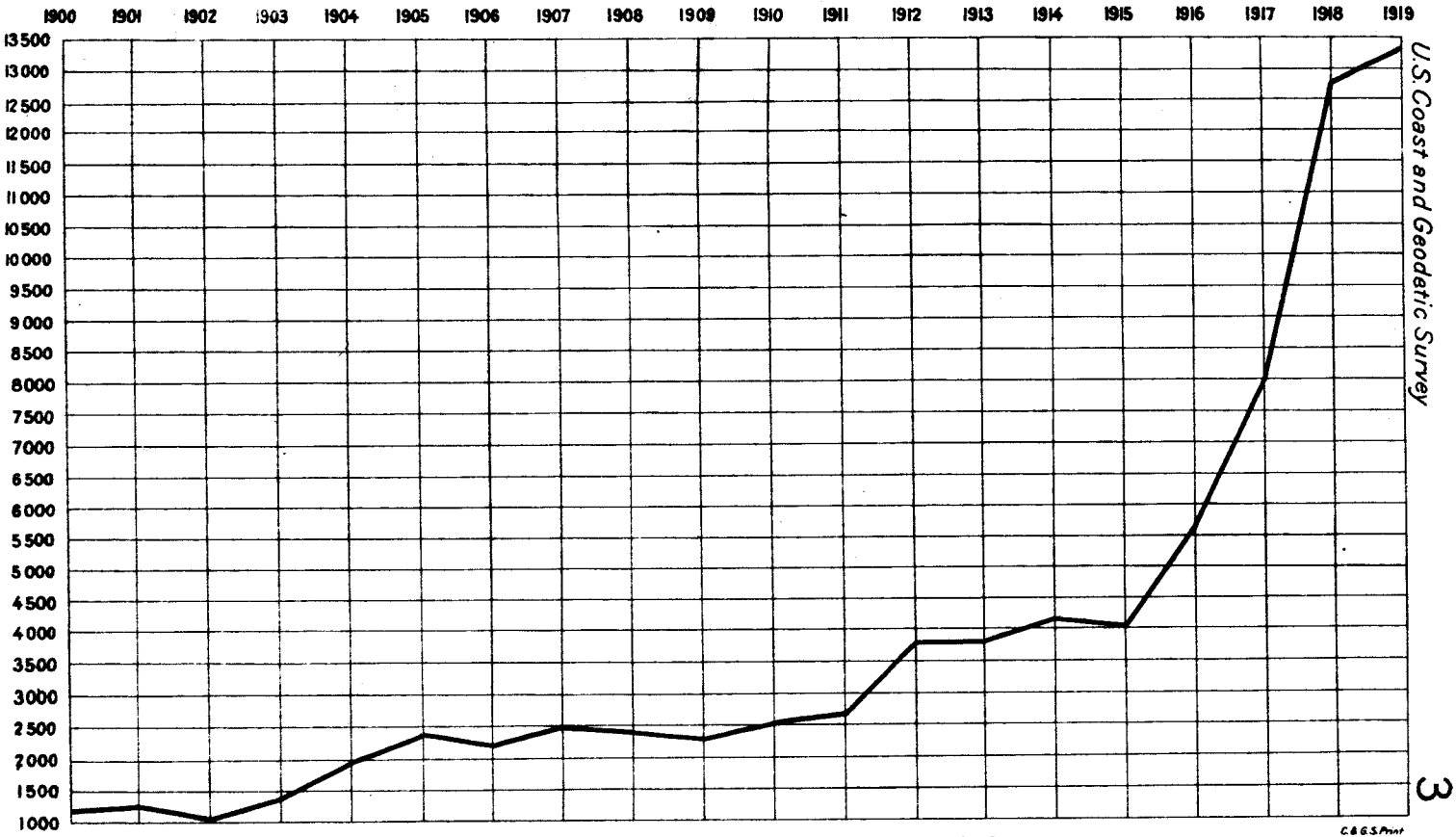
Gives tidal data and other information useful to mariners for the principal ports on the eastern Atlantic coast for the year 1919.

Serial No. 83. Pacific Coast Tide Tables for 1919. 192 pp. Octavo. (Reprinted from the General Tide Tables.)

Gives tidal data and other information useful to mariners for the principal ports on the Pacific coast for the year 1919.



ISSUE OF CHARTS FROM 1895 TO 1919



ANNUAL DISTRIBUTION OF COAST PILOTS

Serial No. 91. United States Coast Pilot, Section B; Cape Cod to Sandy Hook. 326 pp. 2 figs. Octavo. Price, 50 cents.

This volume covers part of the territory formerly included in Atlantic Coast Pilot, Part III, and all of the territory formerly included in Atlantic Coast Pilot, Part IV.

Serial No. 92. General Theory of the Lambert Conformal Conic Projection. By O. S. Adams. Special Publication No. 53. 38 pp. 11 figs. 12mo.

This publication contains a general development of the Lambert conformal conic projection. It supplements Special Publications Nos. 47, 49, and 52, since it gives as a whole the mathematical development of the theory upon which they depend.

Serial No. 94. Results of Observations Made at the U. S. Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1915 and 1916. 112 pp. 21 figs. Quarto.

This is one of the regular series of publications giving results of observations made at the magnetic observatories maintained by the U. S. Coast and Geodetic Survey.

Serial No. 95. General Tide Tables for the Year 1919. 487 pp. 12 figs. Octavo. Price, 50 cents.

Gives tidal data for the principal seaports of the United States and for many foreign ports.

Serial No. 96. Supplement to the United States Coast Pilot, Atlantic Coast, Section D; Cape Henry to Key West, May 24, 1918. 25 leaves. Octavo.

Gives latest corrections in sailing directions, aids to navigation, etc., for that volume of the Atlantic Coast Pilot.

Serial No. 97. Report of the Connection of the Arcs of Primary Triangulation Along the Ninety-eighth Meridian in the United States and in Mexico and on Triangulation in Southern Texas. Special Publication No. 54. 1919. 93 pp. 17 figs. Octavo.

Gives geographic positions and descriptions of stations in the primary triangulation along the ninety-eighth meridian in the United States and in Mexico and of triangulation in southern Texas.

Serial No. 99. United States Coast Pilot, Atlantic Coast, Section A; St. Croix River to Cape Cod, 1918. 305 pp. Octavo. Price, 50 cents.

This publication covers all of the territory formerly included in Atlantic Coast Pilot, Parts I, II, St. Croix River to Cape Ann, and a part of the territory formerly included in the Atlantic Coast Pilot, Part III, Cape Ann to Point Judith, of which three editions each were published.

Serial No. 101. Regulations for the Government of the U. S. Coast and Geodetic Survey. 167 pp. Octavo.

Contains the revised regulations adopted by the Department of Commerce for the government of the U. S. Coast and Geodetic Survey.

Serial No. 102. Uniform Regulations for the Field Corps of the U. S. Coast and Geodetic Survey, 1918. 16 pp. 5 plates. Octavo.

Gives description, specifications, and cuts of the uniforms prescribed for officers and men of the U. S. Coast and Geodetic Survey.

Serial No. 103. Atlantic Coast Tide Tables for 1920. 6 figs. Octavo. Price, 10 cents.

Gives times and heights of high and low water for principal ports on the Atlantic coast for the calendar year 1920, and other information useful to mariners, including current tables and diagrams; times of sunrise and sunset, and moonrise and moonset; and tables of differences by means of which tidal data may be obtained for other ports not mentioned in the tables.

Serial No. 105. Results of Magnetic Observations Made by the U. S. Coast and Geodetic Survey in 1918. 32 pp. Octavo.

Gives results of magnetic observations at the magnetic observatories and in the field in 1918.

Serial No. 106. Supplement to U. S. Coast and Geodetic Survey Catalogue of Charts, Coast Pilots, and Tide Tables, 1918. 5 pp. Quarto. 1919.

Gives corrections to the list of published charts, coast pilots, and tide tables to January 4, 1919.

Serial No. 107. Special Publication No. 56. Construction and Operation of the Wire Drag. 40 pp. 13 figs. Octavo. Price, 10 cents.

Explains briefly the construction and operation of the wire drag, the outfit and organization required, the kind of boats needed, methods of plotting the work, speed, area covered, and cost.

Serial No. 109. Important publications of the U. S. Coast and Geodetic Survey Appearing Since January 1, 1914. 6 pp. Octavo.

Contains a list of the more important publications issued since the date mentioned.

Serial No. 114. Supplement to U. S. Coast and Geodetic Survey Catalogue of Charts, Coast Pilots, and Tide Tables, 1918. (June 1, 1919.) 6 pp. Quarto.

Gives list of new charts; new maps; canceled, suspended, and reissued charts and coast pilots, and supplements; new editions of charts; and errata to last edition of catalogue published in 1918.

Annual Report of the Superintendent, Coast and Geodetic Survey. 1918. 133 pp. 37 figs. Octavo.

Gives an account of the field and office work accomplished by the Survey during the year, and a statement of the most urgent needs of the Bureau. The war activities of the Survey are briefly summarized.

Catalogue of Charts, Sailing Directions, and Tide Tables of the Philippine Islands (reprinted from the General Catalogue). 1918. 46 pp. 23 figs. Quarto.

This is a separate list published for the use of those who are chiefly interested in the publications relating to the Philippine Islands.

Philippine Island Sailing Directions, Sections VI and VII. Mindoro Strait, Palawan Island, and Sulu Sea and Archipelago Bulletin, Coast and Geodetic Survey, Manila, 1918. 290 pp. Octavo.

Gives sailing directions and information for the use of navigators in regard to aids to navigation, dangers, port facilities, etc., for the locations named.

Notices to Mariners. Issued weekly, jointly with the U. S. Bureau of Lighthouses, Nos. 1–52.

Philippine Islands Notices to Mariners, Nos. 2, 3, and 4 of 1918, and No. 1 of 1919.

Coast and Geodetic Survey Bulletin, issued monthly. July, 1918, to June, 1919, inclusive.

Supplement to Catalogue of Charts, Coast Pilots, and Tide Tables, July 10, 1918. 4 pp. Quarto.

Contains list of new charts, new editions of charts, canceled editions of charts, etc., since the last published edition of the catalogue.

NEW CHARTS.

No. 219. North Shore of Long Island Sound, Milford to Stratford, Including Housatonic River, Conn. Scale 1:20,000. Price, 50 cents.

This new chart replaces the larger scale charts Nos. 263 and 264, and by the arrangement of its limits, shows on a larger scale than heretofore the Housatonic River from Long Island Sound to Derby.

No. 337. Lynn Harbor and Approaches, Mass. Scale, 1:40,000. Dimensions, 13 by 17 inches. Price, 20 cents.

No. 1117. Galveston to the Rio Grande. Scale, 1:400,000. Price, 50 cents.

No. 1269. Lakes Ponchartrain and Maurepas, La. Scale, 1:80,000. Dimensions, 30 by 42 inches. Price, 50 cents.

This chart supersedes chart No. 192, having the same descriptive title. It includes New Orleans and a portion of the Mississippi River from Mile Point to Lake Borgne Canal. This extension beyond the southern limit of the old chart shows, in a comprehensive manner, the relation of these lakes to the city and the exit to the Gulf by the river route.

No. 4336. Anchorages in Cuyo Islands, P. I. Cuyo Anchorage and Bisucay Channel, scale 1:10,000; Taganayan Islands, scale 1:10,000. Price, 50 cents.

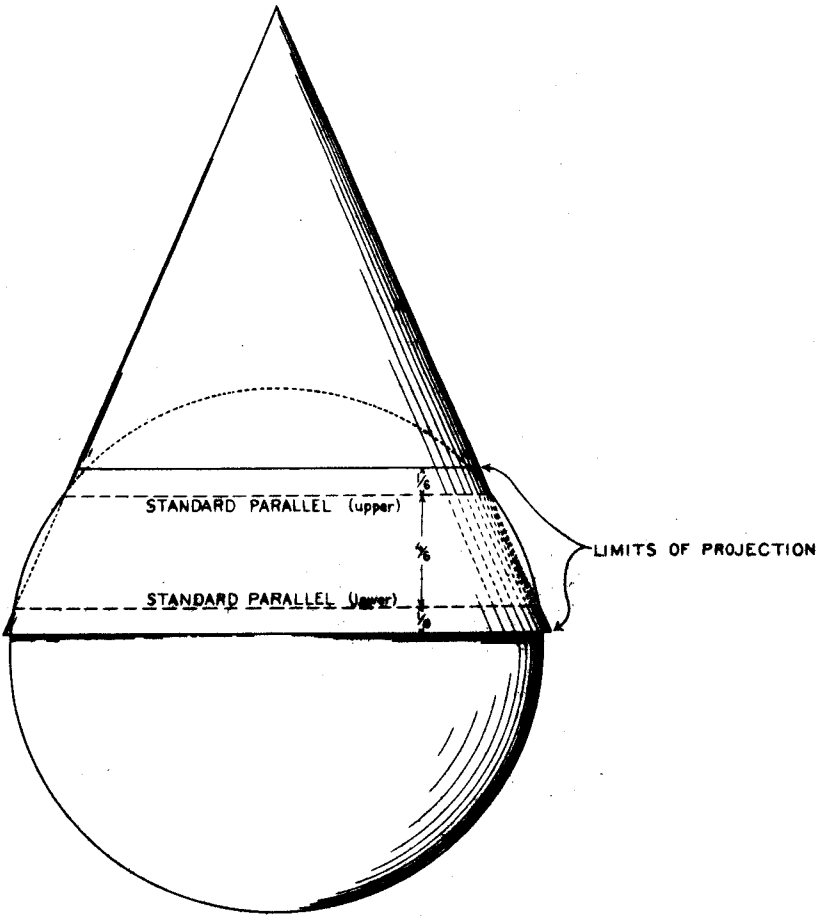
No. 4350. Western Entrance to Coron Bay, Calamian Group, P. I. Scale, 1:50,000. Price, 40 cents.

This new chart shows the western approach from the China Sea to Coron Bay and, with its companion chart No. 4351, gives a representation on a large scale of the thoroughfare between Busuanga and Culion Islands.

No. 6102. Approaches to Strait of Juan de Fuca; Destruction Island to Amphitrite Point. Scale, 1:200,000. Price, 50 cents.

No. 6447. Lake Washington Ship Canal, Puget Sound to Lake Washington, Wash. Scale, 1:10,000. Price, 50 cents.

This is the first published chart of this important recently completed waterway.



LAMBERT'S CONFORMAL CONIC PROJECTION

Diagram illustrating the intersection of a cone and sphere along the two standard parallels.

C.&G.S. Print

No. 8164. Steamer Bay, Wrangell Harbor, and Highfield Anchorage, Alaska. Steamer Bay, scale 1:20,000; Wrangell Harbor and Highfield Anchorage, scale, 1:10,000. Price, 30 cents.

Besides the new charts above listed, 66 new editions of charts were issued, some of which embody important corrections, additions, and new information.

While the foregoing is a complete list of the publications issued by this Bureau during the fiscal year, publications on two subjects have been issued by this Bureau that are of special importance. One of these is the series of publications on the Lambert Conformal Conic Projection. The principal of the Lambert projection is, in a measure, graphically illustrated in the figure opposite.

Many methods of projection have been designed to solve the difficult problems of representing a spherical surface on a plane. As different projections have unquestionable merits, as well as equally serious defects, any region to be mapped should be made the subject of special study, and that system of projection adopted which will give the best results for the area and purposes under consideration.

The Mercator projection, almost universally used for nautical charts, is responsible for many false impressions of the relative size of countries differing in latitude. The polyconic projection, widely used and well adapted for most topographic and hydrographic surveys, when used for the whole of the United States in one map, has the serious defect of unduly exaggerating the areas on its eastern and western limits.

Along the Pacific coast and in Maine the error in scale is as much does this projection attain its maximum error of $2\frac{1}{3}$ per cent.

The value of the new outline map on the new Lambert projection can best be realized when it is stated that, throughout the larger and most important parts of the United States—that is, between latitudes $30\frac{1}{2}°$ and $49°$—the maximum scale error is only one-half of 1 per cent. This amount of scale error of one-half of 1 per cent is frequently less than the distortion due to the method of printing and to changes in the humidity of the air. Only in southernmost Florida and Texas does this projection attain its maximum error of $2\frac{1}{3}$ per cent.

The Lambert projection is well adapted to large areas of predominating east and west dimensions, as the United States, where the distance across from east to west is one and four-fifths times that of the distance north and south.

The strength of the polyconic projection, on the other hand, is along its central meridian. The merit and defects of the two systems of projection may be stated in a general way as being at right angles with each other.

Special features of the Lambert projection that are not found in the polyconic may be stated briefly as follows:

1. The Lambert projection is conformal; that is, all angles between intersecting lines or curves are preserved, and for any point (or restricted locality) the ratio of the length of a linear element on the earth's surface to the length on the corresponding map element is constant for all azimuths or directions in which the element may be taken.

2. The meridians are straight lines and the parallels are concentric circles.

3. It has two axes of strength instead of one, the standard parallels of the map of the United States being latitude 33° and 45°, and upon these parallels the scale is absolutely true. The scale for any other part of the map, or any parallel, can be obtained from tables contained in one of this series of publications. By means of these tables the very small scale errors in this projection can be entirely eliminated.

The other of these publications is the Report on the Connection of the Arcs of Primary Triangulation Along the Ninety-Eighth Meridian in the United States and in Mexico, and on Triangulation in Southern Texas. An event of great importance in the history of geodesy was consummated in the spring of 1916, when observations were made at stations on the northern and southern banks of the Rio Grande, which connected the arcs of primary triangulation which had been established in the United States and in Mexico along the ninety-eighth meridian. The connection is interesting to the geodesist, because it makes available a very long meridional arc of connected and completed triangulation.

This connection will make available data from which to compute with greater accuracy than heretofore the dimensions of the earth. This will in itself make the work a notable contribution to science. But of even greater moment is the fact that the connection of the triangulation of the United States and Mexico will enable the latter country to extend to new areas from the ninety-eighth meridian arc geodetic control for surveys and maps in the form of triangulation which can be made on the North American datum.

This datum had been called the United States standard datum previous to the year 1913, when it was also adopted by Mexico and Canada for their geodetic coordinates. Its designation was changed to the North American datum when it had thus attained an international character.

Part II.—FIELD WORK AND NEEDS OF THE FIELD SERVICE.

CHAPTER I.

STATEMENT OF NEEDS OF THE BUREAU TO BETTER ACCOMPLISH ITS FIELD WORK.

SURVEYING VESSELS.

Again my appeal that the failure to provide modern vessels for our hydrographic work is prolonging inefficiency, increasing cost for what is being produced, and, worst of all, the delay in protecting our waters against loss of life and property.

The end of the fiscal year finds us with a fleet of 15 vessels, a truly considerable number based on a comparison with those available in previous years, and probably more than has ever been at the disposal of the Bureau at any one time in its history. The comparatively large number of vessels at our command at the present time is due to the fact that 5 vessels have been transferred to the Coast and Geodetic Survey from the Navy Department under authority of the Executive order of May 24, 1919. These 5 were part of a number of vessels that the Navy Department found on its hands at the close of the war with Germany, and which had been acquired to meet the temporary naval need for patrol boats, etc. But, with our fleet augmented as it is by these additions from the Navy Department, we have not at all a satisfactory condition. While we have numbers, we have distinct *inefficient* units. When we learned that the Navy had spare vessels that were authorized to be transferred by the act of May 20, 1918, a board of Coast and Geodetic Survey officers was appointed by me to get in touch with the proper officials of the Navy Department and learn what vessels were available for transfer that were best suited for our needs. After a thorough examination of all the vessels that the Navy Department had available for transfer, the board recommended that we take over the 5 vessels from the Navy Department that have been named earlier in this report, and there are 2 other vessels of the Navy Department, probably, that will eventually come to us. These vessels were accepted, not because they were suited for our work, but because they are the best means to an end at the present time. I feel that we have a great responsibility in meeting the marine needs of this country in finding and charting the dangers to navigation. The need is so pressing that I believe that we are justified in doing what we can with these vessels from the Navy Department, though at a considerable excessive expenditure of overhead cost to accomplish the same results that would be brought about much more cheaply if we had vessels that are designed for our work.

While the Navy had a great number and variety of vessels at the close of the war that could be transferred to other services, and without close reflection, it might be assumed that certainly out of these numbers vessels could be selected that would readily meet our needs, and while the board I appointed canvassed the situation thoroughly, and made the best possible selection, the vessels we have thus acquired can not be efficiently operated as surveying vessels. The reasons are these: We can not economically carry on ship hydrography with a vessel that is too large, because she requires too large a complement of officers and men, nor can the work be done with safety with a vessel that is too small, because she can not live through the severe weather that will be met. Furthermore, the character of the area to be surveyed seldom permits clean-cut classification, so that it can be determined beforehand that such and such a portion of it will be done by vessel, and such and such a portion by launches. Therefore, greater progress is made, and more economically, if a vessel is equipped to carry launches on her deck, and when the field of operation is reached the launch hydrography (in waters too shallow for the vessel to operate) is done in conjunction with the ship hydrography. Thus the entire area is covered by the same party during the same season. These combined operations are carried on much more cheaply than if undertaken separately. To meet this condition, a vessel must be large enough to carry three or four heavy launches on her deck. For these reasons our selection of vessels from those available had to be confined to those of a tonnage of 200 to 1,000 tons. The vessels of such tonnage of those available from the Navy Department were yachts.

There are two classes of ship hydrography: Offshore, such as that off the coasts of California, Oregon, and Washington, out to the 1,000-fathom curve; the other class is known as combined hydrography, such as that along the coast of Alaska, where there are many areas of which the deeper water hydrography must be done by a vessel and the waters inshore by launches.

The particular reasons why the yachts that we have obtained from the Navy Department are not suitable for either of these classes of hydrography are these: The offshore hydrography that must be done by ships along the coast of Washington, Oregon, and California out to the 1,000-fathom curve, extends a general average distance of 30 miles from shore. Along these coasts the harbors of refuge are few and far between. Furthermore, the storms encountered within the area that must be surveyed are generally very severe. To buffet the storms that will surely be encountered, a stanch seagoing vessel is required. The yachts that we have acquired have neither the strength required of hull or machinery to stand the strain to which they would be subjected in these storms. Furthermore, if they were stanch enough for this outside work, they have not the fuel capacity to make it economical to operate them there. Too much time would have to be expended in running to the widely separated ports to obtain fuel supplies. This class of hydrography is done by running lines of soundings at right angles to the shore, to and from the shore, out to the 1,000-fathom curve. If a vessel only has fuel capacity to enable her to make but a few of these 50 or 60 mile trips from the shore out to the 1,000-fathom

curve and back to shore, and then must abandon her work, and steam some hundreds of miles to a port to obtain a fresh supply of fuel, it is readily seen that there is an enormous loss of time, and, consequently, a great overhead cost to carry on this class of surveys with such a vessel. Vessels properly designed for this work are oil-burning, and have a cruising radius of several thousand miles. These are the reasons why these yachts are neither safe nor economical for executing offshore hydrography.

In respect to the combined operations—that is, areas where, for the sake of economy, the ship hydrography and the launch hydrography should be executed at the same time—there is this difficulty in undertaking it with the vessels that we have acquired from the Navy Department. The vessels that came to us from the Navy Department are yachts, and were used as patrol boats in searching for submarines. They are, therefore, built for speed, and along narrow lines. Consequently they have neither the deck room for the storage of launches, nor the stability to carry them. Neither have they the deck for installation of hoisting apparatus for hoisting the launch aboard the vessel. If the necessary three or four launches for use in combined operations were installed on the deck of one of these yachts, she would be so top-heavy that it would be hazardous to put to sea with her. Such a vessel would have to be at sea a considerable portion of the time effectively to carry on surveying operations.

The impression has gotten abroad that there is no justification in our asking for appropriations for new vessels especially designed for the work of this Bureau, so long as there would be surplus vessels after the war, but such views are erroneous. A great public need would be more quickly met, and in the long run dollars that come from the public treasury would be saved, if proper surveying vessels were provided for this Bureau. *It costs practically as much in personnel, food, and supplies to operate an inefficient vessel as it does to operate an efficient one.* As it is, we will make what progress we can at a very considerable loss of efficiency, in picking here and there sheltered waters where these vessels can be used, and equip the larger ones with as many launches as they will carry, probably not more than two, so that the vessel hydrography will progress more rapidly than the launch hydrography, and delays will be enforced in regions where combined vessel and launch hydrography are necessary. There is as much necessity for vessels of special design for making surveys as there is for use as tugs, ferries, lightships, and for freight or passenger vessels.

The course that legislation has taken in respect to providing new surveying vessels for this Bureau has largely prompted us to make the experiment of transferring to this Bureau the spare vessels of the Navy Department, and undertaking to make surveys with them. In 16 years, or from 1903 to 1919, but one effective appropriation was made for vessels for the Coast and Geodetic Survey, and that was for the fiscal year ended June 30, 1916, when the sum of $289 000 was authorized for two new vessels, including their equipment. Through this appropriation we procured two vessels, one especially designed and built for a surveying vessel and the other was purchased. For the fiscal year ended June 30, 1919, an appropriation was made in

the following words, "for one new vessel, including equipment, to cost not exceeding $354,000, $50,000." On my submission to you, the question was presented to the Comptroller of the Treasury as to whether there was authority to enter into a contract for the construction of a vessel to cost not exceeding the limit mentioned. The Comptroller held that the legislation did not in specific terms declare that a contract could be executed in excess of the amount appropriated, and, therefore, such a contract would be in violation of the act of June 30, 1906, which provides that "no Act of Congress hereafter passed shall be construed to make an appropriation out of the Treasury of the United States or to authorize the execution of a contract involving the payment of money in excess of appropriations made by law, unless such act shall in specific terms declare an appropriation to be made or that a contract may be executed."

Prior to the late war, under our system of finance, the greater part of the revenue of the Government was derived from the duties paid by our commerce, and the demand that a small portion of the immense wealth, which is thus annually poured into the Treasury, should, for a few years, be expended in protecting the lives and property of those thus contributing, is so plainly just as to need no argument in its support. Conditions have been so abnormal since 1914, and international trade has been so hampered that statistics since that time are not representative. The actual receipts from customs in the Treasury, for the fiscal year ending June 30, 1913, were $312,509,946. For that same fiscal year the appropriations for making hydrographic surveys by the Coast and Geodetic Survey were $261,400, and no appropriation was made granting a vessel for this Bureau. We have not during the past years had the vessels and personnel to bring the surveys of our waters up to a proper standard. The charts of Alaskan waters are entirely incomplete, and the information shown on many of them is from exploration surveys by the Russians before Alaska was acquired by the United States, and with a lack of exactness that would not be tolerated at the present time. The charts of the waters of the three Pacific Coast States do not contain sufficient information for offshore navigation, and many of the charts of the Atlantic coast and Gulf coast of the United States are lacking in the same respect. This should be borne in mind, that heretofore the vessels that plied our waters have been largely of foreign registration, and therefore, losses on account of inadequate surveys have been borne to a considerable extent by other countries than ours, but that the war has brought about a great stimulation of shipbuilding in this country, so that our vessels have increased from 26,397 with a gross tonnage of 8 871,037 in 1917, to 27,217 with a gross tonnage of 11,261,444 at the beginning of the year 1919. What is more significant still is that the increase of our merchant fleet has been, not in small shore-hugging craft, but ships of a size and type adapted to ocean service. While on July 30, 1914, just before the outbreak of the great war, our seagoing merchant ships of 1,000 gross tons or over numbered only 755, of 2,128,731 gross tons, these vessels of more than 1,000 gross tons numbered on June 30, 1918, no fewer than 2,058, of 7,300,022 gross tons, or a net gain of more than 5,000,000 tons in vessels capable of ocean navigation.

WIRE-DRAG LAUNCHES.

In the sundry civil bill for the fiscal year ended June 30, 1919, the sum of $62,500 was appropriated for wire-drag launches, including their equipment, for the Coast and Geodetic Survey. Out of this appropriation four 60-foot launches have been built and equipped and three 30-foot tenders. One 30-foot tender was purchased.

While these launches have been in commission but a very short time, they have already demonstrated their efficiency in carrying on our wire-drag surveys. They are trim vessels with sufficient strength to propel the wire drags, yet economical of fuel consumption. They are especially designed for this class of work, and, therefore, have the proper amount of space, and in right place for storing all the necessary equipment and implements for making wire-drag surveys. They are far superior to the weaker, lumbering fishing vessels that have been hired heretofore for pulling the wire drag, and which we have been forced to alter in order to install the wire-drag equipment, reels, engine, etc. With this demonstrated efficiency and economy that has resulted from the use of these vessels especially designed for this work, there is the stronger reason that such vessels should be utilized for carrying on all our wire-drag surveys. The wire-drag vessels that have been built for us out of the appropriation for 1919 are sufficient to operate two wire-drag parties. There are four regions where the wire-drag survey only is capable of finding the hidden, underwater dangers to navigation, and these are all along the coast of New England, Long Island Sound down to the entrance to New York Harbor. In this region are found the glacial deposits of bowlders that have been left beneath the waters bordering the coast. The second general region is the coast of Florida from Palm Beach southward around the southern shores and up to the neighborhood of Cedar Keys. In these waters the coral reefs are the dangers to navigation. Some of these reefs are in the form of small islands, known locally as keys, while others are entirely submerged, and therefore hidden from sight where they are grave menaces to navigation. While coral reefs are characteristic of all these waters, the regions where wire-drag examinations are most urgently needed are in the vicinity of Key West, and to the westward from there, and then northward through the channels that commercial vessels take in and out of the Gulf from Mobile, New Orleans, etc. The third region where wire-drag surveys are required is in the coral-infested waters of the Porto Rican and Virgin Islands. The fourth general region where wire-drag surveys are required is along the coast, and through the passages of southeastern Alaska. The danger to be found here by the wire drag is the pinnacle rock which is found in the form of a narrow needle-like rock that extends from a very great depth to very near the surface of the ocean. Ordinary soundings with the lead and line are of little avail in finding these pinnacle rocks, and indeed, are often quite deceptive in that such soundings show a very considerable depth, and give assurance of safety, while danger may be at hand. Instances are known where the pinnacle rocks come to within a very short distance of the surface of the water, while soundings showed depths of hundreds of feet in their immediate neighborhood. There is one

other small area where the wire drag should be used, though of no considerable extent. This is at the Atlantic entrance to the Panama Canal.

Below is a summary of the wire-drag surveys yet to be made:

Coast of—	Square statute miles.
New England	1,344
Florida	500
Porto Rico	2,300
Alaska	49,975
Entrance to the Canal Zone	200
Total	54,319

From this it follows that two wire-drag parties that can be operated with the modern wire-drag vessels that we now have at our command, and which were built out of the money appropriated for the purpose in the sundry civil bill for 1919, can accomplish only a fractional part of the wire-drag work that remains to be done. In the belief that the remedy should be applied where the danger is greatest, one of these parties is operating in Long Island Sound and the other off the coast of Maine. Wire-drag work can be effectively carried on in these waters from about the first of April until the close of November. Climatic conditions do not permit the work being carried on during the remainder of the year. We have seriously considered sending these launches to Florida waters for operations during the winter season, and while there would be some gain, there are corresponding losses that we think would more than offset the gain. The main reasons are these: It is a long and somewhat hazardous run for such small vessels from the coast of New England to the coast of Florida. The wear and tear on the engines in making this run twice a year would be very considerable, so much so, that it is believed that it would materially shorten the life of the launches. Past experience has demonstrated that it is economical to give the wire-drag apparatus a thorough overhauling after each season of operation, rather than to continue it in service until a break occurs, which halts the whole party for a considerable time to make a minor repair; and if the equipment is continued in operation too long the minor breaks are very frequent. Practical experience has taught that much more is gained to go into the field with first-class equipment, and work the party to the limit of endurance during the season, disband the party, and place the vessels and equipment under the charge of a drag master during the winter months, and hold him responsible for a thorough overhauling of the equipment.

We have acquired from the Navy two fairly large power launches. While these have not been designed and built for wire-drag purposes, we believe that with some alteration they will fairly answer for this purpose. These will be used in Alaskan waters. The wire drag requires two power launches, one at each end of the drag. The launches that we have acquired from the Navy are larger than those that were built for us out of the appropriation for 1919. They are too large to be used both on the same drag. A very efficient drag would be formed by using one of these launches acquired from the Navy and one of the type of those that have been built for us out of the appropriations for 1919. Therefore, what we really need are four additional 60-foot launches of the type of those built out of the

appropriation for 1919. Two of these in conjunction with the two launches which we have acquired from the Navy would make up two wire-drag parties for the Alaskan waters, and the other two would provide a wire-drag party for the coast of Florida. There is more wire-drag work than can be completed by the five wire-drag parties that would be thus provided within the lifetime of the launches. That is to say, that the period during which one of these launches can be operated in which the expense of maintenance and repair does not become too excessive is, probably, 10 years. After that time the upkeep would be excessive. The wire-drag work remaining to be done is so extensive that it would not be accomplished by five parties in 10 years.

INCREASED APPROPRIATIONS FOR CONTINUING GEODETIC OPERATIONS.

Later in this report is given a statement of the progress of the geodetic survey of the United States and possessions. Therein the statement is made that primary triangulation has been executed to the extent of 14,000 miles, primary traverse to the extent of 2,000 miles, and precise leveling to the amount of 41,000 miles. The location of this geodetic work in the United States is graphically shown on a base map of the United States in another portion of this report. (See fig. 31.) I have also stated earlier in the report that it is our ultimate aim to extend this work so that triangulation and precise leveling bench marks shall be placed within 50 miles of each place in the United States. It needs no argument to convince the practical civil engineer of the necessity of extending this work to this degree of completeness at the earliest possible date. Indeed, he will contend that it has now been far too long delayed. But, as this matter is finally of interest to all, as well as to civil engineers, I feel it proper here to make some explanation of its needs.

Geodetic control brought about by triangulation and precise leveling forms the basic framework on which all our maps of any accuracy are based. If the reader, without preliminary measurements, will draw on a piece of paper a floor plan of his residence showing the various rooms, the chances are that it will be to some extent out of proportion—that is, that all of the lines shown in the diagram thus drawn will not be true to scale. On the other hand, if the reader had measured each of the floor spaces in the floor plan of his residence, including the thickness of walls, and determined on a scale for his drawing, say, 10 feet of floor space to be represented by 1 inch of his drawing, and laid out his drawing in exact accordance with his measurement, his diagram would then be in exact proportion—that is, 1 inch measured on the diagram would always represent 10 feet by actual measurements on the floor plan of his residence. This is an illustration of the application of geodetic control in drawing maps. The area to be mapped is first triangulated through triangulation observations covering the area to be mapped, the same results are obtained as if distances between points were actually measured. With the distances between definitely marked points on the earth's surface thus known and determined, maps can be drawn true to scale. I would, therefore, urge that the main control be extended as rapidly as our equipment and personnel will permit, and that it should be

completed within five or six years. To do this will cost about $1,000,000, and I would urge that one-fifth of that amount be appropriated each year, or about $200,000 per annum. Triangulation stations and precise leveling bench marks within 50 miles of each place in the United States is what this scheme contemplates. This is far from what the final necessity will require, and by no means reaches the degree of completeness of many of the foreign countries.

The Corps of Engineers, United States Army has, as one of its functions, the preparation of special military maps for the defense of the country and for other purposes. Most of the maps made for that organization will be close to the seacoast of the country. The control that will be used on those maps will be largely tertiary triangulation along the coast, done by the Coast and Geodetic Survey. That triangulation is, in some cases, in bad shape, due to the loss of station marks from the erosion of the shores and the work of man. It is, therefore, desirable that parties be sent along all the coasts of the United States to make inspection of the triangulation data. It is believed that, at least once in 10 years, triangulation stations should be visited and supplemented where necessary. During such an inspection the positions of any new permanent objects that can be used in surveying or by the navigator should be determined.

In addition to the use of these branches of surveying for mapping purposes they have a very great value in furnishing the definite geographic location of boundary monuments of the States and between adjacent countries. For this use alone the expenditure would be thoroughly justified, as litigation over State and county boundaries has cost the Nation millions of dollars in the past, and will continue to do so as long as boundaries are uncertain in position.

INCREASED PAY FOR COMMISSIONED OFFICERS.

The pay for the commissioned officers in this Bureau must be increased if we are to retain a corps of experienced and competent men. Under our present scale of salaries the younger and more efficient men are leaving us for better opportunities elsewhere. Within 7 months 11 of our junior hydrographic and geodetic engineers have resigned from this service. Most of these were particularly competent officers who had had considerable training. Besides these, and within the same period of time, 7 of our commissioned aids have resigned, and it has been intimated to me that 2 or 3 additional junior hydrographic and geodetic engineers, as well as many aids, will resign in the near future. These resignations come to us not because of any dislike for the service in this Bureau. For the most part they are tendered reluctantly, because the men dislike to leave this service, but opportunities for better pay, even better initial pay, are offered elsewhere, and advancement is more rapid and expectant.

INVESTIGATION OF THE USE OF THE AIRPLANE FOR MAKING SURVEYS.

Another need of the field service is an investigation of the possibilities of the use of the airplane in making topographic surveys and hydrographic examinations, as well as revisionary surveys. Airplane photographs were used to a very great extent during the war in locating military features of the enemy. The same principle em-

ployed in the military work can be used in surveying and mapping, but a large amount of research work will have to be done before the airplane photograph will give the accuracy required of the highest class of surveying done by this and other organizations.

It is a very difficult matter to keep the topographic features up to date on the 700 charts of the United States Coast and Geodetic Survey with the old methods, but it is possible in many cases, and especially in a flat country, to make very rapid revision of the shore line and adjacent land areas by means of photographs taken from airplanes.

The Coast and Geodetic Survey during the past year has been in close cooperation with the air service of the Army and Navy in making certain tests which indicate that suitable results may soon be expected. In fact, the best method, with proper handling of the airplane during the time that the photographs are being taken, will give results which can be used on at least small-scale charts of this Survey.

The mapping of the country adjacent to the shore where there is considerable relief is at present not practicable from the airplane on account of the great amount of work that would be involved in reducing the photographs to the map, but it is believed that methods will be developed by which this will be done more expeditiously, and then there will be no limit to the character of terrain on which the airplane can be used for surveying.

It must not be supposed that the airplane can entirely supersede the usual methods of surveying. We shall still need triangulation and traverse to give the fundamental control for the work, and much planetable work will have to be done to locate topographical features which may be used in the control of the position of the airplane photographs. It is also probable that the planetable will still be the method for placing the contours on the maps. While it is possible to obtain some idea of the relief of the country from overlapping airplane photographs, at the same time the problem of placing contours accurately on the map is one which will be difficult to solve. The office expense of contouring a map from airplane photographs will, undoubtedly, be greater than by an instrumental party working in the field, if the contouring is to be of a higher grade of accuracy.

The most promising field for surveying and mapping from an airplane is over flat country, or country with low relief, and in revision surveys where the contouring has already been accurately done. The changing features are shore lines, woods, roads, villages, and these features can be readily placed on the old map by fitting in the new features shown on the photograph, to the unchanged features shown both on the old map and on the photograph. It is in this revision work that the Coast and Geodetic Survey expects much help from the air services of the Army and of the Navy.

What seems to be most desirable at present is that we should have a research laboratory connected with the air service of the Army or of the Navy at which various methods and instruments might be tested. Such a laboratory should be preferably, in the vicinity of Washington, where the Government survey and mapping organizations are located.

This Bureau and other surveying and mapping organizations of the Government have frequently called to the attention of the public the desirability of having our vast area mapped at an early date

for the benefit of commerce and industry. There is hardly a human effort that is not more or less dependent upon some kind of a map, and the more accurate the map the greater its use to commerce and industry. There are many sparsely settled places in the United States where elaborate maps could not be justified, on account of the time and expense involved in their preparation. But there are many other communities where there are no maps to-day, where we would be far better off if we had an accurate map for the extension of roads, utilization of water power, and many other branches of human activity.

The Coast and Geodetic Survey is doing what it can in the interest of the country in establishing the control for accurate maps. This work has been more vigorously carried on in the past two years.

For the next fiscal year I have asked for a considerable increase in the amount of money to be devoted to this control work, and I hope that Congress will see its way clear to grant this increase, for it is undoubtedly true that the public will be benefited every year many times the cost of the original surveys.

On account of the great need of the public for maps, both along the coast and in the interior, the airplane photographs should be developed to such an extent that the usual methods of surveying could be supplemented by the airplane photograph and the work very greatly expedited. To this end the Coast and Geodetic Survey will lend its energy and support.

CHAPTER II.

WHAT HAS BEEN DONE DURING THE FISCAL YEAR.

In the 1918 annual report of this Bureau the field accomplishments for the year were summarized under the following classifications:

Hydrography: (1) Ship and launch hydrography, (2) wire-drag surveys, (3) revision work, (4) current observations, (5) tidal observations, and (6) topography.

Geodesy: (1) Triangulation, (2) precise levels, and (3) magnetic observations.

These same classifications will be adhered to in summarizing the work accomplished during the fiscal year ended June 30, 1919.

HYDROGRAPHY.

This country was at war with Germany during the period this report covers and the naval needs of the country called for the use of all able vessels for one purpose or another, so it was very late in the fiscal year 1919 before any vessels could be released for civil duties. By the Executive order of September 24, 1917, three vessels of the Coast and Geodetic Survey (the *Surveyor*, the *Bache*, and the *Isis*) were transferred to the service and jurisdiction of the Navy Department for temporary use, and by the Executive order of May 16, 1918, two vessels of the Coast and Geodetic Survey (the *Explorer* and the *Patterson*) were likewise transferred to the service and jurisdiction of the Navy Department. The vessels thus taken over by the Navy Department were retained until late in the fiscal year 1919, an Executive order having been issued under date of February 26, 1919, authorizing their return to the Coast and Geodetic Survey by April 1, 1919. By the Executive order of May 24, 1919, under authority of the act of Congress, chapter 78, section 2, approved May 20, 1918, the Secretary of the Navy is authorized to transfer—

> any or all vessels, boats, and auxiliary ships of the Navy classified as yachts, colliers, transports, tenders, supply ships, hospital ships, submarine chasers, patrol boats, motor boats, fishing vessels, and special types built, purchased, or commandeered for a substantial consideration by the Navy subsequent to the declaration of Congress by joint resolution approved April 6, 1917, that war exists between the United States and Germany, and provided said vessels were built, purchased, or commandeered for the purposes of said war, and any other executive department of the Government is desirous of securing from the Navy Department such vessels, boats, and auxiliary ships, or any of them which are, in the opinion of the Secretary of the Navy, not necessary for the needs of the Navy, upon such terms as may be agreed to by the executive head of such department and the Secretary of the Navy.

Acting under this authority the following vessels of the Navy Department were transferred to the service and jurisdiction of the Coast and Geodetic Survey: *Natoma*, April 9, 1919; *Wenonah*, April 12, 1919; *Onward*, April 19, 1919; *Ranger*, April 28, 1919; *Arcturus*, May 5, 1919.

The following table gives a condensed statement of the vessels at the disposal of the Coast and Geodetic Survey within the fiscal year:

Name of vessel.	Transferred to Coast and Geodetic Survey by Navy.	Loaned to Coast and Geodetic Survey by Philippine Government.	Owned by Coast and Geodetic Survey at beginning of fiscal year.	Sold during the fiscal year.
Arcturus	1			
Bache			1	
Cosmos			1	
Explorer			1	
Fathomer		1		
Hydrographer			1	
Isis			1	
Matchless			1	1
Natoma	1			
Onward	1			
Pathfinder			1	
Patterson			1	
Ranger	1			
Romblon		1		
Surveyor			1	
Wenonah	1			
Total	5	2	9	1

Transferred from Navy	5
Loaned by Philippine Government	2
Owned by Coast and Geodetic Survey	9
Total	16
Sold during the year	1
Total vessels at disposal of the Survey at end of fiscal year	15

The following is a brief statement of the assignments of the 17 different vessels at the disposal of the Coast and Geodetic Survey at some time within the fiscal year:

Arcturus.—This vessel was transferred to the Coast and Geodetic Survey by the Navy Department under authority of the Executive order of May 24, 1919, above cited. The transfer was effected May 5, 1919. She was stationed at New York City when taken over. From the time of the transfer to the close of the fiscal year she remained at New York where she was being put into condition for making surveys for this Bureau.

Bache.—The *Bache* was returned to the Coast and Geodetic Survey from the Navy Department by authority of the Executive order of February 26, 1919, which directed that she be returned not later than April 1, 1919. From that time until the end of the fiscal year she was being put into condition to take up survey work for the Bureau.

Cosmos.—The *Cosmos* is a small vessel used by the Bureau when making inshore surveys in Alaskan waters. When not in commission she is pulled out of the water and stored in a boathouse maintained by the Bureau. She was in commission from July 25 to September 30, 1918. During the rest of the year she was in storage.

Explorer.—The *Explorer*, which had been taken over by the Navy Department by the Executive order of September 24, 1917, was retained by the Navy until April 1, 1919, when she was transferred to the Coast and Geodetic Survey by authority of the Executive order of February 26, 1919. In my report for the fiscal year ended

June 30, 1917, on page 60 I made the following statement regarding the *Explorer*:

In the design and construction of this vessel, it was endeavored to provide for the utmost space in her. To provide this space, some of the strengthening members usually provided in a vessel were omitted. While no weakness was noticed in consequence of the absence of these strengthening members during her earlier work, she is now showing their absence, and in rough seas her sides are pliable to the extent that the bolts holding them together are subject to shearing stresses, and if she is continually employed in rough seas, it means that she will ultimately become too weak to be of any service.

Because of this structural weakness and the belief that the vessels which have been received from the Navy, after they have undergone certain alterations, will be capable of executing more work at the same cost, and the same amount of work at less cost than will be possible with the *Explorer*, no attempt has been made to put her in the field since her return from the Navy. She will, however, be used temporarily as a housing vessel for detached parties in Alaskan waters.

Fathomer.—This vessel operated in the Philippine waters and was in commission throughout the entire fiscal year.

Hydrographer.—This vessel was in commission throughout the entire fiscal year in Atlantic coast and Gulf coast waters.

Isis.—This vessel was returned to the Coast and Geodetic Survey by the Navy Department by authority of the Executive order of February 26, 1919, which provided that she should be returned by April 1, 1919. From the time of her return to the close of the fiscal year she was being outfitted and overhauled to fit her for resuming her normal surveying duties.

Matchless.—This vessel is a wood, two-masted schooner. She was built at Key West, Fla., in the year 1859. Of late years she has been used as a house-boat from which parties operated in making surveys of inland waters. Experience developed the fact that she was no longer economically operated, even for this purpose, and accordingly, the necessary steps were taken and she was sold June 28, 1919.

Natoma.—This vessel was transferred to the Coast and Geodetic Survey from the Navy Department by authority of the Executive order of May 24, 1919. The transfer was effected April 9, 1919. From that date until May 23 she was being put into condition to take up survey work for this Bureau. Her field of operation will be on the Pacific coast. She left New York on May 23 for the Pacific coast and had reached the Canal Zone June 30.

NOTE.—While the *Natoma* had not reached her field of operation by the close of the fiscal year for which this report is written, it was particularly gratifying to me to receive a letter from our inspector in charge of our field station at San Francisco, Calif., under date of July 31, 1919, containing the following statement: "The arrival of the *Natoma* was particularly timely, as a request had been received from Admiral Rodman, in command of the Pacific Fleet, for an examination of the Bonita Channel, and in particular the location of the 5-fathom curve on the western edge of the channel, along the 'Potato Patch.'" Admiral Rodman asked that the result of the examination be furnished him on or before August 10. At the date of this report the work is in progress.

Onward.—This vessel was transferred to the Coast and Geodetic Survey from the Navy Department by authority of Executive order of May 24, 1919. The transfer was effected April 19, 1919; from that

date until the close of the fiscal year she was being overhauled and altered for the purpose of taking up survey work for the Coast and Geodetic Survey.

Pathfinder.—This vessel operated in Philippine waters throughout the entire fiscal year.

Patterson.—In my report for the fiscal year ended June 30, 1917, on page 61 I made the following statement regarding the *Patterson:*

> The barkentine *Patterson* is structurally too weak to be used in exposed waters and too expensive of operation to be used as a house-boat for inside surveys. She has lately been employed in making surveys of the inside Alaskan waters, but is such an antiquated craft that the overhead cost of operation makes the results far less in quantity and more costly than they would be with a modern vessel. The *Patterson* was built 35 years ago.

By the Executive order of February 26, 1919, the *Patterson* was directed to be returned to the Coast and Geodetic Survey not later than April 1, 1919. Under date of May 26, 1919, I made the following recommendation to you regarding the *Patterson:*

> The *Forward*, ex-*Patterson*, is virtually an auxiliary sailing vessel of such small steaming power that she can not make headway against a heavy wind. Consequently, her use on an exposed coast where there are no harbors is hazardous. As hydrography can not be efficiently executed to-day under sail, the only use to which this vessel can be put as a surveying craft is in the transportation of parties between Seattle and Alaska. On arrival in Alaska she is of little use except as a house-boat, because her low power and slow speed prevent her from executing enough hydrography to justify the cost of operation. The Bureau considers this an inefficient way to operate a hydrographic party.

It accordingly has met with your approval, that she be disposed of, and this will be done as soon as the necessary formalities can be complied with.

Ranger.—The *Ranger* was transferred to the Coast and Geodetic Survey from the Navy Department under authority contained in Executive order of May 24, 1919. The transfer was effected April 28, 1919. Parties from her effected local surveys in New York Harbor between the date of transfer to the close of the fiscal year. At the same time she was being overhauled and outfitted for purposes of going to the field and making surveys.

Romblon.—This vessel was employed in making surveys of the Philippine waters throughout the fiscal year.

Surveyor.—She was returned from the Navy Department under authority of the Executive order of February 26, 1919. The return was effected April 1, 1919. From April 1 to April 21, she was at Norfolk, Va., in preparation for leaving for the Pacific coast to take up surveys in Alaskan waters. En route to Alaska she took deep-sea soundings on the steamer track from Norfolk to the Panama Canal and from the Panama Canal to San Diego, Calif. She had not reached Alaskan waters by the close of the fiscal year.

Wenonah.—This vessel was transferred to the Coast and Geodetic Survey from the Navy Department by authority of the Executive order of May 24, 1919. The transfer was effected April 12, 1919. From that date until June 7, the vessel was being overhauled and outfitted. On April 7 the vessel left for the Pacific coast, where she will be employed in making surveys. She also took deep-sea soundings en route to the Pacific coast.

As to the relative size of surveying vessels now controlled by this Bureau, I believe the following statement will be instructive:

	Gross tonnage.		Gross tonnage.
Surveyor	1,000	Explorer	335
Pathfinder	690	Wenonah	240
Patterson	500	Ranger	219
Arcturus	456	Onward	157
Fathomer	431	Matchless	118
Romblon	411	Hydrographer	116
Isis	377	Natoma	112
Bache	370		

Ship and launch hydrography.—

	Square statute miles.
Ship hydrography performed during the fiscal year:	
Chesapeake Bay	435
Vicinity of Key West, Fla	72.2
Hampton Roads and vicinity	277
Philippine Islands	2,885.5
Total	3,669.7
Launch hydrography:	
Turtle River, Ga	1.8
Miami, Fla	82
Morro Bay, Calif	4
Cook Inlet, Alaska	1.3
Philippine Islands	320.6
Total	409.7

Wire-drag surveys.—There were five wire-drag parties in the field within the year. For purposes of identification they were given designation numbers.

	Square miles.
Wire-drag party No. 1: This party was in the field from July 1 to November 25, 1918. It operated in Long Island Sound, Fishers Island Sound, Block Island Sound. It covered	97
Wire-drag party No. 2: This party was in the field from July 1 to November 15, 1918. It operated along the New England coast and in Passamaquoddy Bay. It covered	220.6
Wire-drag party No. 3: This party was in the field from July 1 to September 27, 1918. It operated in Cook Inlet, Alaska. It covered	24.8
Wire-drag party No. 4: This party was in the field from April 18 to June 5, 1919. It operated in Lake Tahoe, Calif. It covered	30
Wire-drag party No. 2: This party was in the field from July 1 to November 26, 1918. It operated in Long Island Sound, Fishers Island Sound, Block Island Sound. It covered	138.2
Total	510.6

Revision surveys.—Revision surveys were made in the localities named below.

	Square miles.
Coast of Massachusetts	68
Pascagoula, Miss	5
Commencement Bay, Wash	9
Total	82

Current observations.—As you are aware, Congress last year authorized a nominal extra compensation to employees of the Bureau of Lighthouses stationed on lightships when they are engaged in making current observations for this Bureau. Observations were

begun as soon as instruments could be procured and installed. The table below shows what was accomplished during the year:

Light vessel.	State.	Station.	Time employed.		
			Y.	m.	d.
Portland	Maine	1	0	0	13
Pollock Rip Slue	Massachusetts	1	0	5	20
Stone Horse Shoal	do	1	0	6	0
Finch	New York	1	0	3	4
Nantucket Shoal	Massachusetts	1	0	7	0
Cardinal	New York	1	0	1	0
Falcon	New Jersey	1	0	3	24
Northeast End	do	1	0	9	0
Overfalls	Delaware	1	0	6	0
Brant	Virginia	1	0	4	0
Winter Quarter	do	1	0	9	0
Tail of the Horse Shoe	do	1	0	2	0
Diamond Shoal	North Carolina	1	0	2	0
Cape Lookout	do	1	0	9	0
Frying Pan Shoals	do	1	0	9	0
Long Island	South Carolina	1	0	2	0
Brunswick	Georgia	1	0	7	0
Heald Bank	Texas	1	0	4	0
San Francisco	California	1	0	9	0
Blunts Reef	do	1	0	9	0
Columbia River	Oregon	1	0	7	0
Umatilla Reef	Washington	1	0	6	0
Swiftsure	do	1	0	6	0
Total		23	10	7	1

Short series of current observations were made at the following localities:

Locality.	Stations.	Time employed.	
		m.	d.
Cape Porpoise Harbor, Me	1	0	3
Portsmouth Harbor and vicinity, N. H	5	0	23
Block Island Sound, R. I	4	0	11
York River, Va	6	0	14
Hampton Roads, Va	7	0	21
Chesapeake Bay, Va	11	0	24
Pamlico Sound, N. C	6	0	9
Mobile Bay, Ala	5	1	3
Mississippi Sound, Miss	7	0	15
Rigolets, La	3	0	11
Morro Bay, Calif	2	0	4
Total	57	5	18

Tidal observations.—Tidal observations were made throughout the year at the following permanent tidal stations:

1. Portland, Me.
2. Fort Hamilton, N. Y.
3. Atlantic City, N. J.
4. Philadelphia, Pa.
5. Baltimore, Md.
6. Fernandina, Fla.
7. Key West, Fla.
8. Cedar Keys, Fla.
9. Galveston, Tex.
10. San Diego, Calif.
11. San Francisco, Calif.
12. Seattle, Wash.

Important tidal observations were made at the following stations:

1. St. Andrew, New Brunswick.
2. Midjik Bluff, New Brunswick.
3. Eastport, Me.
4. Jonesport, Me.
5. Block Island, R. I.
6. Stonington, Conn.
7. Little Gull Island, N. Y.
8. New Suffolk, N. Y.
9. Sandy Hook, N. J.
10. Breakwater Harbor, Del.

11. Cape Charles City, Va.
12. Fishermans Island, Va.
13. Gloucester Point, Va.
14. York River, Davis Wharf, Va.
15. Thimble Shoal Lighthouse, Va.
16. Wolftrap Lighthouse, Va.
17. York Spit Lighthouse, Va.
18. Back River, Va.
19. Old Point Comfort, Va.
20. Miles Watch House, Va.
21. Middle Ground Lighthouse, Va.
22. Newport News, Va.
23. Sewall Point, Va.
24. Lynnhaven Roads, Va.
25. Brunswick, Ga.
26. St. Augustine, Fla.
27. Miami, Fla.
28. Cutler, Fla.
29. Cape Florida, Fla.
30. Fort Morgan, Ala.
31. Pinto Island, Ala.
32. Alabama Port, Ala.
33. Weeks Bay, Ala.
34. Great Point Clear, Ala.
35. Morro, Morro Bay, Calif.
36. The Strand, Morro Bay, Calif.
37. Ketchikan, Alaska.
38. Craig, Alaska.
39. Petersburg, Alaska.
40. Port Chatham, Alaska.
41. Anchorage, Alaska.
42. Malbinchilao Island, P. I.
43. Illulluk Bay, P. I.
44. Mericaban Barrio, P. I.

Topography in connection with hydrographic work was executed as follows:

	Square miles.
Vicinity of Hampton Roads and York River, Va	11.5
Turtle River, Ga	2.2
Virgin Islands	55.5
Vicinity of Morro Bay, Calif	10.5
Vicinity of Keete Inlet, Alaska	16
Vicinity of Cook Inlet, Alaska	1
Philippine Islands	511.7
Total	608.4

GEODESY.

Triangulation.—Primary triangulation was executed from the ninety-eighth meridian, in the vicinity of Waco, Tex., to Robeline, La. The length of the scheme is 255 miles, and an area of 3,570 square miles was covered. Secondary triangulation was run from Sanford, N. C., to the vicinity of Madison, N. C. The length of the scheme is 120 miles, and the area covered is 1,700 square miles. Secondary triangulation was also run from Turkey Point Light to Sandy Point Light, Chesapeake Bay. The length of this scheme is 37 miles, and the area covered is 210 square miles.

Tertiary triangulation: Morro Bay, Calif., length of scheme, 5 miles; area covered, 8 square miles. Key Biscayne, in the vicinity of Miami, Fla., length of scheme, 15 miles; area covered, 42 square miles. Vicinity of Charleston, S. C., length of scheme, 14 miles; area covered, 27 square miles.

Primary traverse: A primary traverse was run from Vaughan, N. C., to Blaney, S. C. The length of the line of primary traverse is 235 miles. Another primary traverse was run from Wilmington to Sanford, N. C. The length of this line is 125 miles.

Reconnoissance: One arc of reconnoissance extends from the vicinity of Waco, Tex., eastward to Robeline, La. The length of this reconnoissance is 255 miles. Another reconnoissance was run in the vicinity of Prescott, Ariz. This reconnoissance is 50 miles in length. Also a line of reconnoissance, 50 miles in length, was run in the vicinity of Richfield, Utah.

The following summary gives the statistics of the above accomplishments:

	Length of scheme.	Area covered.
	Miles.	*Square miles.*
Primary triangulation	255	3,570
Secondary triangulation	157	1,910
Tertiary triangulation	34	77
Total	446	5,557
Reconnoissance	355	.....
Primary traverse	360	.....

Precise levels.—There were 1,190 miles of precise leveling run during the fiscal year 1919. The lines of precise leveling are as follows:

	Miles.
Jeanerette to New Orleans, La	115
Fifteen miles east of Pensacola to River Junction, Fla	124
Four miles south of Margaret to Moncure, N. C	155
Blaney, S. C., to Moncure, N. C	149
Wilmington to Sanford, N. C	132
Greensboro to Sanford, N. C	47
Harlingen to Eagle Pass, Tex	311
Hillsboro, Tex., eastward (estimated)	82
Troy to Whitehall, N. Y	75
Total	1,190

Magnetic observations.—In the continuation of the magnetic survey of the United States, observations were made during the year at 77 stations in 11 States, of which 34 were new primary stations, 17 auxiliary stations, 22 repeat stations for the determination of secular change, and 4 new stations in old localities. Meridian lines were established when they were requested by the local authorities.

The observatories at Cheltenham, Md., Vieques, P. R., Tucson, Ariz., Sitka, Alaska, and near Honolulu, Hawaii, were in operation throughout the year. A continuous photographic record was secured of the variations of declination, horizontal intensity, and vertical intensity. Absolute observations were made at least once a week.

CHAPTER III.

SHOWING CONDITIONS AND NEEDS OF HYDROGRAPHIC AND GEODETIC SURVEYS, WITH ILLUSTRATIONS—UNITED STATES AND POSSESSIONS.

HYDROGRAPHIC SURVEYS.

The discussion of the condition of the hydrographic surveys of our coasts is taken up section by section from northward to southward on the Atlantic coast and southward to northward on the Pacific coast. It is, of course, impossible within the limit of the scope of this volume to give a detailed analysis of conditions for every small inlet, bay, and harbor. What will be undertaken will be to show in general terms the condition of the surveys of the important areas and what needs to be done to enable the charting of all dangers to navigation, many of which are now suspected but undetermined. To facilitate reference to the text and to the locality, I have inserted diagrams on which the important steamer courses are indicated and numbered and the paragraphs of the text relating to these areas bear corresponding numbers.

1. *Deep draft, along-shore course from the Canadian boundary to the outer limit of Isle au Haut Bay.*—The entire area that this course covers is a region of ledges and bowlders. The ledges rise abruptly from the deep water and the bowlders ordinarily lie singly or in clusters on an otherwise flat bottom, so that the navigator can not depend on the lead to avoid them. This area is as yet untouched by the wire drag with the exception of a section about 15 miles in extent between Machias Seal Islands and Petit Manan Island. There are a number of towns along this course that depend largely on water-borne traffic for their supplies. The commerce consists in fuel and miscellaneous merchandise constituting the supply of the smaller and larger fashionable summer resorts, of which the largest is Bar Harbor, Me. The exceptionally rocky coast makes it certain that a wire-drag survey will result in the discovery of many rocks which now endanger the safety of commerce over this course. (See fig. 5, opposite p. 52.)

2. *Frenchman Bay.*—This body of water lies westward of Schoodic Peninsula and eastward of Mount Desert Island. It is the approach to the town and important summer resort of Bar Harbor, Winter Harbor, South West Harbor, North East Harbor, and many small villages. The bay is frequented by many passenger steamers, yachts, small craft, fishing vessels, and a few cargo vessels. This area has been dragged, though not to depths now considered necessary. The value of the work is further impaired by the necessity of passing over not less than 14 miles of undragged, doubtful area in order to reach the bay from the open sea. (See fig. 5, opposite p. 52.)

3. *Inland thoroughfares from Mount Desert Island to Rockland.*—There is a series of valuable inside passages along the Maine coast that are very narrow in places and wind between rocky ledges. Owing to the nature of the bottom they are particularly likely to be obstructed by pinnacle rocks or the extension of narrow ridges out into the channel. The only part of these channels which has been dragged lies between Blue Hill Bay and the western entrance of Penobscot Bay. The results obtained have been so startling that they clearly indicate danger in the use of channels that have been dragged. (See fig. 5, opposite p. 52.)

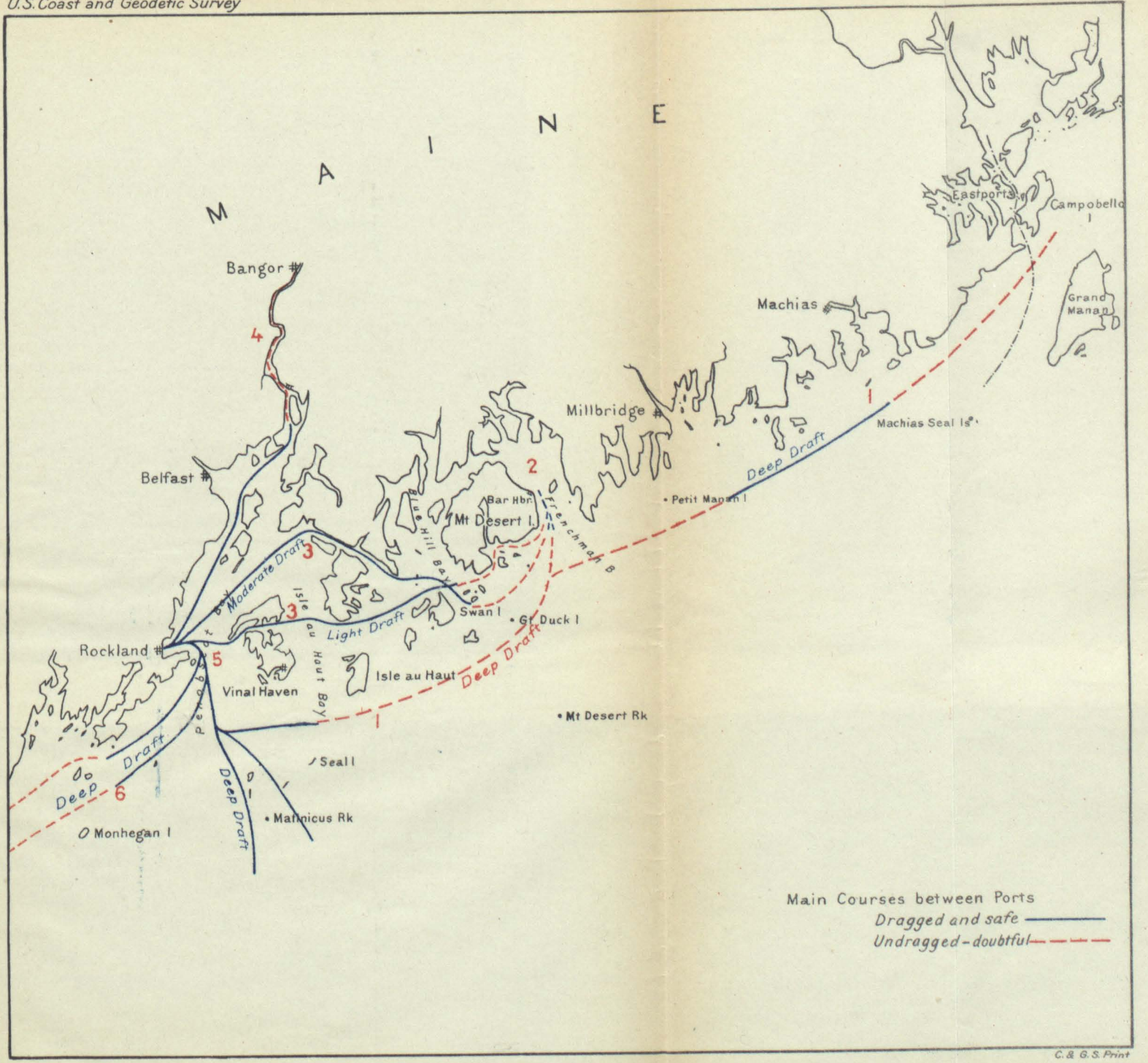
4. *Penobscot River.*—This river, emptying into the head of Penobscot Bay, forms the approach to the towns of Bucksport, Winterport, Hampden, and Brewer, and the city of Bangor, the latter two at the head of navigation, about 24 miles above Fort Point Lighthouse at the entrance. It has considerable trade in regular steamer drawing about 10 feet, and many vessels of deepest draft ordinarily trading to Bangor being about 18 feet. Practically the entire river above Bangor is used in lumbering. From the mouth of the river to Bangor there is no positive certainty of the absence of all dangers to navigation until the area has been dragged. (See fig. 5, opposite p. 52.)

5. *Penobscot Bay.*—In Penobscot Bay every port has benefited by the practical completeness of the wire-drag work. There are, however, some of the less important sections to be dragged and some of the approaches from the eastward are not yet completed. The wire drag, as used by the Coast and Geodetic Survey, was developed in this region, and some of the area was not dragged to the depth now believed necessary. The size of vessels has increased rapidly, and additional work is necessary to protect this increased draft. (See fig. 5, opposite p. 52.) As it has required time to solve all the problems involved in dragging to this greater depth, it is probable that much of the deeper part of Penobscot Bay will later have to be dragged to a greater depth.

6. *Penobscot Bay to Casco Bay (deep draft).*—The coast of New England throughout its length presents practically one uniform problem to the hydrographic engineer. Surveys of varying degrees of completeness have been made of the entire area, and it is possible for navigators to select channels which are apparently safe. They would be of ample depth if it were not for the ice-worn granite rock or the large bowlders deposited during the glacial period. The lead line is not adapted to find without assistance dangers of this character. This thoroughfare presents uneven and rocky bottom between Monhegan Island and the eastern entrance to Casco Bay, which should be dragged to remove all doubt of the existence of pinnacle rocks or small ledges. (See fig. 5, opposite p. 52.)

7. *Penobscot Bay to Casco Bay (moderate draft).*—From the western entrance of Penobscot Bay to Casco Bay there has been no wire-drag work done. The inside route is constantly used by coasting steamers, but it is certain that it has within its limit many uncharted rocks, some known locally and some unknown. (See fig. 6, opposite p. 54.)

8. *Booth Bay Harbor.*—This forms the approach to the town of Booth Bay Harbor and numerous smaller summer resorts. It is fre-


M A I N E
Bangor
Belfast
Rockland
Vinal Haven
Isle au Haut
Isle au Haut Bay
Swan I
Gt Duck I
Mt Desert I.
Bar Hbr
Blue Hill Bay
Frenchman B
Mt Desert Rk
Seal I
Matinicus Rk
Monhegan I
Penobscot Bay
Millbridge
Machias
Machias Seal Is
Petit Manan I
Eastport
Campobello I
Grand Manan
Moderate Draft
Light Draft
Deep Draft
Deep Draft
Deep Draft
Deep Draft
1
2
3
3
4
5
6
Main Courses between Ports
Dragged and safe
Undragged - doubtful

quented by many vessels, and by a large number of fishing boats and pleasure craft in summer. It is one of the best anchorages on the coast of Maine and is much used as a harbor of refuge by all classes of vessels. This area is in urgent need of a wire-drag survey. (See fig. 6, opposite p. 54.)

9 *Kennebec River.*—It is the approach to the cities of Bath and Augusta, the towns of Woolworth, Richmond, and Gardiner, and numerous smaller villages and summer resorts. The river has considerable water-borne commerce. The deepest draft being about 21 feet to Bath and 14 feet to Augusta. There is urgent need for a wire-drag survey of this river. (See fig. 6, opposite p. 54.)

10. *Casco Bay.*—Casco Bay and the approaches to Portland have been dragged with the result of finding numerous uncharted shoals, thereby furnishing important evidence of the need of completing the survey to the eastward and westward. A resurvey of inner Casco Bay is badly needed, the glaciers having left a series of long narrows and dangerous ledges which require closer examination. (See fig. 6, opposite p. 54.)

11. *Portland Harbor and approaches.*—These have been dragged, and all dangers to navigation are shown on the charts. (See fig. 6, opposite p. 54.)

12. *Portland to Portsmouth (moderate draft).*—Westward of Portland the succession of sand beaches, of which Old Orchard is the best known, might appear to indicate an absence of rocks in this region. The depth of sand above the underlying rock is not great, however, and pinnacle rocks occur outside these beaches. Southward of Cape Porpoise the surveys are entirely inadequate, and the need of immediate surveys is evident by the appearance on the chart of a rocky shoal with 5 fathoms or less, marked "position doubtful." This was recently reported by a fisherman, but it has not yet been practicable to locate it. However, arrangements are made to extend the wire-drag survey from Boon Island to a junction with the wire-drag work at Cape Elizabeth, Me., beginning July 1, 1919. This will include the area reported dangerous. (See fig. 6, opposite p. 54.)

13. *Portland to Cape Ann (deep draft).*—The region from Boon Island to Isle of Shoals is very rocky, and its importance as the approach to Portsmouth is so well recognized that work is now progressing, on the completion of which a perfectly safe track will be provided from Portland to the vicinity of Cape Ann. (See fig. 6. opposite p. 54.)

14. *Portsmouth Harbor.*—This area has been dragged, and all dangers to navigation are known. (See fig. 6, opposite p. 54.)

15. *Massachusetts coast north of Cape Ann.*—From the New Hampshire border to Cape Ann the shores are entirely different from those to the north or south. There are high sand bluffs in places and low sandy shores in others. As a result the depths along the shore are changeable, and though they have been recently surveyed, they will need further attention. (See fig. 6, opposite p. 54.)

16. *Cape Ann to Cape Cod Canal.*—A completely dragged area extends from Cape Ann to the Cape Cod Canal and from the head of Buzzards Bay to Sakonnet Point, R. I. With the exception of the inner part of Boston Bay and the areas near the shores of Buzzards Bay, this important survey is complete. This work was made

especially necessary by the opening of the Cap Cod Canal in 1915, the original surveys having been made while the commerce of the region was relatively unimportant. A number of shoals were found of less than the proposed canal depth, so that the needs would at some further date make it necessary to deepen this canal to take care of the largest vessels. With this view, the drag was carried at a sufficient depth to meet such requirements. Even should a depth of 40 feet be adopted for the canal, the present surveys of the approaches will be found adequate, and where less depths have been found the information will be invaluable to the engineers making the improvement. (See fig. 6, opposite p. 54.)

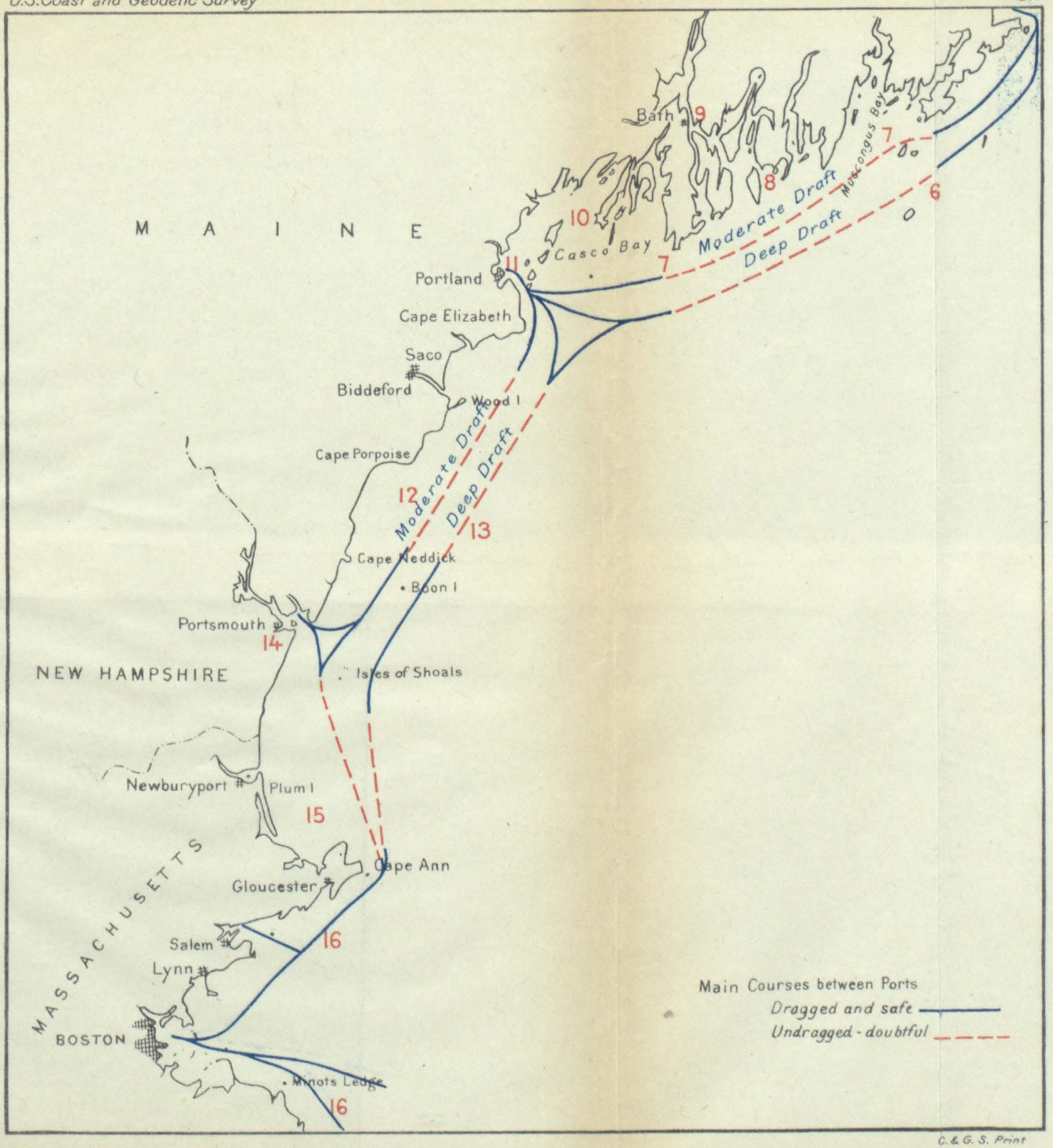
17. *From Boston south outside Cape Cod.*—Much of the traffic between eastern New England and points west and south passes outside of Cape Cod; most of it through Nantucket and Vineyard Sounds. Off Cape Cod the surveys are not complete. In Nantucket Sound the entire route is through channels bounded by shifting sand, and require revision work from time to time. In one part of the channel most used, through Pollock Rip Slue, a shoal was formed in the last few years that has been steadily narrowing and decreasing the depth of the channel. A resurvey of parts of this route is needed every few years to insure safety to navigation. No rocks around eastward of Cape Cod, but in the north half of Nantucket Sound and the western part of Vineyard Sound large bowlders occur and wire-drag work is needed. At present vessels must pass over 10 miles of undragged area in following the best channel through Vineyard Sound. (See fig. 7, opposite p. 54.)

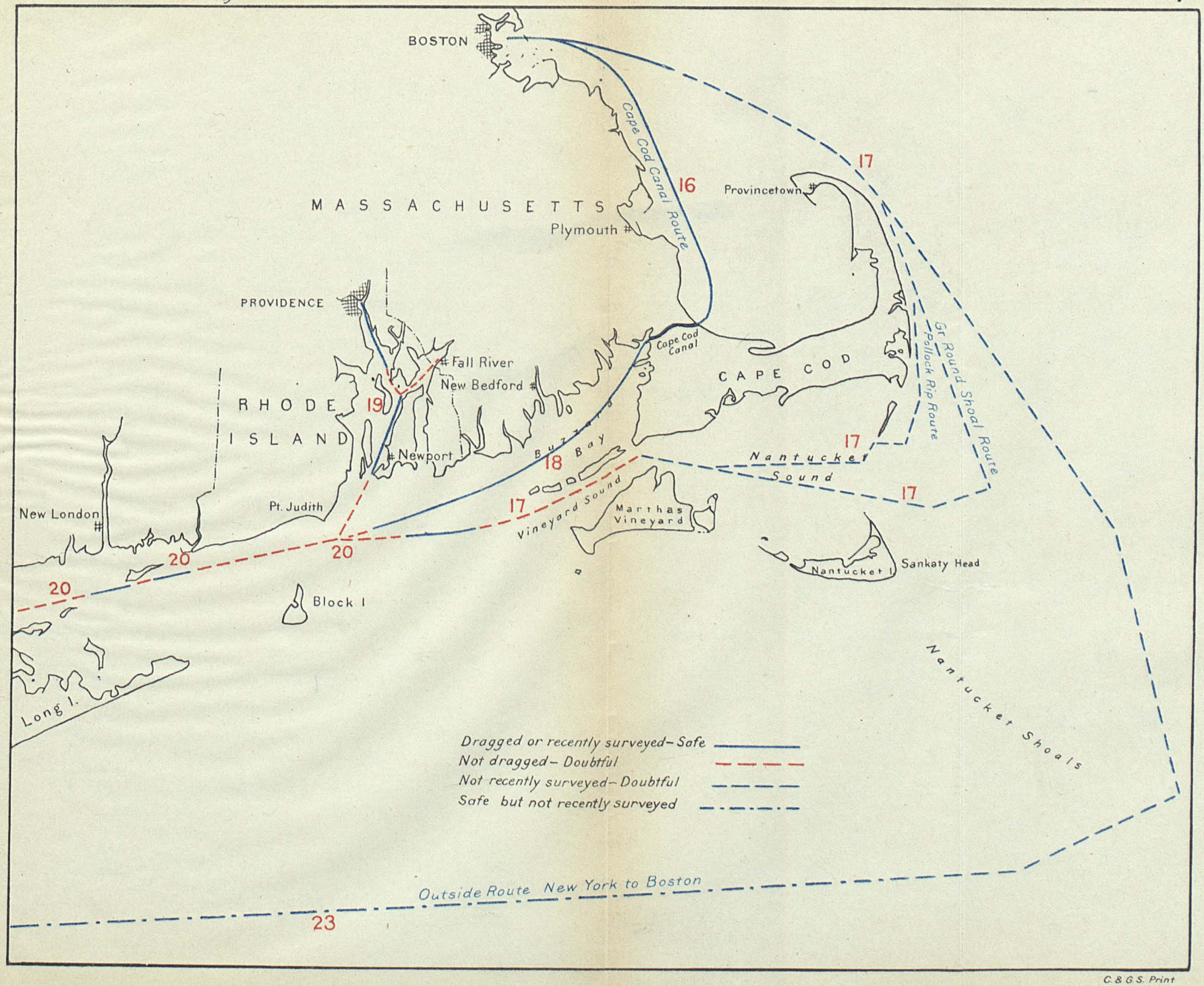
18. *From Cape Cod Canal through Buzzards Bay.*—This route has been dragged out to the eastern limit of Block Island Sound. (See fig. 7, opposite p. 54.)

19. *Narragansett Bay.*—This area has been dragged with the exception of the thoroughfare leading through Mount Hope Bay to Fall River, and the small stretch to the north and east of Prudence Island. (See fig. 7, opposite p. 54.)

20. *Entrance to Narragansett Bay, Block Island Sound, Fishers Island Sound, and eastern part of Long Island Sound.*—These areas are in a stage of completion. The work of the present season will complete their survey with the exception of the central and western parts of Long Island Sound, which remain to be dragged. (See fig. 7, opposite p. 54.)

21. *Gulf of Maine.*—The portion of the Gulf of Maine of which this Bureau makes surveys may be considered as lying to the westward of meridian 67° 0′ and extending to Nantucket Shoals. This entire area has been surveyed, but the surveys are inadequate. Not only are the soundings obtained insufficient, but many of them are not located correctly on the charts. A good example of this is the discovery several years ago that only one shoal rock exists on Cashes Ledge, where two were charted, and that Sigsbee and Ammen Rocks, formerly shown 4 miles apart, are really the same rock. These defects in the charts are serious for two reasons: The trans-Atlantic steamers approaching the ports of northern New England, especially Portland and Boston, are unable to depend on the charts of the gulf sufficiently to locate themselves accurately by sounding. This is particularly serious during the fog of summer which often extends


MAINE
Bath
9
8
7
6
Muscongus Bay
Moderate Draft
Deep Draft
10
Casco Bay
11
Portland
Cape Elizabeth
Saco
Biddeford
Wood I
Cape Porpoise
Moderate Draft
Deep Draft
12
13
Cape Neddick
Boon I
Portsmouth
14
NEW HAMPSHIRE
Isles of Shoals
Newburyport
Plum I
15
MASSACHUSETTS
Cape Ann
Gloucester
Salem
16
Lynn
BOSTON
Minots Ledge
16
Main Courses between Ports
Dragged and safe
Undragged - doubtful


BOSTON
Cape Cod Canal Route
16
17
Provincetown
MASSACHUSETTS
Plymouth
PROVIDENCE
Fall River
New Bedford
Cape Cod Canal
CAPE COD
Gr. Round Shoal Route
Pollock Rip Route
RHODE ISLAND
19
Newport
Buzzards Bay
18
17
Nantucket Sound
17
17
Vineyard Sound
Marthas Vineyard
New London
Pt. Judith
20
20
20
Block I
Nantucket I
Sankaty Head
Long I.
Nantucket Shoals
Dragged or recently surveyed–Safe
Not dragged–Doubtful
Not recently surveyed–Doubtful
Safe but not recently surveyed
Outside Route New York to Boston
23

far out to sea and lasts for days, and during the winter snowstorms. In addition to this, the fisheries of the Gulf of Maine are an important national asset. Not only are many important fishing banks uncharted, but the limit and depths of known banks are not correctly given. Besides, there is not at present enough information available as to the character of the bottom. The knowledge of rocky bottom may lead to the discovery of good fishing grounds. (See fig. 8, opposite p. 56.)

22. *Nantucket Shoals to Georges Banks.*—Extending eastward from Nantucket Sound there is an immense shoal area, consisting of sandy ridges which are shifted by the waves and currents. Nantucket Shoals extend about 50 miles offshore, then there is a deep channel followed by ridges. It is readily seen that it is important to keep the channel surveyed and to examine the adjacent shoals to detect changes; but it might readily be asked, What is the use of surveying such areas as Nantucket Shoals, which vessels are most careful to avoid? First, it is necessary to be certain that the outer limits of these shoals are clearly defined in order that they may be avoided. Second, the shoals are important fishing grounds. Third, more careful surveys may develop safe channels for coastwise navigation—channels which are already indicated on the charts but are unsafe to use because of inadequate surveys. The existing surveys are nowhere adequate. The shoals are so numerous and the channels so intricate that a difficult problem is presented in their examination by accurate methods. The ground fishing, which has in recent years assumed large proportions, is steadily moving seaward. During the winter Nantucket Island is the headquarters of this industry. Not only do the present charts lack the needed information in the search for new grounds, but the absence from the charts of existing shoals is a source of danger to the boats running to and from the harbor. Breakers often occur where there is ample depth for boats when the water is smooth. This is an excellent example of how a region usually avoided by commerce may be of importance to an industry which furnishes part of the food supply of the Nation. (See fig. 8, opposite p. 56.)

23. *Trans-Atlantic approach to New York.*—There is scarcely any part of our coast where correct soundings are of more importance than in the approach to New York from the eastward, as all trans-Atlantic steamers bound to that port pass over this area. Many of them have to depend on soundings for safety. A fairly good survey of this area is available, but additional work should be done by modern methods in the portion out of sight of land so that the needs of the enormous traffic will be met. (See fig. 8, opposite p. 56.)

24. *From Point Judith to New York.*—It is almost unnecessary to go into particulars except to make it clear that the central and western parts of Long Island Sound remain to be dragged. This work will be undertaken at the earliest opportunity. The project to deepen East River to 40 feet makes it necessary to be certain where the channels with such depths are located in Long Island Sound. The work done in Block Island Sound has defined the limit of such depths in the eastern approach to Long Island Sound, and it is urgent that the entire area should be completed without delay. The approaches to all the harbors on Long Island Sound should be

dragged. The shoaler bays are filled with motor boats, and the number in operation for a given area is probably greater than anywhere else in the United States. (See fig. 9, opposite p. 56.)

25. *Hudson River.*—The Hudson River is a valuable waterway between New York and Albany and is a part of the canal system of the State. A few years ago a dangerous rock was found directly in the path of steamers between New York and Albany. With such a possibility all the doubtful part of the Hudson should be dragged. (See fig. 9, opposite p. 56.)

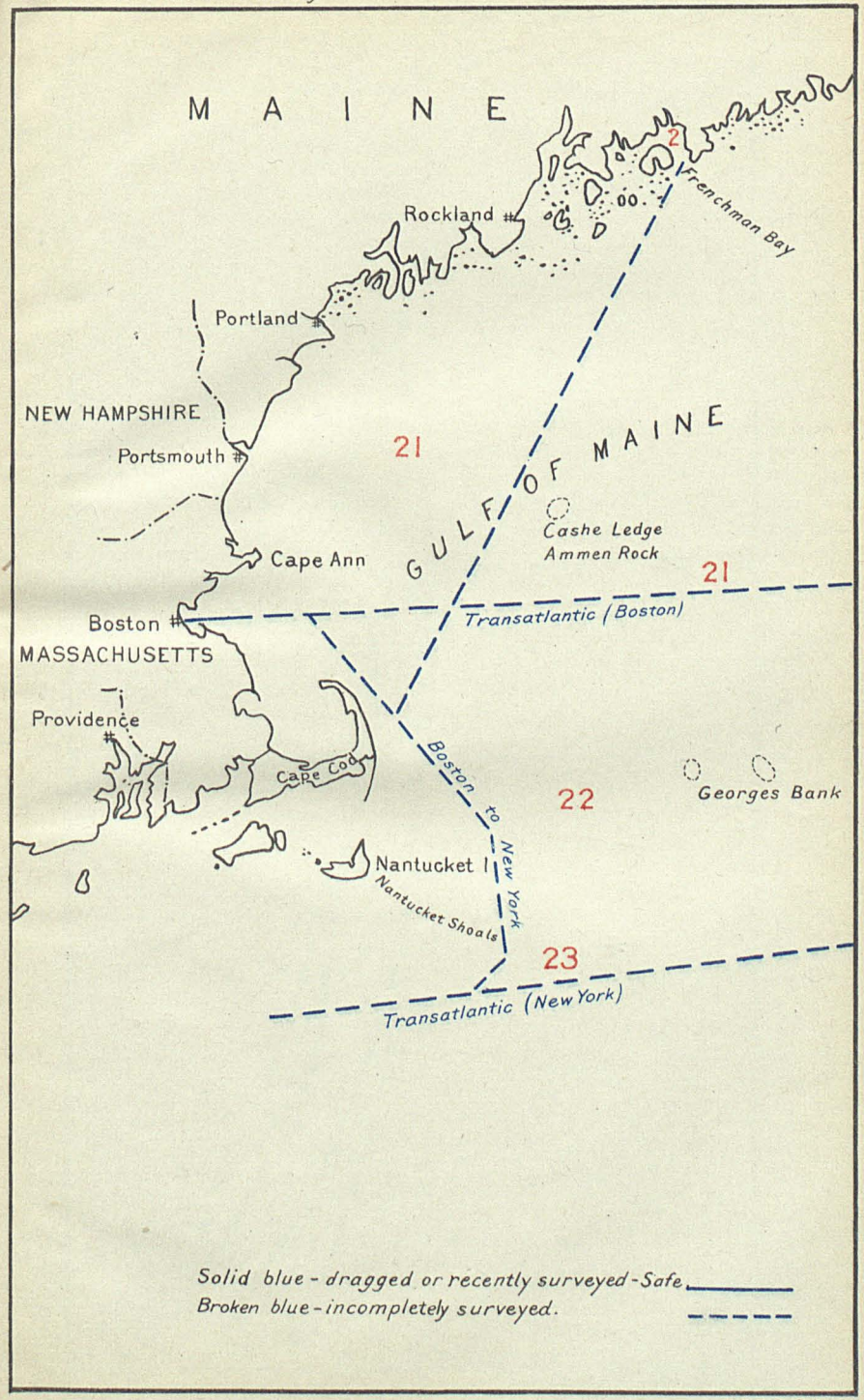
26. *New York Harbor.*—New York Harbor has had a recent survey, but as it is an area subject to change, it will require a survey, at least in part, every few years. (See fig. 9, opposite p. 56.)

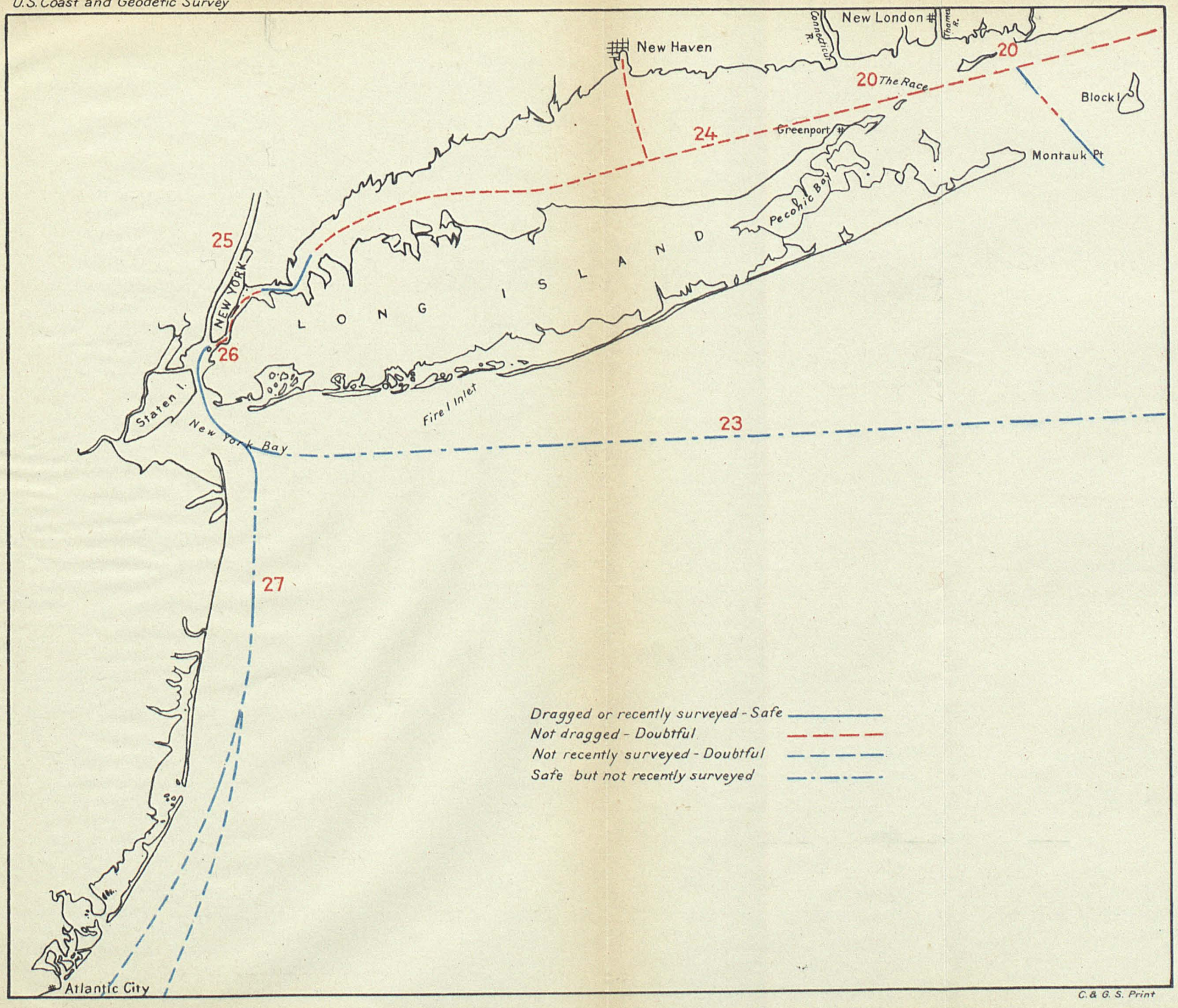
27. *Coast of New Jersey.*—Along the most of the coast of New Jersey the character of the bottom is such that the exact existing depths should be ascertained beyond all doubt, particularly as shoals dangerous to coastwise traffic have been reported from time to time. The only reliable surveys along this stretch of coast have been made in connection with searches for these reported shoals. Eastward of Cape May there are shoals that need a resurvey. Arrangements have been made to begin a survey from Cape Henlopen to New York on July 1, 1919. This survey will extend out to the 100-fathom curve. (See fig. 9, opposite p. 56.)

28. *Delaware Bay.*—Delaware Bay has as its most marked characteristic a series of narrow, fairly deep channels separated by long, narrow shoals. These shoals are subject to change. A survey is needed now, and one should be made about every 10 years in the entrance, and at longer intervals in the upper bay. While dredged channels are maintained for most of the distance from the entrance of the bay to Philadelphia, vessels of moderate draft use the other channels. In view of the importance of the cities at the head of the bay and on the river it is highly important that the needed survey of Delaware Bay be made so that a chart of the proper standard may be issued. (See fig. 10, opposite p. 58.)

29. *Delaware Bay entrance to Chesapeake Bay.*—From Delaware Bay entrance to Chesapeake Bay there is a succession of shoals and banks. Many of these are buoyed so that moderate-draft vessels may pass inside of them. In certain regions it is of the highest importance that the survey should be correct and kept up to date. At only one place has a comprehensive survey been made, and this was the investigation of a reported shoal. Arrangements have been made to take up the survey of the entire area in July, 1919. (See fig. 10, opposite p. 58.)

30. *Chesapeake Bay and tributaries.*—These have been extensively surveyed in recent years, and a large number of tributaries will not require resurveys for many years. This is also true of the Potomac River. The parts which need resurveying are parts of the bay from Cape Charles to a point opposite Annapolis, parts of the James River, and the Rappahannock and Susquehanna Rivers. The entrance has been recently surveyed, but another survey will probably be needed in 10 years. The bay is greatly in need of examination at critical localities where depths are near the draft of vessels; frequent reports indicating presence of new shoals. (See fig. 10, opposite p. 58.)


MAINE
2
Frenchman Bay
Rockland
Portland
NEW HAMPSHIRE
Portsmouth
21
GULF OF MAINE
Cashe Ledge
Ammen Rock
Cape Ann
21
Transatlantic (Boston)
Boston
MASSACHUSETTS
Providence
Cape Cod
Boston to New York
22
Georges Bank
Nantucket I
Nantucket Shoals
23
Transatlantic (New York)
Solid blue - dragged or recently surveyed - Safe
Broken blue - incompletely surveyed.


New Haven
New London
Connecticut R.
Thames R.
20
20 The Race
Block I.
24
Greenport
Montauk Pt
Pecohic Bay
LONG ISLAND
25
NEW YORK
26
Staten I.
New York Bay
Fire I Inlet
23
27
Atlantic City
Dragged or recently surveyed - Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed

31. *Chesapeake Bay entrance to Cape Hatteras.*—The diagram shows the tracks for both the light-draft and deep-draft vessels. While a resurvey is desired, the most pressing need is that the present limit of shoal areas be accurately determined. (See fig. 10, opposite p. 58.)

32. *Albermarle Sound.*—Albermarle Sound and its tributaries, with a few exceptions, have been resurveyed within the last few years and will not require resurveying for a long time. The uncompleted portions, including the North and Alligator Rivers, should be finished in the near future, as they form part of the project for a through 10-foot channel of the inside waterway route. The Chowan River, which is the western extension of the sound, should also be finished, and then the surveys of this region would be in a most satisfactory up-to-date condition. (See fig. 10, opposite p. 58.)

33. *Croatan Sound.*—Croatan Sound, the connecting link between Albemarle and Pamlico Sounds, has recently been resurveyed, but the depth is so near to the draft of vessels using it that the surveys will have to be revised from time to time. Changes in the main channel have occurred within the last two years. (See fig. 10, opposite p. 58.)

34. *Pamlico Sound.*—Pamlico Sound has additional importance owing to its relation to the inland waterway route. The eastern half of the sound is well surveyed, but the entire western half and the Neuse River, which, in addition to its local use as part of the through 10-foot channel, have not been covered by recent surveys. (See fig. 10, opposite p. 58.)

35. *Diamond Shoals.*—Diamond Shoals off Hatteras should be resurveyed chiefly to determine changes in their extent, and particularly to obtain a knowledge of the correct depths on the seaward side. (See fig. 10, opposite p. 58.)

36. *Cape Hatteras to Winyah Bay, S. C.*—Nearly the whole of this area is in need of a new survey, as those now charted are not in sufficient detail for modern navigation. Next to Diamond Shoals in importance to coastwise navigation are the shoals extending seaward from Cape Lookout and Cape Fear. They are subject to change and should be examined at short intervals. (See fig. 11, opposite p. 58.)

37. *Winyah Bay to Fernandina, Fla.*—From Winyah Bay to Fernandina, Fla. This region has been recently surveyed, the work extending out to the 100-fathom curve. (See fig. 11, opposite p. 58.)

38. *Fernandina to the Florida Reefs.*—From Fernandina to the Florida Reefs the area of moderate depths continually narrows, until at Palm Beach the distance to the 100-fathom curve is very small. The completed survey extends southward to a little below St. Augustine. South of St. Augustine, the bottom is probably not subject to change except as noted below, and the surveys, while by no means complete, are fair. Off Cape Canaveral and outside the southern half of the Indian River there are extensive banks and ridges in urgent need of resurvey. Known depths of 11 to 16 feet a long way offshore show the need of further surveys to make certain that all the shoals are correctly charted. From Jupiter Inlet to Fowey Rocks, where the Florida Reefs begin, the deep water approaches so close to the shore that it will be a slight task to complete inshore work in connection with the offshore surveys. (See fig. 12, opposite p. 60.)

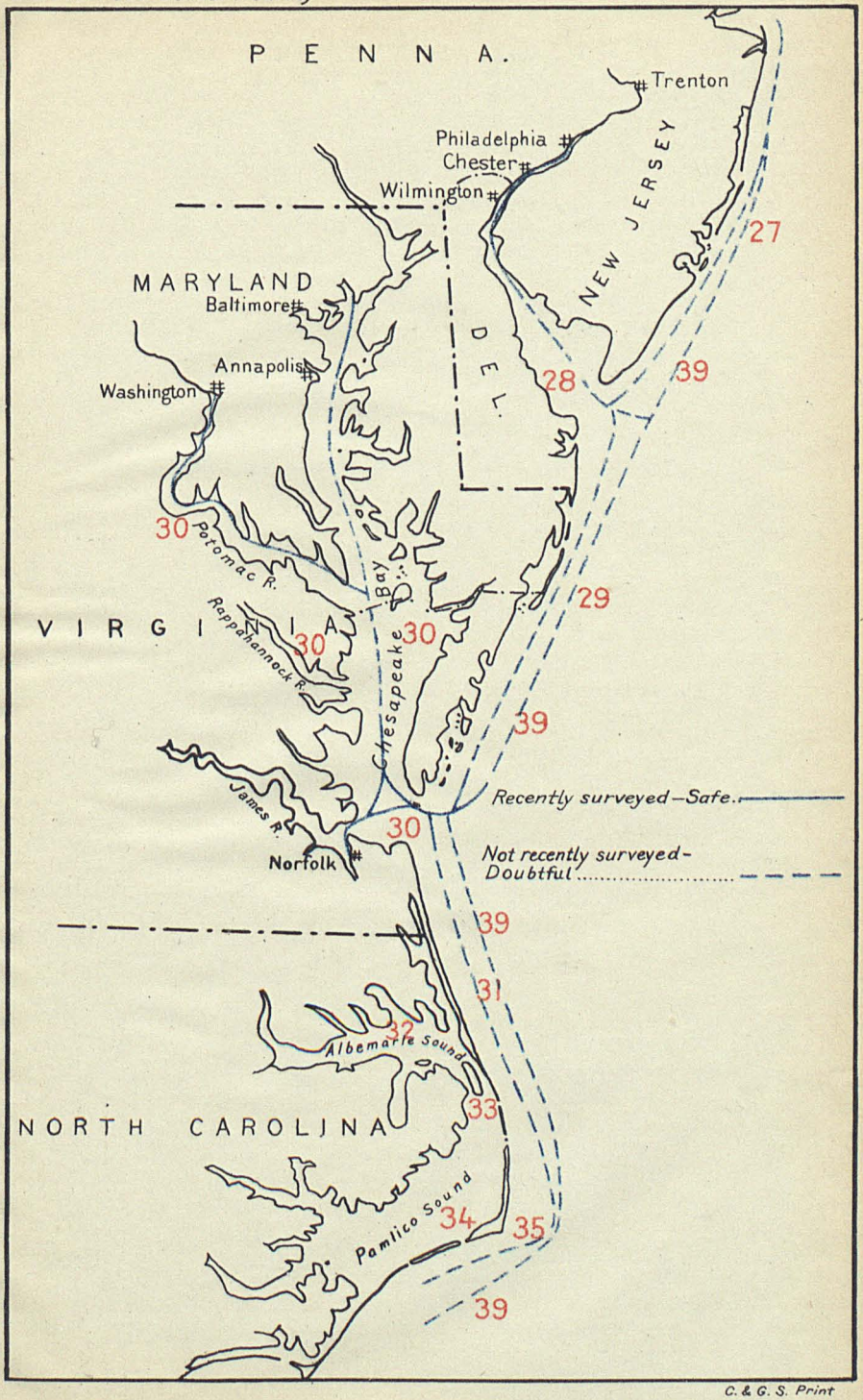
39. *General, Atlantic and Gulf coasts.*—An explanation of the method used in locating a vessel by sounding will show why accurate charts are particularly needed from New York to Palm Beach and from Key West to the Mexican border. At fixed intervals the vessel takes soundings, which are plotted to the scale of the chart on tracing paper, and this is moved over the chart, keeping the line joining the soundings parallel to the course of the vessel until the soundings agree with those shown on the chart. If the charts are correct and based on a sufficiently modern survey, the method is one of the best known for locating its position. If, on the other hand, the soundings are few and far apart so that the ship's soundings fall between them, and if those on the chart are wrongly placed, this method becomes much more difficult and an accidental agreement may lead the vessel into danger. From New York to Cape Hatteras the charts are fairly good, by no means good enough to meet the full needs of navigation, but the work required to bring them up to date has been postponed, as the need for resurveys has been more urgent farther south. Up to a few years ago the offshore surveys from Cape Hatteras to the Florida Reefs were almost unbelievably deficient. This condition is being remedied as rapidly as possible, and between Winyah Bay, S. C., and St. Augustine, Fla., the offshore work out to the Gulf Stream is complete. It is important that this work be extended both north and south from its present limit as rapidly as possible. With adequate funds full advantage can be taken of the seasons and by working north in the summer and south in the winter the cost of the work will be greatly reduced. (See figs. 10 and 11, opposite p. 58.)

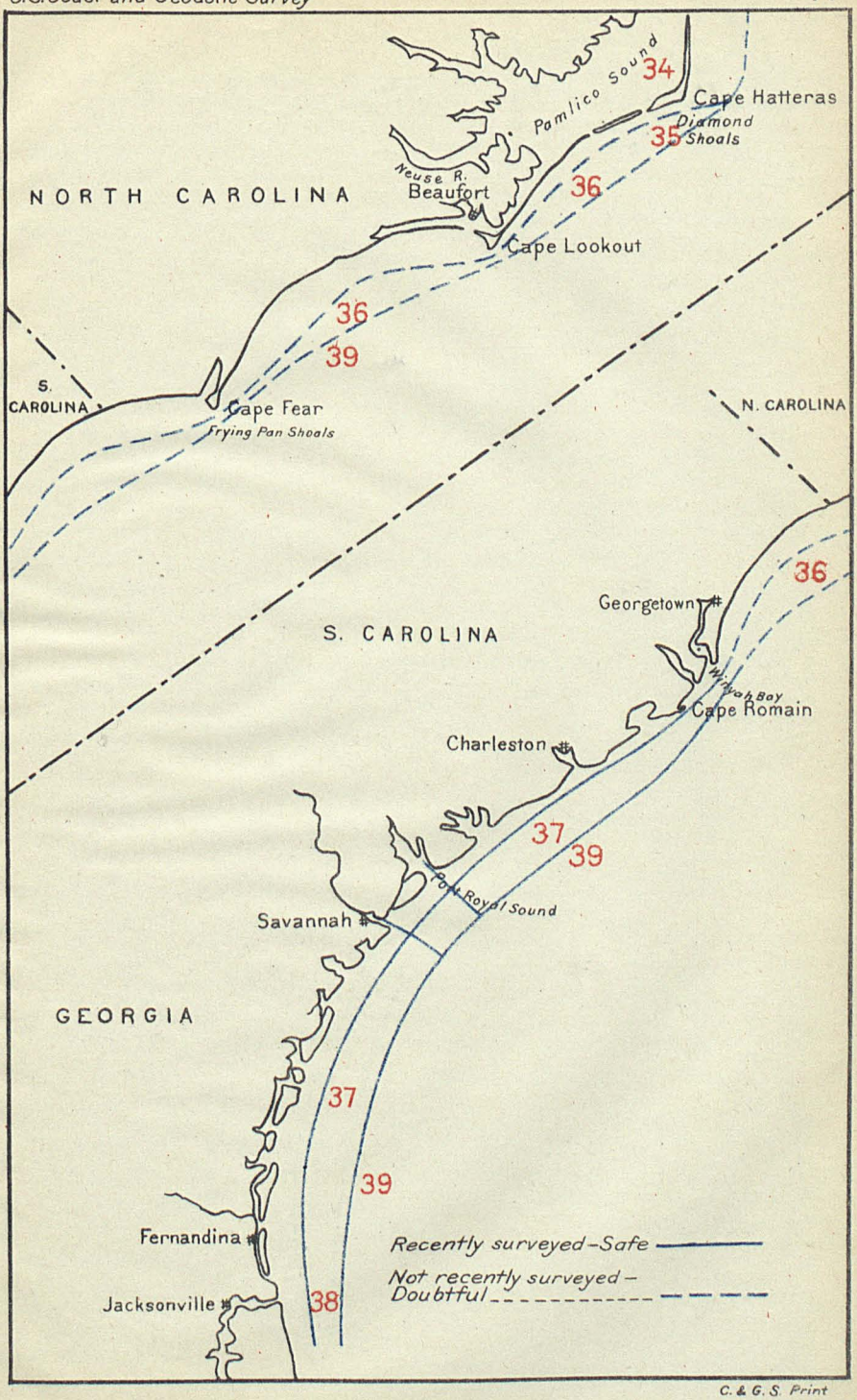
40. *Indian River.*—There have been no recent surveys of these waters. Revisionary work is needed. (See fig. 12, opposite p. 60.)

41. *Biscayne Bay.*—Recent surveys have been made of this area. In the vicinity of Miami and as far south as Fowey Rocks. (See fig. 12, opposite p. 60.)

42. *Vicinity of Fowey Rocks Light.*—No recent surveys have been made. Inshore and offshore work is needed. The present surveys are not sufficient in detail. (See fig. 12, opposite p. 60.)

43. *Coast of Florida from Palm Beach around to Cedar Keys.*—For a distance along the shore of 567 miles from Palm Beach southward around to Cedar Keys on the west coast of Florida, coral reefs are found, in some places more abundant than in others. Coral reefs, whether the result of disintegration or of a building up by animal growth, are found in a great variety of forms and in vast numbers of sharp projections from the general bottom where conditions are favorable for the growth of coral. While we are informed that an enormous number of uncharted rocks exist in this region, the fact that they are so numerous, that the region is so large, and that there is little navigation over much of it, it appears to the interests of navigation to drag areas of the coast used by commercial and naval vessels, because of both the time and cost involved. Wire-drag work is accordingly undertaken in localities where there are commerce and naval operations. To accomplish even this will require years of work. Westward-bound vessels through the Florida Straits have to force their way against the strong current of the Gulf Stream, which in places attains a velocity of 5 miles per hour. Along the northerly edge of


PENNA.
Trenton
Philadelphia
Chester
Wilmington
NEW JERSEY
MARYLAND
Baltimore
Annapolis
Washington
DEL.
27
28
39
30
Potomac R.
Bay
Chesapeake
29
VIRGINIA
30
Rappahannock R.
30
39
James R.
Norfolk
30
Recently surveyed—Safe.
Not recently surveyed—Doubtful
39
31
32
Albemarle Sound
33
NORTH CAROLINA
Pamlico Sound
34
35
39


NORTH CAROLINA
Pamlico Sound
34
Cape Hatteras
Diamond Shoals
35
Neuse R.
Beaufort
36
Cape Lookout
36
39
S. CAROLINA
Cape Fear
Frying Pan Shoals
N. CAROLINA
36
Georgetown
S. CAROLINA
Winyah Bay
Cape Romain
Charleston
37
39
Port Royal Sound
Savannah
GEORGIA
37
39
Fernandina
Jacksonville
38
Recently surveyed-Safe
Not recently surveyed-Doubtful

the stream and close to the reefs the current is very weak and at times runs to the westward. There is a strong temptation to keep dangerously close to the reefs and save fuel, and this is the cause of frequent accidents. Besides the danger of running into the known reefs, which are in many places bare and are of no great depth throughout their length, another danger, the extent of which is not yet known, has been discovered in a secondary reef, parallel to the main reef, and about one-half mile outside of it. This secondary reef is found to approach the surface in places as a narrow ridge with depths as little as 25 feet. Twenty-five miles of this reef has been examined, but 200 miles remain to be examined. It is important to nearly all the great traffic entering the Gulf of Mexico that this examination be completed at the earliest possible moment. (See fig. 12, opposite p. 60.)

44. *Vessel courses north from Key West.*—Vessels bound for eastern Gulf ports naturally wish to take the shortest route. If of light draft, they can cross the Florida Reefs at Key West. The next channel is between Rebecca Shoal and Dry Tortugas, and if this is not used vessels must pass well to the westward of Dry Tortugas to avoid a shoal bank west of it. The Rebecca Shoal channel has been dragged and has ample depth of water. The bank west of Tortugas should be dragged, especially as vessels making land from the westward have to cross part of it. Northward of the keys from Key West to Tortugas a doubtful area should be dragged. The channel between the keys and the reef known as the Hawk Channel is important for moderate-draft vessels. While it is not at present planned to drag it, it may be found necessary to drag the axis of the channel. (See fig. 12, opposite p. 60.)

45. *Cape Ramano.*—This area is in need of surveys. (See fig. 12, opposite p. 60.)

46. *Charlotte Harbor.*—No recent surveys have been made of this area and should be resurveyed. (See fig. 12, opposite p. 60.)

47. *Tampa Bay and approach.*—The existing surveys at present meet the needs of navigation of these waters. (See fig. 12, opposite p. 60.)

48. *Cedar Keys.*—No recent surveys have been made of this region. Wire-drag surveys are badly needed. (See fig. 12, opposite p. 60.)

49. *Apalachee Bay.*—No recent surveys have been made of this region and revision work is needed. (See fig. 13, opposite p. 60.)

50. *Inshore waters, Gulf coast.*—The chief characteristics of the west coast of Florida are the distance to which shoal water extends offshore between Cape Sable and Cape Romano and from Tampa Bay to Apalachicola, and the existence of a number of large bays connected with the sea by deep channels, either natural or dredged. From Apalachee Bay to Cape San Blas the coast begins to assume a character more like the South Atlantic coast, and coral bottom is no longer found. This stretch of coast is sandy and sand shoals extend off some distance, especially in the vicinity of Cape San Blas. This region needs a resurvey and, like other sandy portions of the coast, will need resurveying from time to time. The Florida and Alabama coasts are somewhat different, as deep water approaches close to the shore in the latter. The coast of Mississippi and Louisiana has a very large proportion of changeable area, and resurveys

are needed now and will be needed from time to time in the area from Mobile Bay to the end of the offshore shoals of Vermilion Bay. The immense load of sediment carried by the Mississippi River, especially in time of flood, causes constant changes in the delta. The deposit of sediment and the action of the waves on the deposit results in rapid growth in some places and of erosion in others. Sixty miles west of the Mississippi Delta there begins an extensive shoal region which is in need of survey. The inshore portion along the rest of the Louisiana coast, and the Texas coast, with an important exception, has deep water fairly close to the shore. The exception is along the eastern part of the Texas coast from Sabine Pass to Galveston. Sabine Bank and Heald Bank have shoal depths at a considerable distance from the shore, and they should have a thorough resurvey. Galveston Bay also needs resurveying. (See fig. 13, opposite p. 60.)

51. *St. Josephs Bay.*—No recent surveys have been made of this area and a reexamination is needed. (See fig. 13, opposite p. 60.)

52. *Offshore waters, Florida reefs to the Mexican border.*—Along the northern edge of the Florida Straits the soundings are insufficient, and they will have to be carried out somewhat beyond the 100-fathom curve. Along the west coast of Florida the distance out to the 100-fathom curve is about 100 miles. Over much of this area the depths are moderate and the charts are based on reconnoissance surveys only. The bottom is coral rock in many places, and projections from coral banks may come sufficiently near the surface to be a menace to navigation. Fishermen have reported several uncharted ridges, and while the somewhat incomplete surveys of the reported localities have not confirmed all the details of their reports, important differences from the charted depths have been found. The 100-fathom curve approaches fairly close to the Mississippi Delta, then swings offshore again, so that it is about 60 miles south of Sabine Pass. It then swings to the southward in a curve, which brings it within about 80 miles offshore at the Mexican border. This whole offshore area is badly in need of a thorough resurvey. There is no other part of the work in offshore water so likely to be productive in furnishing important changes in existing charted depths. (See fig. 13, opposite p. 60.)

53. *Pensacola Bay.*—Surveys are now under way at the entrance to the bay; the entire bay requires reexamination. (See fig. 13, opposite p. 60.)

54. *Mobile Bay.*—A resurvey of this bay has been completed. (See fig. 13, opposite p. 60.)

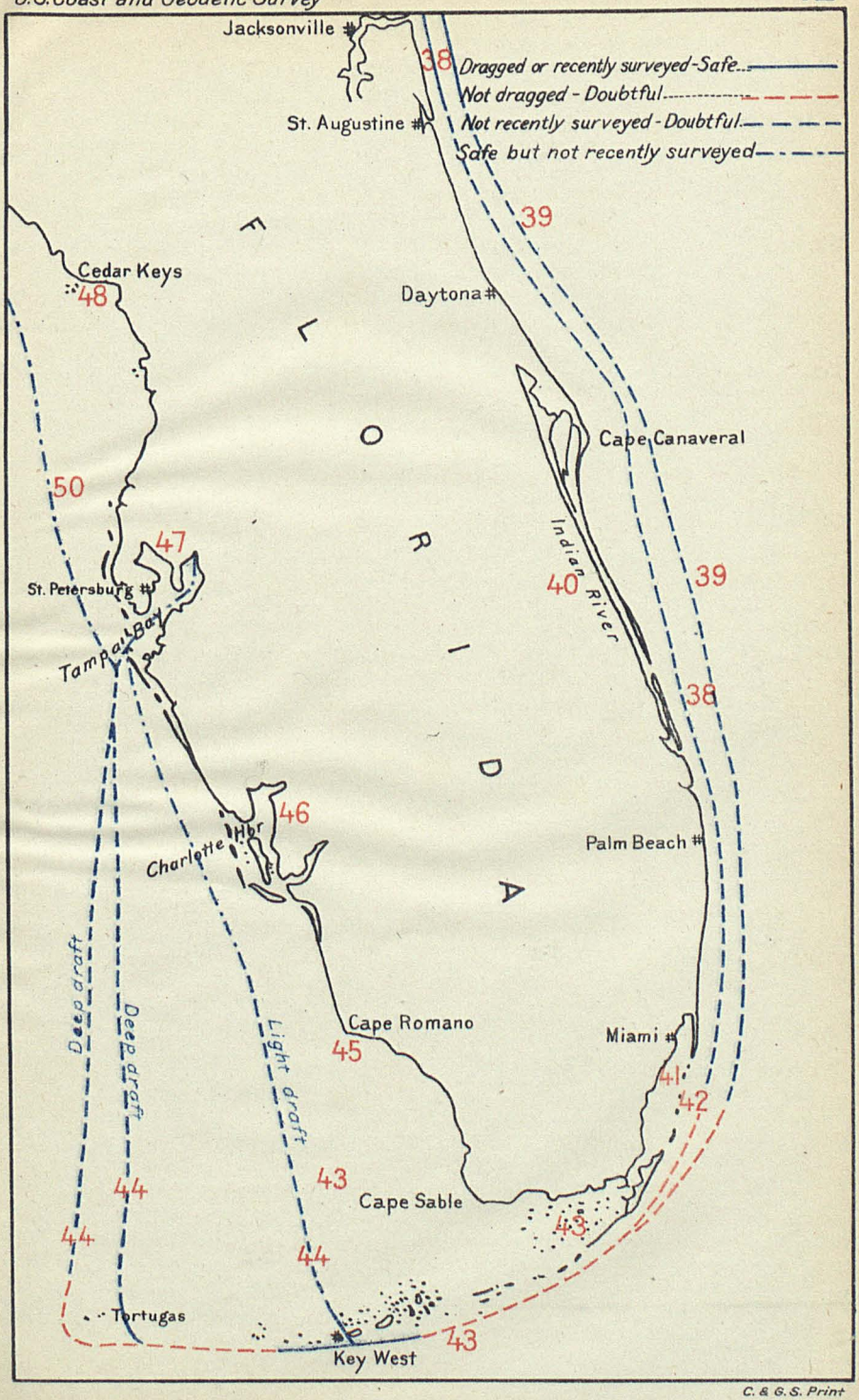
55. *Mississipi Sound.*—A resurvey of this sound has been completed. (See fig. 13, opposite p. 60.)

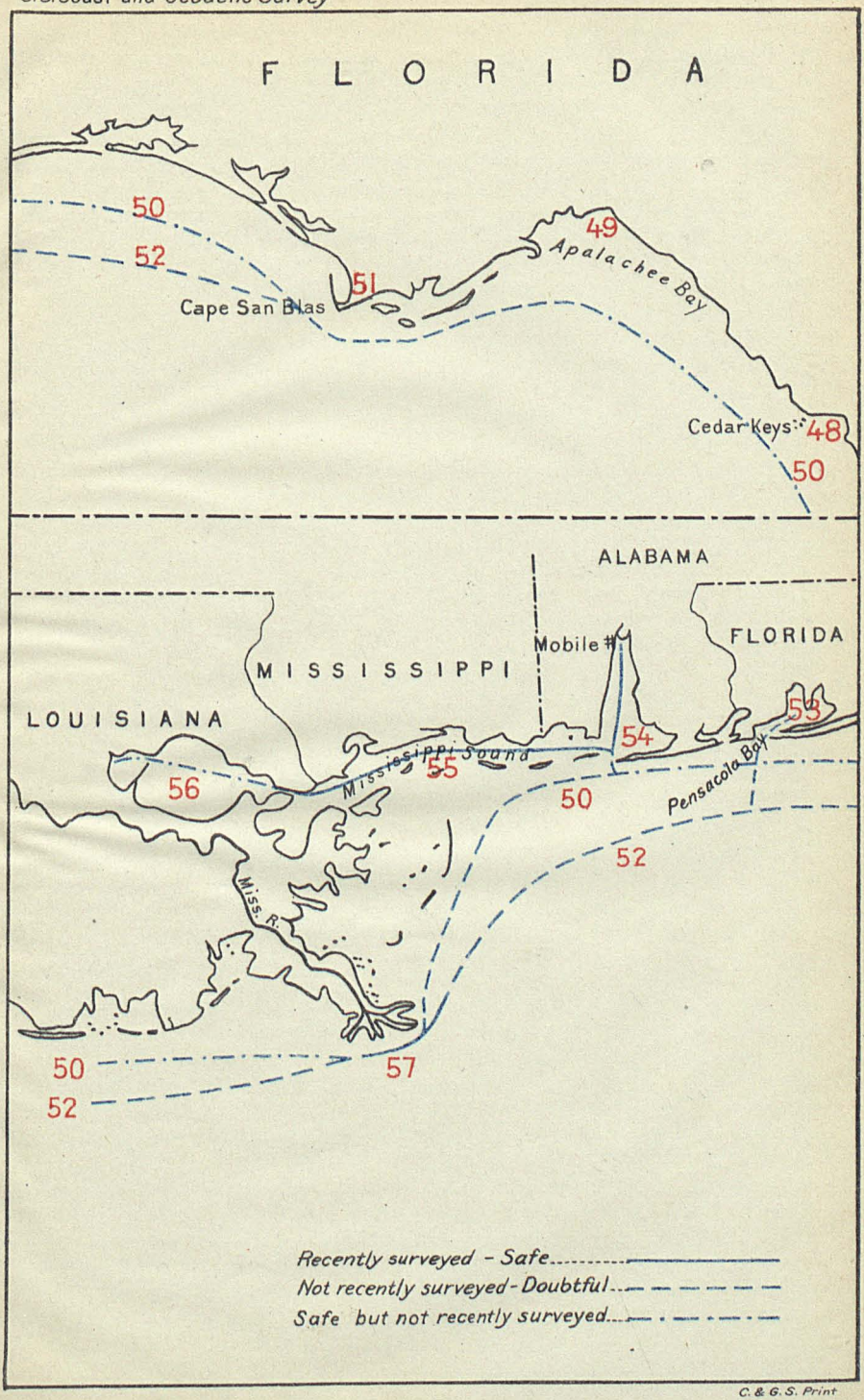
56. *Lake Pontchartrain.*—In connection with the surveys in Mobile Bay and Mississippi Sound, a recent survey has been made at the eastern end of the lake. The greater part of the lake has not been examined for 20 years. (See fig. 13, opposite p. 60.)

57. *Approaches to Mississippi passes.*—Resurveys have been completed recently. (See fig. 13. opposite p. 60.)

58. *Vermilion Bay and Cote Blanche.*—No recent surveys have been made of these areas. Surveys are needed. (See fig. 14, opposite p. 62.)

59. *Approach to Sabine Pass.*—No recent surveys have been made here and revisionary surveys are needed. (See fig. 14, opposite p. 62.)


Jacksonville
St. Augustine
Dragged or recently surveyed-Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed
38
39
Cedar Keys
48
Daytona
FLORIDA
Cape Canaveral
50
47
Indian River
40
39
St. Petersburg
Tampa Bay
38
46
Charlotte Hbr
Palm Beach
Deep draft
Deep draft
Light draft
Cape Romano
45
Miami
41
42
44
43
Cape Sable
43
44
44
Tortugas
43
Key West


FLORIDA
50
52
51
Cape San Blas
49
Apalachee Bay
Cedar Keys
48
50
ALABAMA
FLORIDA
Mobile
MISSISSIPPI
LOUISIANA
53
54
Mississippi Sound
55
56
50
Pensacola Bay
52
Miss. R.
50
57
52
Recently surveyed - Safe
Not recently surveyed - Doubtful
Safe but not recently surveyed

60. *Porto Rico.*—The surveys of Porto Rico were begun when the island came under the jurisdiction of the United States as a result of the Spanish-American War. By 1910 the surveys of the bays, channels, and inshore waters were completed and a number of deep-sea soundings were taken around the island. There are, however, extending to the eastward and westward of the island and along the south coast extensive areas where the bottom is of coral formation. There are also reefs along the north coast, but as they are close to shore and must be avoided by vessels, it is only important to know their location and limits. The areas on the east, south, and west are different in that there is traffic between the reefs and over areas where the depth is little greater than the draft of the vessel, and the probable existence of uncharted projections is a source of danger. Vieques Sound between Culebra and Vieques Island, east of Porto Rico, Virgin Passage, and the approaches to the harbors of the American Virgin Islands are in need of wire-drag surveys. The only work of this character that has been accomplished here is in the vicinity of Mayaguez. This work resulted in the abandonment of one channel and the rebuoying of another. (See fig. 15, opposite p. 62.)

61. *Virgin Islands.*—The Virgin Islands were purchased from Denmark, and the United States took possession in 1917. The surveys that have been made are by the British and Danish Governments. At the present time the available data regarding these surveys are being examined with the view to determining whether or not they are sufficient for the needs of our naval and commercial vessels. It is certain that the coral formation in the waters touching these islands requires extensive wire-drag surveys before accurate charts can be issued. (See fig. 15, opposite p. 62, and fig. 30, opposite p. 116.)

62. *Panama Canal.*—The Atlantic approach to the Panama Canal has been surveyed since work started on the canal construction. Limon Bay is, however, a region where pinnacle rocks occur. All the anchorages should be dragged, and the work should be carried a short distance outside. The Pacific approach to the canal has had a recent survey and has been dragged. No further surveys are needed at the western end at present. (See fig. 16, opposite p. 62.)

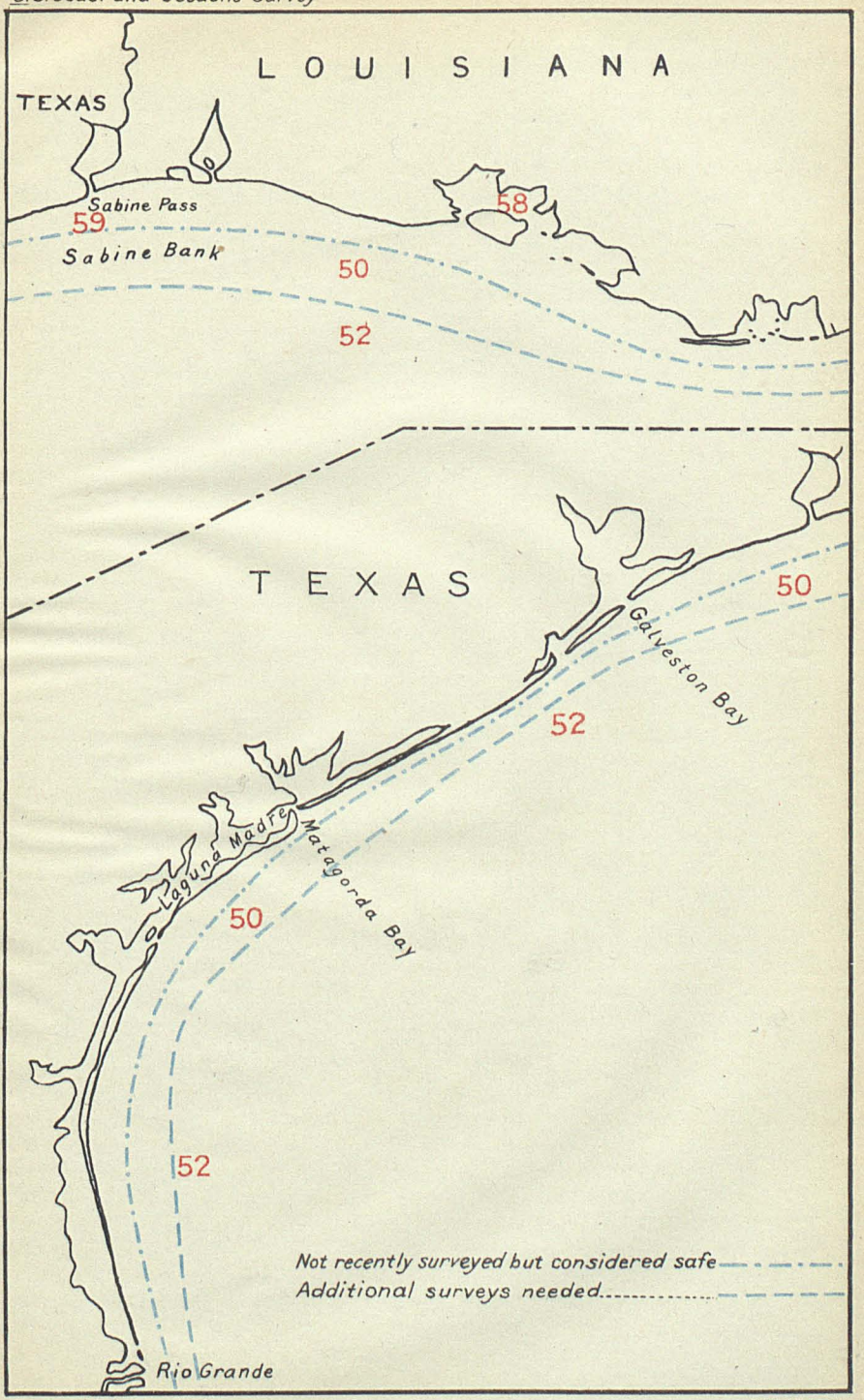
63. *Pacific coast of the United States.*—The western coast of the United States is very different from the eastern. Generally mountainous, with comparatively few harbors or inside waterways and with comparatively deep water close to the shore, it presents little resemblance to the low shores and wide continental shelf of the Atlantic. The purpose of the surveys is, then, to meet the needs of vessels approaching from seaward and coasting vessels which keep to a few comparatively narrow tracks, to insure up-to-date charts of the various harbors, to make soundings offshore, and to develop fishing banks that are known to exist. The weather is an important factor in increasing the importance of the charts of this coast. From Los Angeles Harbor northward fog is very common in the summer time, and in the winter gales accompanied by thick weather are of frequent occurrence. On the coast in the vicinity of San Francisco thick weather is of frequent occurrence. On the coast in the vicinity of San Francisco thick weather is prevalent for perhaps 25 per cent of the time. Under such conditions the navigator must rely entirely

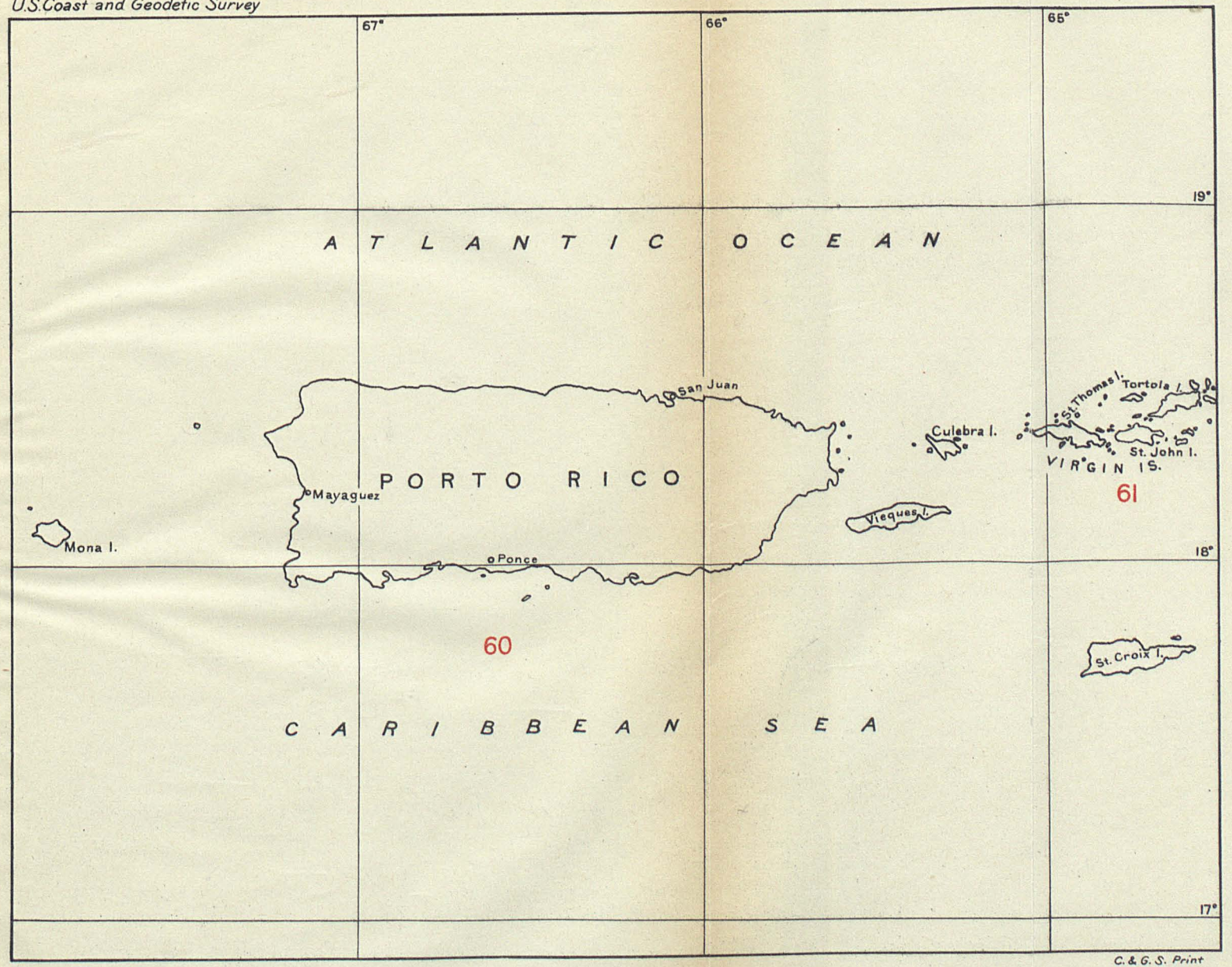
upon his chart, and it is essential that detail surveys be made to beyond the limit of soundings taken by merchant vessels, which is the 100-fathom curve. Along the shore of southern California much work was done up to 1895, and some of the surveys then made may be accepted as final. In the vicinity of the outer islands surveys extended only a little way from the shore, and the deep waters between and outside of them are surveyed. The few soundings taken show irregular bottom and breakers have been reported in places where the chart shows 600 fathoms. These waters, therefore, should be surveyed out to the 1,000-fathom depth. The Oregon coast is practically unsurveyed. A limited amount of work was done years ago south of Cape Blanco and in the vicinity of the Columbia River, but this was not more than a reconnoissance and does not extend out far enough to be of practical value to navigators. Elsewhere no surveys have ever been undertaken. Even in such an important locality as Cape Blanco, which must be rounded by all vessels plying between the Columbia River and San Francisco, there are no soundings to serve as a guide in thick weather, and vessels have been lost wholly on account of this lack of surveys. On the coast of Oregon there are eight important harbors on which the Government and private interests have expended approximately $40,250,000 in improvements designed to facilitate navigation. One of these is the Columbia River, the gateway to one of the most important transportation centers of the Pacific coast. Yet in spite of these immense expenditures for improvement, there is not a single one of these harbors the approaches to which have been adequately surveyed. The approaches to the Columbia have been sounded for a short distance offshore, but even in this area the soundings are too far apart to more than indicate, in a general way, the depths which may be expected. This partial survey extends southward along the coast to include the approaches to two other harbors. The approaches to the remaining five, on which $3,826,000 have been expended in improvement, are entirely unsurveyed. The entire Washington coast stands in urgent need of a first survey, except in the approach to the Straits of Juan de Fuca and in the straits themselves where the present work is adequate. (See figs. 17 and 19, opposite p. 62.)

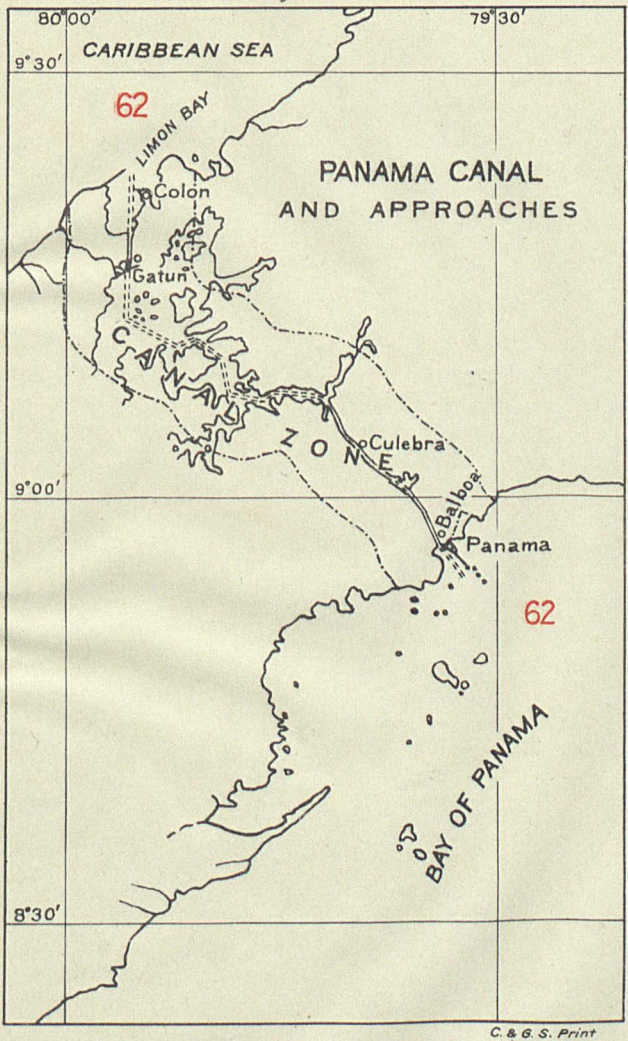
64. *Los Angeles Harbor.*—Los Angeles Harbor should be dragged. (See fig. 17, opposite p. 62.)

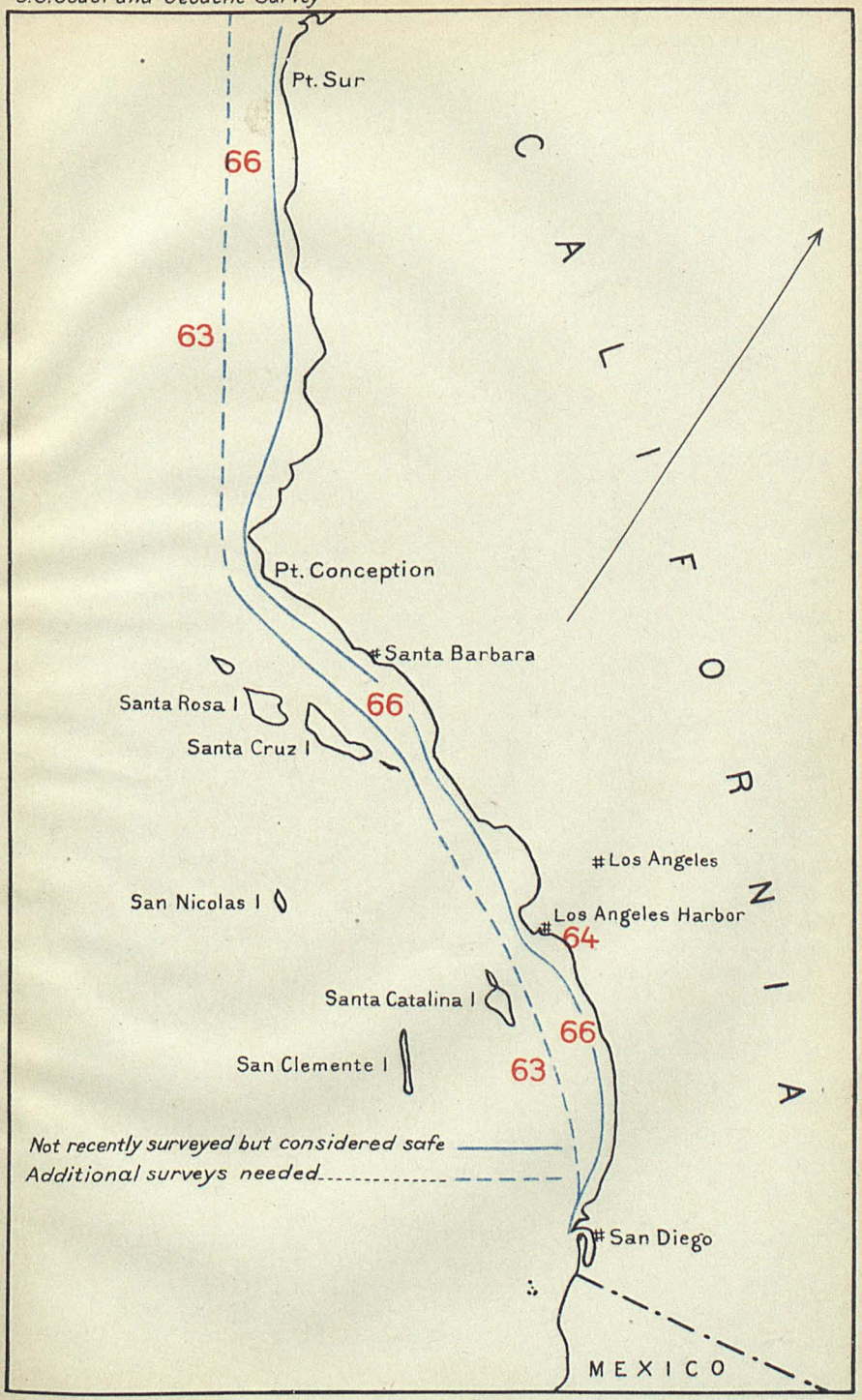
65. *San Francisco Bay.*—San Francisco Bay is of varied character of bottom and the needed surveys vary to correspond. The outer approaches are complete except in the vicinity of the Farallones. Here additional sounding is needed and an investigation should be made with the wire drag to verify the existence of other rocks than those charted. The bar outside the Golden Gate needs a resurvey. Wire-drag work has been carried through the Golden Gate and inside, both northward and southward of San Francisco to the limit of the rocky area. The southern part of the bay where the bottom is subject to change by currents is in need of resurvey. (See fig. 18, opposite p. 62.)

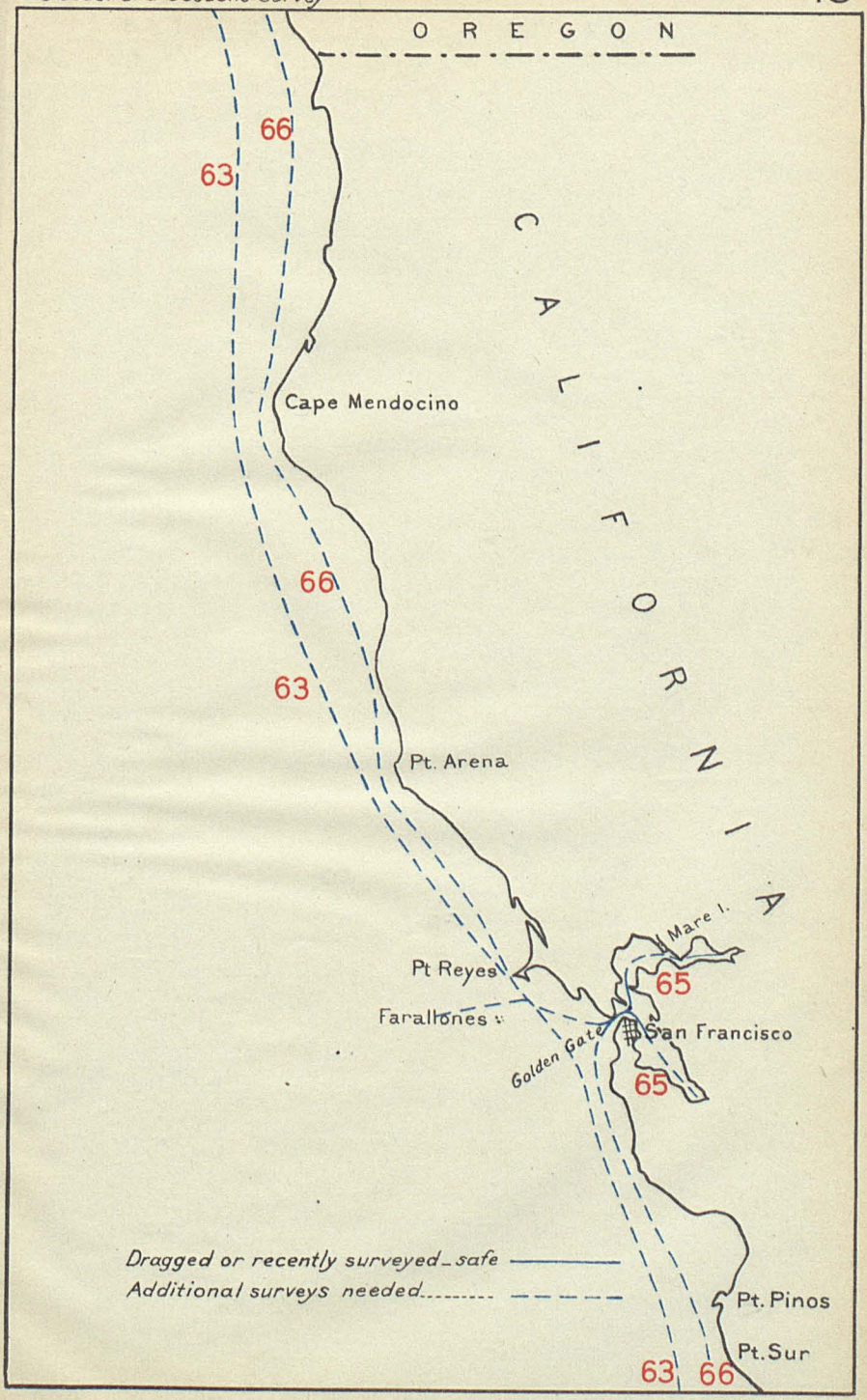
66. *Along shore waters of the Pacific Coast States.*—From the western end of the Santa Barbara Channel to Monterey Bay the surveys, as a rule, extend only to the 50-fathom curve, which lies but a short distance offshore. These surveys should be extended seaward to include the usual track of coastwise vessels, which lies an


LOUISIANA
TEXAS
Sabine Pass
59
Sabine Bank
58
50
52
TEXAS
50
Galveston Bay
52
Laguna Madre
Matagorda Bay
50
52
Not recently surveyed but considered safe
Additional surveys needed
Rio Grande


67°
66°
65°
19°
18°
17°
ATLANTIC OCEAN
PORTO RICO
San Juan
Mayaguez
Ponce
Mona I.
Culebra I.
Vieques I.
St. Thomas I.
Tortola I.
St. John I.
VIRGIN IS.
St. Croix I.
CARIBBEAN SEA
60
61


80°00′
79°30′
9°30′
CARIBBEAN SEA
62
LIMON BAY
Colon
PANAMA CANAL
AND APPROACHES
Gatun
CANAL ZONE
Culebra
9°00′
Balboa
Panama
62
BAY OF PANAMA
8°30′


Pt. Sur
66
63
CALIFORNIA
Pt. Conception
Santa Barbara
Santa Rosa I
66
Santa Cruz I
Los Angeles
San Nicolas I
Los Angeles Harbor
64
Santa Catalina I
66
San Clemente I
63
Not recently surveyed but considered safe
Additional surveys needed
San Diego
MEXICO


OREGON
CALIFORNIA
66
63
Cape Mendocino
66
63
Pt. Arena
Mare I.
Pt Reyes
65
Farallones
Golden Gate
San Francisco
65
Dragged or recently surveyed_safe
Additional surveys needed
Pt. Pinos
Pt. Sur
63
66

average distance of about 10 miles from shore. From San Francisco Bay to Point Arena a widely-spaced system of sounding lines has been carried out to the 100-fathom curve. Here, an additional amount of work, about equal to that already accomplished, is necessary before the survey can be considered complete. Between Point Arena and Cape Mendocino the surveys extend a uniform distance of 6 miles from shore, reaching depths varying from 50 to 200 fathoms. Additional detailed surveys should be made in the vicinity of each cape, and between them the work should be carried seaward to beyond the steamer track. From Cape Mendocino northward to the Oregon boundary the limited surveys existing were made many years ago and are entirely inadequate. A complete resurvey should be made at the earliest possible date. There are no adequate surveys of the inshore area along the State of Oregon. Of the water off the northern part of the Pacific coast, little is known except that the Bureau of Fisheries, acting on the information obtained from fishermen, has located certain banks. These banks should be surveyed to determine their depths and extent, and it is believed that a general survey carried out to the 1,000-fathom curve will result in the discovery of other banks of great value. (See fig. 19, opposite p. 64.)

67. *Interior waters of the State of Washington.*—The interior waters of the State of Washington represent the point of change from a practically straight coast line to the broken formation of the coast of British Columbia and southeastern Alaska. There are many channels of importance leading to Seattle, Tacoma, Everett, Bellingham, and Olympia, and connecting with the inside passage to southeastern Alaska. All these waters should be dragged wherever there is the slightest doubt as to the presence of dangers to navigation. (See fig. 20, opposite p. 64.)

67a. *Alaska, general.*—An important difference between Alaska waters and those of the continental United States is that scarcely enough work has been done to let us know just how much must be done to complete the charts. The development of the country has far outstripped the progress of surveys, not only because of the few vessels and parties engaged in the work, but because of the great length of coast over which the various activities are scattered and the intricate system of channels for so much of its extent. In order to appreciate the need of rapidly extending the surveys of these waters, it should be clearly understood that Alaska's only connection with the rest of the world is by the water routes. The amount of the natural resources of Alaska ripe for exploitation has been so great and the prize they offered so tempting that transportation could not wait for the Government to make the way to them secure. It has gone ahead finding its own path to new fields, suffering great losses in so doing, but content to suffer them because the returns were so immensely greater. (See fig. 21, opposite p. 64.)

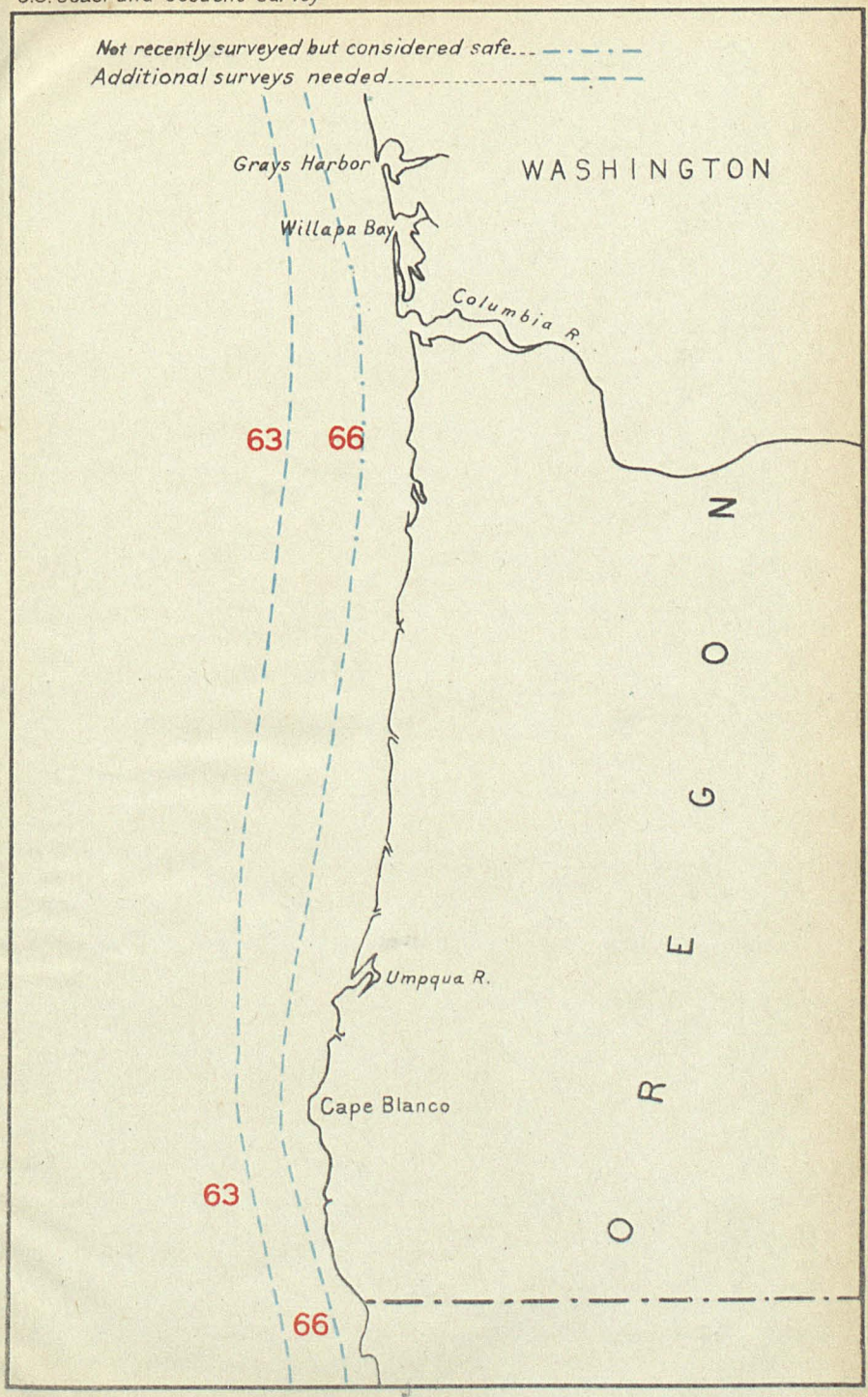
68. *Steamer routes, southeastern Alaska.*—In southeastern Alaska the first and most obvious need is to complete the wire-drag work. Most of these waters have been sounded, so that only dragging is necessary to complete this survey. This drag work should be taken up in the order of its importance, beginning with the main steamer route through the region and then taking up the various tributary waters leading to areas of commercial importance. For some years past, two parties have been actively engaged in dragging the main

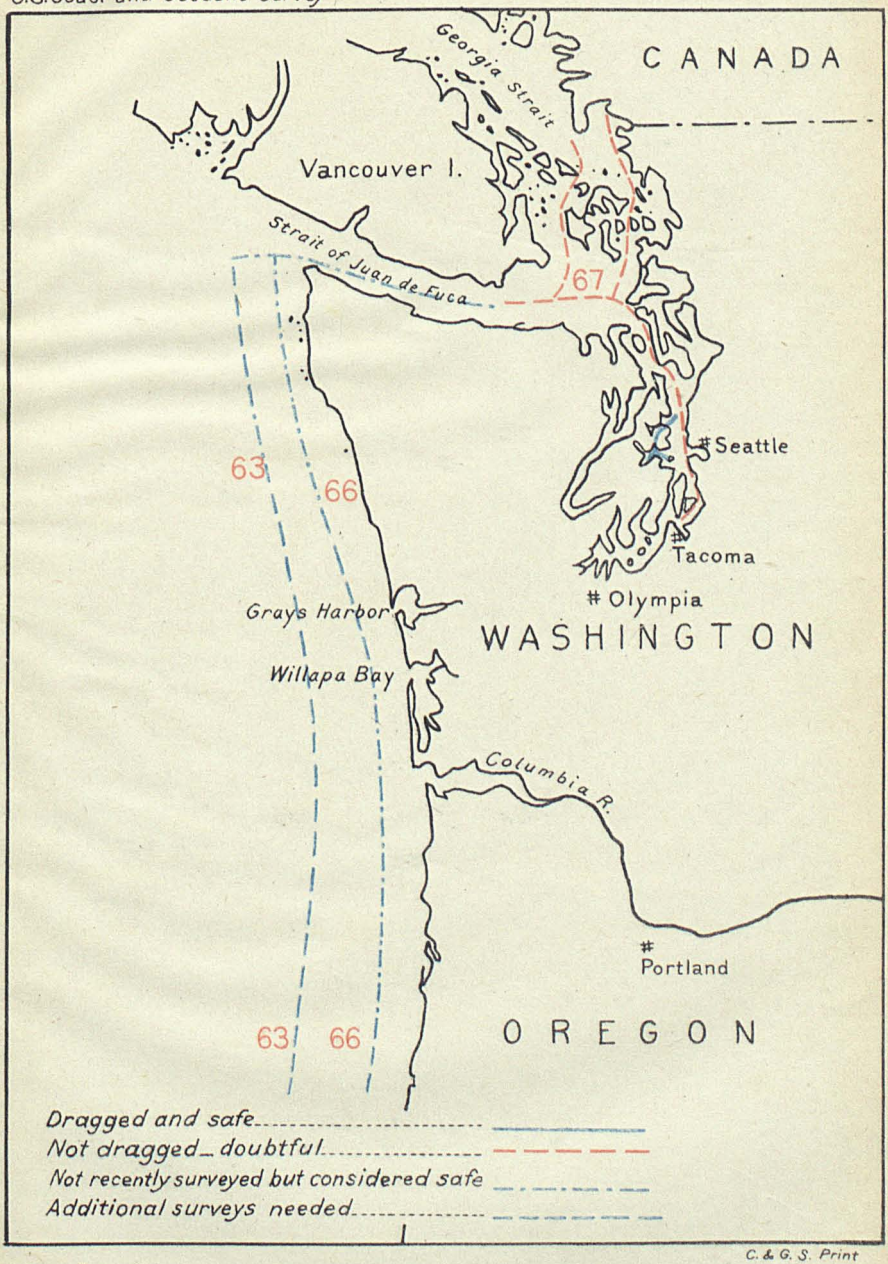
steamer routes, and this work is now about 55 per cent complete. (See fig. 21, opposite p. 64.)

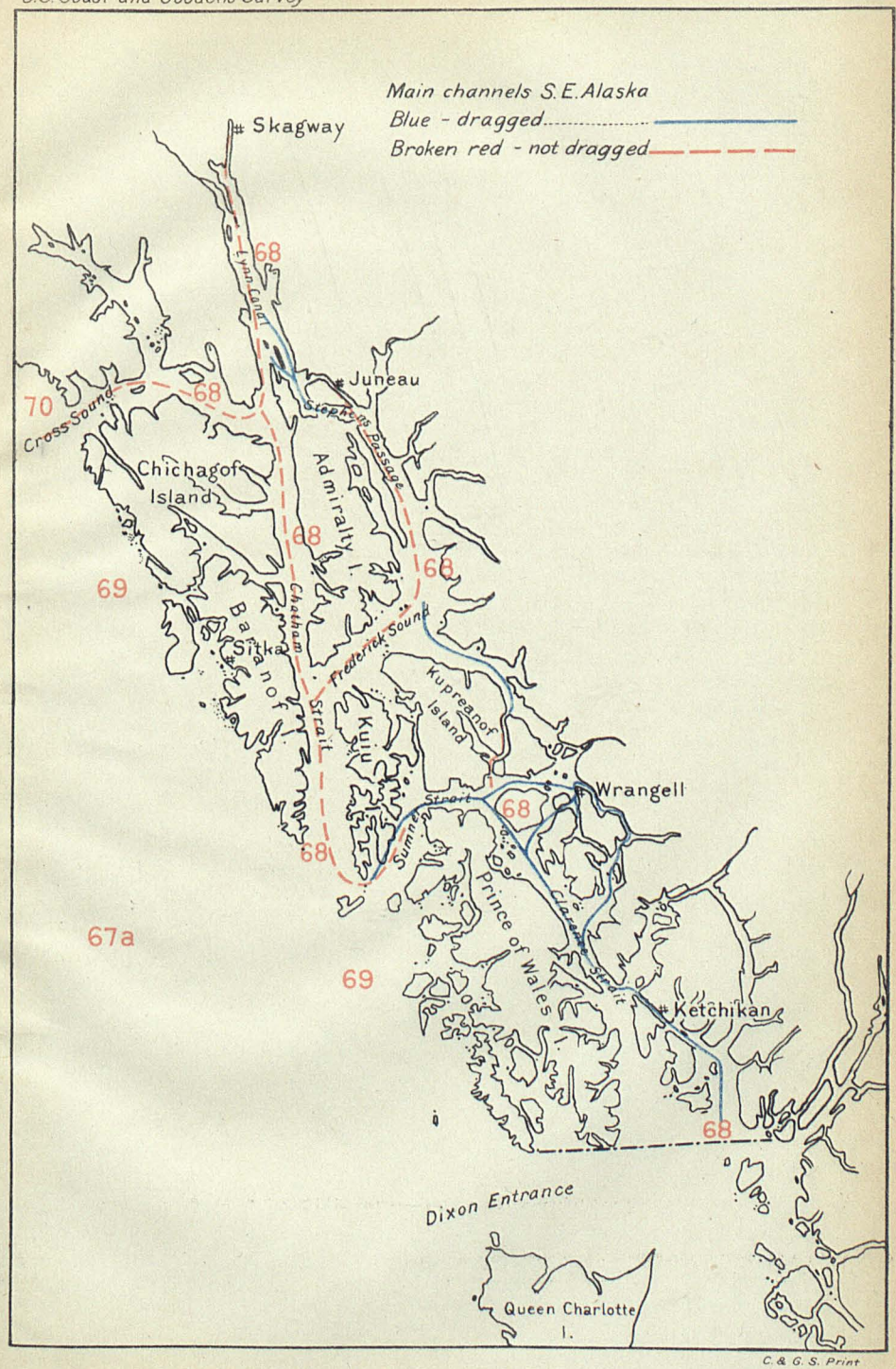
69. *The outside coast waters of the islands bordering on the open Pacific.*—These and their connecting channels are largely unsurveyed and should be navigated with great caution. A navigator, seeing a chart on which the shore line is stretched, no soundings, several rocks and shoal banks, notes as to rocks and breakers reported, and a statement on the chart to the effect that the area is unsurveyed, is, to say the least, unable to proceed with confidence; and this situation is by no means unusual. The same pressing need of such regions is a complete hydrographic survey followed later in places by wire-drag work. The rapidly increasing commercial importance of this region and the exceptionally dangerous character of the waters through which traffic must pass, render surveys in the near future imperative. (See fig. 21, opposite p. 64.)

70. *Cross Sound to Prince William Sound.*—From Cross Sound, the northernmost channel from the inside waters to the sea, to Prince William Sound, the coast has few features of present or prospective importance. There is, however, urgent need for surveys to insure the safety of vessels approaching and passing along this coast. In this region the charts are very defective in the manner of showing sounding and prominent coastal mountain peaks and headlands that would enable the navigator to obtain his position on approaching from seaward. The only important break on this coast, Yakutat Bay, has some canneries, and additional surveys are needed here on this account. (See fig. 22, opposite p. 66.)

71. *Prince William Sound to Unimak Pass.*—A very important section of the Alaska coast extends from the waters of Prince William Sound westward to Unimak Pass. Not only are the industries of present importance, but there are extensive mineral resources largely undeveloped through lack of cheaper transportation. The point to be emphasized is that this is not an old, settled country with its needs in the matter of transportation fixed, but it is still capable of great future development, and in considering the needed surveys its future must be taken into account. The approaches to Prince William Sound have been surveyed and no resurveys for the present are needed except in the vicinity of Cape St. Elias and Middleton Island. Wire-drag work will be needed in both of these localities as reefs and pinnacle rocks exist. Prince William Sound needs additional soundings over most of its area, and many of its branches need original surveys. Cordova is the terminus of the Copper River & Northwestern Railway which gives access to the important copper mines on the Copper River. The approaches to Cordova have been surveyed, except for wire-drag surveys needed to insure complete safety. Seward, on Resurrection Bay, is the terminus of the Alaska Railroad now being built by the Government. The surveys of its approach are completed except for wire-drag work. It is probable that much of the trade originating along the line of the Government railway will be transshipped at Anchorage at the head of Cook Inlet. Not only will this make it necessary for many vessels to navigate these waters, but there are now very large salmon canneries all along its shores, as well as considerable mining. The present surveys are inadequate and wire-drag work is needed over much of its area.


Not recently surveyed but considered safe
Additional surveys needed
Grays Harbor
WASHINGTON
Willapa Bay
Columbia R.
63
66
OREGON
Umpqua R.
Cape Blanco
63
66


CANADA
Georgia Strait
Vancouver I.
Strait of Juan de Fuca
67
Seattle
Tacoma
Olympia
63
66
Grays Harbor
WASHINGTON
Willapa Bay
Columbia R.
Portland
63
66
OREGON
Dragged and safe
Not dragged_ doubtful
Not recently surveyed but considered safe
Additional surveys needed


Main channels S.E. Alaska
Blue - dragged
Broken red - not dragged
Skagway
Lynn Canal
68
Juneau
Stephens Passage
70
Cross Sound
68
Chichagof Island
Admiralty I.
68
68
69
Baranof
Sitka
Chatham Strait
Frederick Sound
Kupreanof Island
Kuiu I.
Wrangell
Sumner Strait
68
68
Prince of Wales I.
Clarence Strait
67a
69
Ketchikan
68
Dixon Entrance
Queen Charlotte I.

Kodiak Island, with a number of canneries and with some cattle grazing, is largely unsurveyed. From Kodiak Island westward to Unimak Pass only a comparatively small part has been surveyed at all. While the amount of present traffic is small it is sufficient to need protection. At present the Coast Guard vessels and the freight and passenger vessels run grave risks in using the protected natural channel leading along the coast inside the island. This is a particularly bad stretch of coast with many reefs and islands. Only in the vicinity of the Shumagin Islands and from Unimak Pass to Unalaska Islands have surveys been made, and they are inadequate. It is not now practicable to drag the entire area, but it is important that the immediate needs of navigation, even though of limited amount, be met by dragging a selected channel to insure the safety of vessels from Shelikof Strait to Unimak Pass. Unimak Pass is the almost universally used channel into Bering Sea. It has been surveyed, but it is probable that part of it should be dragged or at least further soundings be taken. (See fig. 22, opposite p. 66.)

72. *Aleutian Islands.*—The Aleutian Islands have comparatively little traffic and are without survey. It is necessary that this region be patrolled by Coast-Guard vessels. The loss of one of the vessels of this service a few years ago was wholly due to the lack of adequate surveys. (See fig. 22, opposite p. 66.)

73. *Bristol Bay.*—A large part of the salmon shipped from Alaska comes from Bristol Bay. This is without surveys except in Nushagak Bay and Kuskokwim Bay and River. Both of these have recent surveys, but as the bottom is subject to change on account of the large rivers, future additional surveys will be needed. As an example of what surveys mean in a new region, the discovery of an entrance to the Kuskokwim River suitable for moderate-draft vessels opened up an immense area for grazing and also in places for general agriculture. (See fig. 22, opposite p. 66.)

74. *Norton Sound.*—The importance of Norton Sound is due to the gold mining on its northern shores and as being the outlet of the Yukon delta on the southern shore. In all of Norton Sound additional surveys are needed. It is curious that in this sound, which according to all available information is of quite level, sandy, or muddy bottom, Besboro Island rises very abruptly to a height of 1,012 feet. With such an occurrence it is not absolutely certain that no pinnacle rocks exist. (See fig. 22, opposite p. 66.)

75. *Bering Sea and Arctic Ocean.*—Except in the vicinity of Pribilof Islands, there are no other existing surveys in Bering Sea or to the north which can be considered of value. (See fig. 22, opposite p. 66.)

76. *Guam.*—The present chart of the island of Guam is compiled from Spanish and British charts and some harbor surveys by the United States Navy. No attempt at a comprehensive survey has been made. A complete survey should be made, not only including the harbors, but the surrounding waters, carrying the work out to a depth that will be certain to include all dangers. In these waters shoals rise abruptly from great depths, and the absence of soundings on the charts does not imply safety, but simply absence of surveys.

77. *Hawaiian Islands.*—There are only two good harbors on all the Hawaiian Islands and both of these are on Oahu Island. All of the islands except Hawaii have coral reefs around at least part of

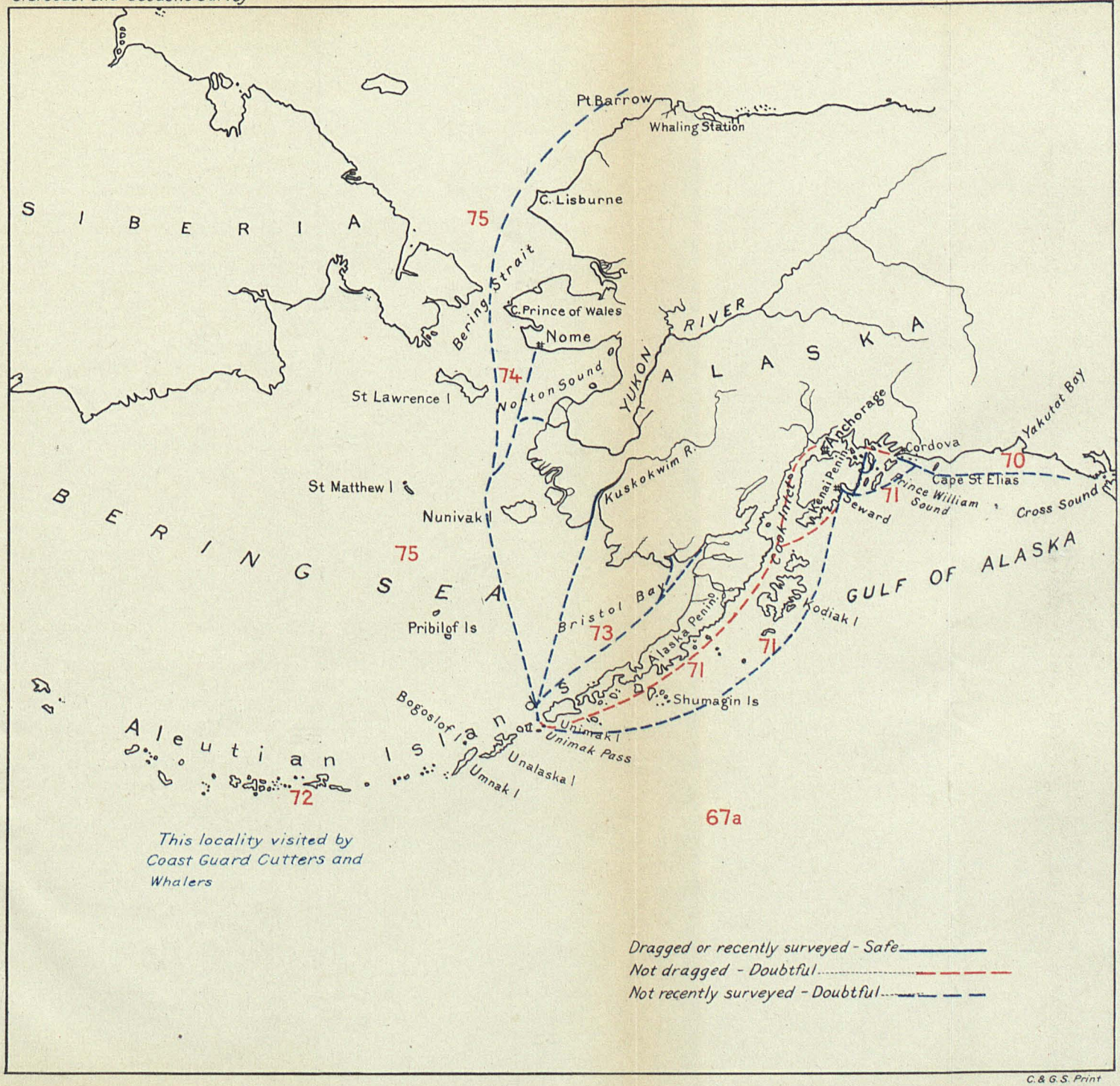
them. In the vicinity of Oahu, Maui, Kahoolawe, and the south coast of Molokai the surveys are fairly complete. In the vicinity of Hawaii the surveys are very inadequate except in the only harbor, Hilo Bay. The west coast of Lanai and the vicinity of the two westernmost islands, Jauai and Niihau, are practically unsurveyed. The various channels between the islands from Maui to Oahu are fairly well surveyed. The others are practically without surveys. (See fig. 23, opposite p. 66.)

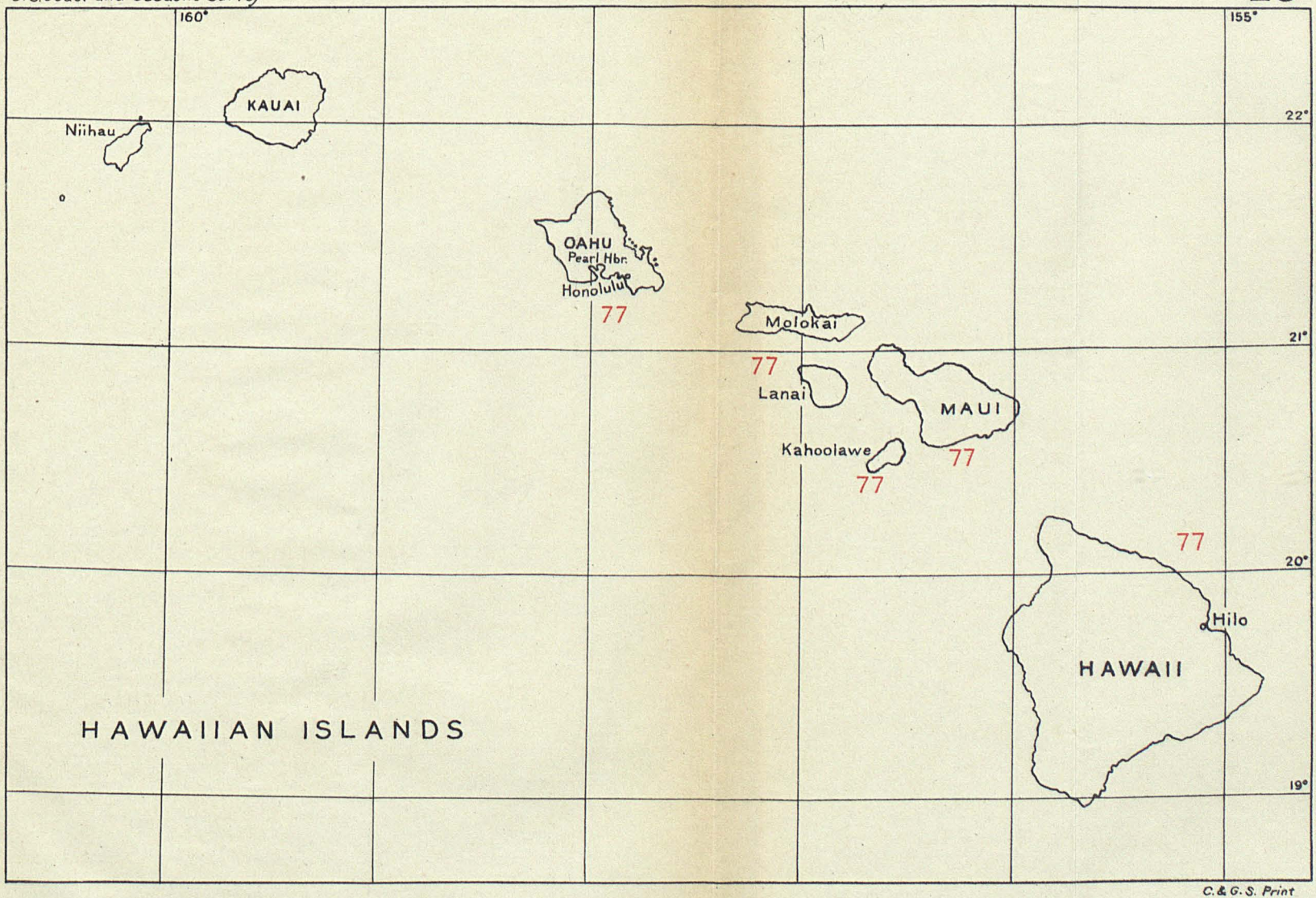
78. *Philippine Islands.*—The Philippine Islands are composed of not less than 3,000 islands and islets covering an area of approximately 150,000 square miles, about the same as that of the five New England States and the State of New York combined. The total length of the general coast line, measured on small-scale charts using 3-mile spaces of dividers and omitting islands and bays less than 3 miles long, is approximately 10,850 miles, or about the same as that for the entire Atlantic coast of the United States, including the islands. About 75 per cent of this shore line has been completed. The unsurveyed hydrography covers a large area on account of the necessity of extending this work, in some localities, for many miles offshore, and on account of the very extensive area of the Sulu Sea. It is estimated that about 50 per cent of this class of work has been completed. The unsurveyed regions are as follows: The northeast coast of Luzon from Polillo Island northward to Aparri; the region off the north coast of Luzon, including the Babyan Islands, Balintang Channel, the Batan Islands, and Bashi Channel; the entire west coast of the island of Palawan, the west coast of Mindanao, from Blanca Point south to Zamboanga; the south coast of Mindanao, from Pola Point to Malita, in Davao Gulf; the Sulu Archipelago and the Sulu Sea from Cuyos south to the limit of our possessions off the coast of Borneo. (See fig. 24, opposite p. 66.)

79. *Northeast coast of Luzon.*—This entire unsurveyed region, from Polillo Island on the south to Aparri on the north, is of little commercial importance, and being quite free from dangers to navigation, the execution of the work is being delayed until more important localities are completed. Little reliable information relating to this region is available, but a number of good anchorages have been reported. Among these are the inner harbor of Port San Vincente, Dilasac Bay, Casiguran Sound, and Dingalan Bay. The first and third mentioned are excellent typhoon harbors. The work must, however, be done during the season of frequent typhoons, it being impossible to approach the coast at any other time of the year on account of the heavy sea caused by the northeast monsoon. (See fig. 24, opposite p. 66.)

80. *Off north coast of Luzon.*—A survey should be made of the islands and the waters to the northward of Luzon as far as Bashi Channel, as, in accordance with the numerous reports, there is considerable uncertainty in regard to the true location of the islands and the rocks that are dangerous to navigation in the locality. As it is in the region visited by frequent typhoons, the work should be undertaken during the period when the typhoons are less frequent. (See fig. 24, opposite p. 66.)

81. *West and east coast of Palawan.*—The coast line of the island of Palawan is very irregular, indented with deep bays forming some


Pt. Barrow
Whaling Station
C. Lisburne
S I B E R I A
75
Bering Strait
C. Prince of Wales
Nome
YUKON RIVER
A L A S K A
74
Norton Sound
St Lawrence I
Anchorage
Yakutat Bay
Cordova
70
Cape St Elias
Kuskokwim R.
St Matthew I
Nunivak I
Kenai Penin.
Prince William Sound
71
Seward
Cross Sound
B E R I N G S E A
75
Cook Inlet
GULF OF ALASKA
Bristol Bay
Kodiak I
Pribilof Is
73
Alaska Penin.
71
71
Shumagin Is
Bogoslof I
Unimak I
Unimak Pass
Aleutian Islands
Unalaska I
Umnak I
72
67a
This locality visited by Coast Guard Cutters and Whalers
Dragged or recently surveyed - Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful


160°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Pearl Hbr.
Honolulu
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Molokai
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Lanai
MAUI
Kahoolawe
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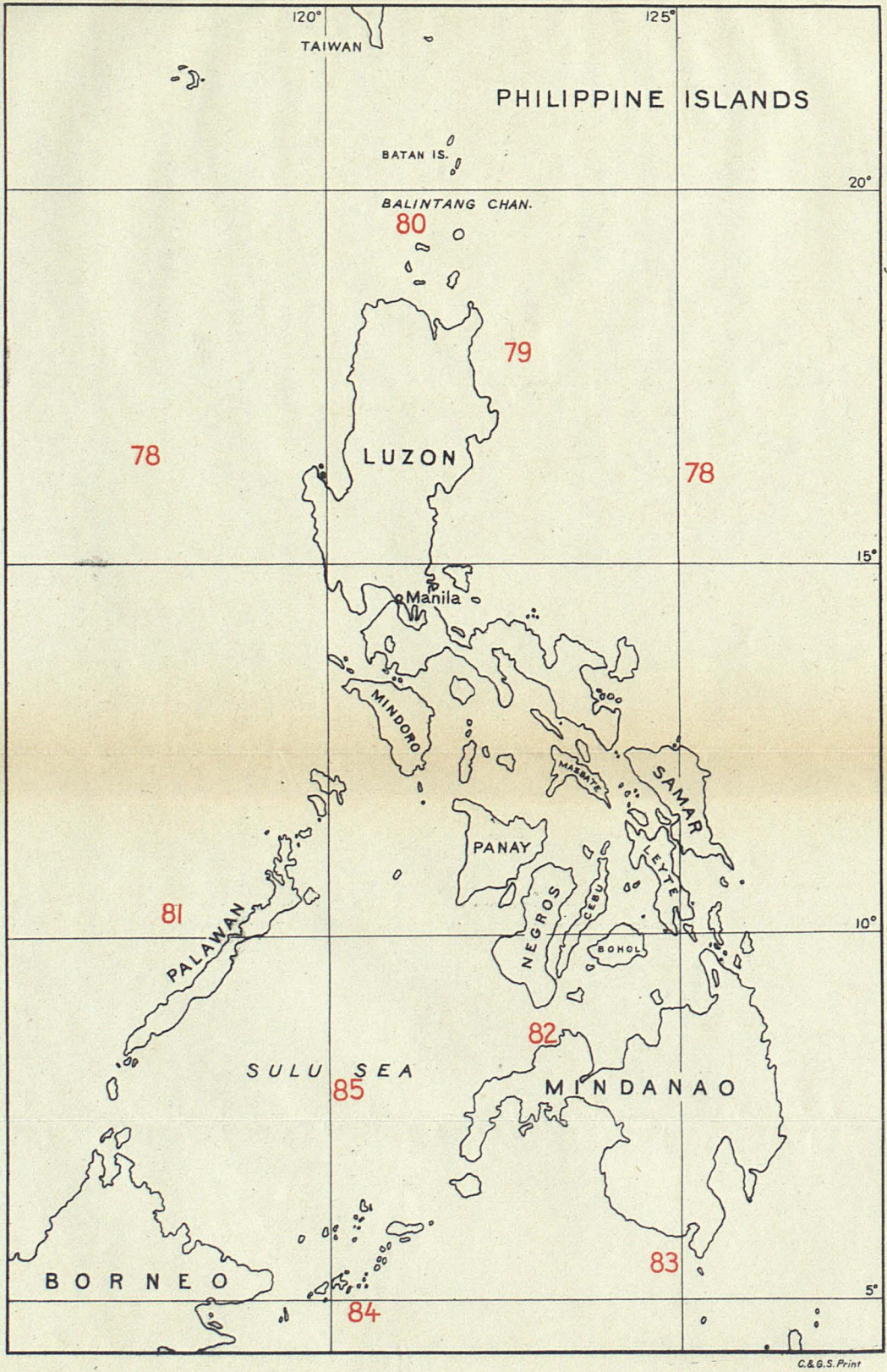
Hilo
HAWAII
HAWAIIAN ISLANDS



U.S. Coast and Geodetic Survey

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of the finest harbors in the Archipelago. The whole region about the island and extending southward to Balabac Island, Banguey Island, to Cagayan Sulu, and off the north coast of Borneo consists of coral reefs, many small islets, and innumerable hidden dangers to navigation. To the westward of Palawan, reefs and dangers extend to over 100 miles offshore. The hydrographic survey of this region involves an immense amount of labor. A preliminary survey for the location of channels through the reefs and entrances to harbors will first be necessary, after which these localities must be swept with the wire drag. (See fig. 24, opposite p. 66.)

82. *West coast of Mindanao.*—The necessity of the survey of this unfinished portion of Mindanao, from Blanca Point to Zamboanga, a stretch of about 150 miles, is not urgent, as the region is of no commercial importance and is considered to be free from dangers to navigation. The coast is bold and rocky, exposed to both the northeast and the southwest monsoons, and there are only a few months in the year before the change in the monsoons that are favorable for work in this region. (See fig. 24, opposite p. 66.)

83. *South coast of Mindanao.*—This stretch of about 160 miles, from Pola Point to Malita in Davao Gulf, involves no great difficulty. The coast, in general, is bold and steep with numerous outlying reefs which, however, do not extend a great distance from shore. (See fig. 24, opposite p. 66.)

84. *Sulu Archipelago.*—This region, about 75 miles wide, extending in a southwesterly direction from Zamboanga on the southern coast of Mindanao, to the coast of Borneo, a distance of about 180 miles, has scattered over it about 300 islands and islets and numerous hidden dangers to navigation. It requires a survey of the most careful and intricate character, and much of the locality must be swept with the wire drag. The formation is coral and dangerous to navigation, as rocks are frequently found in localities where they are least expected to exist. The currents in the region are very strong. The physical conditions are such that excellent control to coordinate the work with that along the coast of Mindanao can be obtained. (See fig. 24, opposite p. 66.)

85. *Sulu Sea.*—The northern end, as far south as the Tubbataha Reefs, except certain small areas, has been surveyed with a fair degree of accuracy, but owing to the coral formations, where hidden dangers frequently exist, wire-drag sweeping will be necessary in selected passages. The entire region to the south of the Tubbataha Reefs remains unsurveyed except for a reconnoissance with approximate locations by navigational methods. Numerous rocks and reefs dangerous to navigation are scattered throughout the sea, but certain well-defined passages have been examined with sufficient accuracy to make navigation through them reasonably safe. (See fig. 24, opposite p. 66.)

GEODETIC SURVEYS.

The foregoing is a general review of the condition of our hydrographic survey. A general discussion of the condition of our geodetic survey follows.

It has been the purpose of the Coast and Geodetic Survey for some years to extend its geodetic work so as to have control available for all Government, State, city, and private engineers and surveyors.

There are many cities to-day whose maps will be placed on the wrong datum with respect to both elevations and positions as a result of the lack of primary triangulation and precise leveling in the interior of the country. Every city of any size and every State of the Union should be furnished by the Federal Government with the fundamental control of which can be based surveys and maps of detailed character in any particular locality.

It is difficult to overestimate the necessity of having a proper amount of horizontal and vertical control in this country for the use of map makers, surveyors, and civil engineers. For this purpose triangulation and precise leveling bench marks should be placed within 50 miles of each place in the United States. With the Federal control carried to this extent it would be a very simple matter in the future to have detailed control placed in many areas just ahead of the surveyors and engineers who are to make the surveys and maps. This main control should be extended as rapidly as equipment and personnel of the Coast and Geodetic Survey will permit, and say, within five or six years, should be practically completed as far as the main part of the work is concerned.

It is, of course, difficult to give exact figures to show how much leveling and triangulation will be needed to finish the minimum that is essential, because plans must be changed from time to time to meet the need of the topographic engineers, but it is reasonably certain that the primary triangulation and precise leveling which should be done within the next five years will cost about $1,725,000. It is therefore believed that Congress should be asked to furnish for the geodetic work one-fifth of that amount each year, or about $345,000 per annum. With this distance of 50 miles as a criterion it can be seen that lines of precise leveling and arcs of primary triangulation would be approximately 100 miles apart. When it is considered that this distance is equal to that between Philadelphia and Baltimore or Philadelphia and New York is it realized that this is not an excessive amount of control. This estimate of fundamental control is made with a view to covering all of the country with a fair distribution of the control and later to filling in the intermediate areas as the demands of surveyors and engineers arise.

The amount of geodetic control in the United States at the present time is as follows: (See fig. 31.)

	Miles.
Primary triangulation	14,000
Primary traverse	2,000
Precise leveling	41,000

The amount of control to be executed to bring the horizontal and vertical control within 50 miles of any place in the United States is as follows:

	Miles.
Primary triangulation and primary traverse	17,000
Precise leveling	30,000

We have many needs for accurate control and accurate maps. The principal one of these is probably for Federal, State, city, and highway engineers. There will be hundreds of millions of dollars spent each year in the United States in building new roads and in maintaining and improving old ones. It is reasonably certain that this

road work could be done at a considerable saving if the country through which the road work is carried on were properly mapped. The total cost of mapping the country topographically will be not more than $100,000,000, and this is the amount which will be spent on roads every three months for probably 10 years. It would certainly be good policy to have the maps precede the building of roads rather than to have them follow.

It is planned to have primary triangulation done during the next year in Oklahoma, New Mexico, Arizona, California, Colorado, Oregon, and Idaho.

Leveling should be done now in Utah, Colorado, New Mexico, Texas, Wyoming, Montana, Arizona, Iowa, and Wisconsin.

Astronomic work is to be done in the States where primary triangulation is done.

Gravity work will be done principally in Texas, Oklahoma, Missouri, Kansas, and Nebraska.

The magnetic work of the Coast and Geodetic Survey has grown out of the practical needs of the navigator and the surveyor. With the development of long-distance aviation, the demands of the aerial navigator are added to those of the ocean navigator.

The ultimate object of the survey of the coast of a country is the construction and distribution of charts showing the hydrographic and topographic features and other information needed by the mariner for the safe navigation of the adjacent waters. When no landmarks or heavenly bodies are visible, the navigator must depend upon the compass to guide him on his way. Unfortunately the compass needle does not in general point due north nor is its direction at any particular place constant. In the United States, for example, the compass points 22° west of north in the northeastern part of Maine and 25° east of north in the northwestern part of Washington. In Porto Rico the compass needle now points 1° 30′ more to the west than it did 10 years ago. It is evident, therefore, that a knowledge of the variation of compass or the magnetic declination, as it is better to call it, is one of the essential features of a chart, and in order that a chart may be serviceable for a number of years it must give not only the declination at some particular date, but also the rate of change.

Nearly all of the original land surveys of the United States were made by compass, and the boundaries in the deeds were defined by compass bearings. With the lapse of time, land values increased and controversies arose as to the location of boundary lines which had not been marked or of which the markings had disappeared. In order to retrace the lines of a tract of land surveyed originally by compass, the surveyor must know the change in the direction of the compass needle; that is, the change in the magnetic declination between the date of the original survey and of the resurvey. To meet the demand for information of this kind the Coast and Geodetic Survey took up the study of the secular change of the elements of the earth's magnetism and of the magnetic declination in particular. A collection was made of all the available results of magnetic observations in the United States and a few foreign countries, paying particular attention to results at places where observations had been made more than once. Observations were made from time

to time at many of these "repeat" stations in order to keep the secular change data up to date. From a discussion of all the available material and a comparison with similar data for places in Europe at which more extended observations had been made, it was possible to prepare tables giving the secular change of the magnetic declination in all parts of the United States from the time of the earliest observations, tables which have many times stood the test of comparison with the observed changes of bearings of well-defined boundary lines, with the result that the Coast and Geodetic Survey has come to be recognized as ultimate authority in land-boundary controversies involving the secular change of the magnetic declination.

In view of the difficulty experienced in attempting to retrace the lines of old compass surveys, accentuated at times by instrumental errors due to imperfect construction or lack of proper care, it became important to guard against a similar condition regarding present-day compass surveys, by determining in as great detail as available funds would permit, the distribution of the magnetic declination throughout the country and in secular change, at the same time providing local surveyors with meridian lines or other means of testing their compasses.

The importance of a magnetic survey of the country to meet these needs was recognized at the time of the reorganization of the Coast and Geodetic Survey in 1843, but it was not until 1899 that the necessary funds became available for taking up this work systematically. The plan for the magnetic survey for the United States, as laid down in 1899, provided for a first general survey with stations 30 or 40 miles apart, to be followed by a more detailed investigation of regions where the general survey indicated irregular distribution of the earth's magnetism. The plan also included the reoccupation at intervals of five years of a sufficient number of "repeat" stations to determine the change of the magnetic elements with lapse of time, and the operation of magnetic observatories for determining in more detail the changes in the direction and intensity of the earth's magnetic field, and the accumulation of the data needed for the study of the nature and cause of the phenomenon.

Following this general plan, the distribution of stations has been made largely upon the county subdivisions of the States, the idea being to have one magnetic station in each county so that the necessary data might be available for the use of the county surveyors in testing their compasses. With this end in view, most of the stations have been marked in a permanent manner and true bearings of prominent objects have been determined. In many cases meridian lines have been established for greater convenience of the local surveyors. Observations have been made at all but about 130 of the county seats and a number of areas of marked local disturbance have been examined for detail. The density of the distribution of the stations corresponds in a general way with the density of the population, so that in the unsettled and less accessible portions of the country they are widely scattered, but for the whole United States the average distance between stations is 25 to 30 miles. About 75 repeat stations a year have been occupied. Magnetic observatories have been in continuous operation at Cheltenham, Md., since 1901;

at Sitka, Alaska, and near Honolulu, Hawaii, since 1902; Vieques, P. R., since 1903; at Baldwin, Kans., from 1900 to 1909; and near Tucson, Ariz., since 1909.

In Alaska the magnetic survey has gone on in conjunction with other branches of the work of the Bureau, so that the observations have been for the most part confined to the seacoast, except for a series of stations along the Yukon River, and a series of observations secured by the parties surveying the one hundred and forty-first meridian boundary line. A general magnetic survey of Porto Rico, Hawaii, and the Philippine Islands has been completed and some observations have been made in Guam and on the Canal Zone.

In the United States proper there still remain many locally disturbed areas which require investigation, the extent to which the investigation should be carried in any particular case being a question which can not be determined in advance. There are other regions where more stations will be required as they become settled. In addition, in order that the accumulated results may continue to be of use, observations at repeat stations must be kept up regularly.

Most of the leading nations of the world are cooperating in a study of the earth's magnetism, in an effort to determine its origin, the cause of its many fluctuations, and the laws which govern them. Some of these fluctuations require a long term of years for their full development. In order that accurate data may be available for these investigations, therefore, many magnetic observatories must be kept in continuous operation, recording every change in the direction and intensity of the earth's magnetic field. As the changes are found to be different in different parts of the earth, it is important to have the observatories as widely distributed as possible. The United States, by reason of its wide extent of territory, is very favorably situated for carrying on a large share of this work, and the sites of the five magnetic observatories now in operation were chosen with this object in view. With the addition of observatories in the Canal Zone and on the island of Guam we should have a chain of stations extending nearly half way around the globe from longitude 65° to 216° west, and extending from latitude 9° to 57° north. These would be supplemented by the observatory near Manila, P. I., now being maintained by the Jesuits.

Part III.—WAR WORK OF THE BUREAU.

SUMMARY OF WAR WORK OF THE BUREAU.

This Bureau bore an important burden during the war, both in the field and in the office. All told, 272 men, drawn both from the field and the office, took part in the war. These were drawn from all ranks of our employees, ranging from the Superintendent of the Bureau to temporary hands employed by the field parties of the Bureau. In our report for 1918 we gave a list of those from this Bureau in the War Department and in the Navy Department with their ranks, but as some of them had attained higher ranks by the close of the war, it seems proper to again repeat the list giving the now correct ranks. In my report for 1918 I gave the names only of those who were commissioned either in the Army or the Navy. For the purpose of making a permanent record, I shall herein include in alphabetical order, showing their rank so far as we have the information, all of the men who served in either branch of the military service, from this Bureau. The list follows:

Adams, Kenneth T., Lieut. (j. g.), Navy.
Akerstrom, O. R., Seaman, Navy.
Alber, Amado, Seaman, Navy.
Albang, B., Seaman, Navy.
Anderson, G. E., Seaman, Navy.
Angelo, John A., Pvt., Army.
Aven, W. R., jr., Pvt., Army.
Bacchus, A. W., Seaman, Navy.
Bales, A. W., Pvt., Army.
Bargmann, F. H., Seaman, Navy.
Barker, Stanley T., Lieut., Navy.
Bartlett, Harrison R., Lieut., Navy.
Bean, George L., Lieut. (j. g.), Navy.
Belcher, J. R., Pvt., Army.
Bennett, R. K., Second Lieut., Army.
Bilby, W. J., Pvt., Marines.
Blas, Pabon, Seaman, Navy.
Bolles, C. M., Pvt., Army.
Borden, F. S., First Lieut., Army.
Bowie, Wm., Maj., Army.
Bowman, A. L., Pvt., Army.
Braden, Mart, Pvt., Army.
Brittingham, C. B., Seaman, Navy.
Brookbank, J. S., Pvt., Army.
Brown, Dave, Pvt., Army.
Brown, G. S., Seaman, Navy.
Brown, R. M., Pvt., Army.
Buckley, R. J., Pvt., Army.
Bullock, J. H., Pvt., Army.
Bush, Harold, Pvt., Army.
Bussell, Conrad T., Lieut., Navy.
Bussey, W. R., Pvt., Army.
Caldwell, W. B., Seaman, Navy.
Callis, D. S., Seaman, Navy.
Campbell, Andrew, Pvt., Army.
Carey, William P., Seaman, Navy.
Caron, W. H. J., Seaman, Navy.
Carothers, Pvt., Army.
Casbeer, George, Pvt., Army.
Cassedy, Miller A., Pvt., Army.
Castles, P. B., First Lieut., Army.
Church, E. F., First Lieut., Army.
Churchill, J. B., Seaman, Navy.
Clark, W. H., First Lieut., Army.
Cooper, Guy H., Pvt., Army.
Colbert, L. O., Lieut. Comdr., Navy.
Coleman, M. M., Pvt., Army.
Conoly, Luther H., Pvt., Army.
Conover, C. N., Lieut., Navy.
Cook, Thomas, Seaman, Navy.
Cotton, H. A., Lieut. (j. g.), Navy.
Cowie, G. D., First Lieut., Army.
Cox, John W., Second Lieut., Army.
Crawford, J. H., Pvt., Army.
Cunningham, F. B., Pvt., Army.
Curtice, Sanger, Seaman, Navy.
Dailey, I. M., First Lieut., Army.
Daniels, Alonzo, Seaman, Navy.
Dann, B. G., Pvt., Army.
Deck, W. H., Sergt., Army.
Deggeller, Martin N., Pvt., Army.
Deritis, A., Seaman, Navy.
Disney, Lindsay P., Pvt., Army.
Dolan, D. J., Seaman, Navy.
Dreifus, A., Seaman, Navy.
Durgin, George H., Lieut. (j. g.), Navy.
Dwyer, J. F., Pvt., Army.
Eickelberg, E. W., Capt., Army.
Ela, Arthur J., Lieut., Navy.
Ellenbogen, L. K., Pvt., Army.

Ellis, Edmund K., Capt., Army.
Ellis, E. P., Pvt., Army.
Engle, F. G., Lieut., Navy.
Farrow, J. B., Seaman, Navy.
Ferguson, A. G., Seaman, Navy.
Fleetwood, J. R., Seaman, Navy.
Floyd, Morey, Seaman, Navy.
Foxhall, Edward, Seaman, Navy.
Freeman, Bert C., First Lieut., Army.
Galos, Benjamin, Ensign, Navy.
Gannon, H. F., Seaman, Navy.
Gatje, E. A., Pvt., Army.
Giacomini, Alfred L., Lieut., Navy.
Gidayawan, Aurilio, Seaman, Navy.
Gilden, G., Seaman, Navy.
Godsey, J. E., Pvt., Army.
Graham, Lyman D., Lieut., Navy.
Gramm, S. G., Pvt., Army.
Green, Charles K., Lieut. (j. g.), Navy.
Greenfield, Murray G., Sergt., Army.
Groshong, F. R., Seaman, Navy.
Grummann, Herbert R., First Lieut., Army.
Hall, F., Seaman, Navy.
Hallberg, Arthur S., Lieut., Army.
Hardy, Francis H., Lieut. Commander, Navy.
Harris, J. J., Seaman, Navy.
Harrison, Henry, Seaman, Navy.
Harsh, Dwight B., Pvt., Army.
Hart, Oscar, Seaman, Navy.
Hartley, George R., First Lieut., Army.
Haydon, Rufus, Pvt., Army.
Hayes, Chester, Pvt., Army.
Heck, N. H., Lieut. Commander, Navy.
Hicks, Russell J., Pvt., Army.
Hinkley, Wilmer O., Ensign, Navy.
Hodgson, C. V., Maj., Army.
Hole, Robert J., First Lieut., Army.
Hollander, F., Seaman, Navy.
Horne, R. D., First Lieut., Army.
Howes, Leonard G., Seaman, Navy.
Hughes, James, Seaman, Navy.
Hunter, C. M., Pvt., Army.
Huse, Emery, Pvt., Army.
Hutchinson, R. F., Pvt., Army.
Jacobsen, William F., Pvt., Army.
Joachims, Arthur, Lieut. Commander, Navy.
Joekel, F. E., First Lieut., Army.
Joers, Rudolph, Lieut., Navy.
Johanson, W., Seaman, Navy.
Johnson, Berkeley, Pvt., Army.
Johnson, B. L., Seaman, Navy.
Johnston, W. R., Pvt., Army.
Jones, E. Lester, Col., Army.
Kates, P., Seaman, Navy.
Kelsh, Harry T., First Lieut., Army.
Kerns, J. L., Seaman, Navy.
Keyse, William S. P., Lieut. Commander, Navy.
Kight, J. F., Seaman, Navy.
Kilgore, Addison, Seaman, Navy.
King, J. L., Seaman, Navy.
Kirby, Harold L., Pvt., Army.
Kremkau, Omer G., Pvt., Army.
Lambert, Frank, Pvt., Army.
Lambert, Walter D., First Lieut., Army.
Landing, T. R., Seaman, Navy.
Lane, Paul V., Lieut., Navy.
Lea, Wilbur R., Pvt., Army.
Lee, Alfred M., Seaman, Navy.
Lee, Harvey, Pvt., Army.
Levy, M. E., Lieut. (j. g.), Navy.
Lewis, W. P., Seaman, Navy.
Littlefield, R. C., Pvt., Army.
Loken, A., Seaman, Navy.
Laubat, Frank J. C., Pvt., Army.
Luce, G., Lieut., Navy.
Luce, Robert F., Lieut. Commander, Navy.
Lukens, Richard R., Lieut. Commander, Navy.
McComb, H. E., Lieut. (j. g.), Navy.
McFarland, W. M., Second Lieut., Army.
McGuire, J. W., Capt., Army.
MacKenzie, W. J., Second Lieut., Army.
McMillin, Clarence E., Seaman, Navy.
McMinn, Robert, Pvt., Army.
Maher, Thomas J., Lieut., Navy.
Manget, H. F., Pvt., Army.
Marchand, G. E., Lieut., Navy.
Marsh, J. E., Lieut., Navy.
Martin, R. B., Pvt., Army.
Mattison, George C., Lieut. (j. g.), Navy.
Midgett, L. L., Seaman, Navy.
Midgett, Orlando, Pvt., Army.
Miller, Raymond V., Lieut. (j. g.), Navy.
Mills, Gilbert E., Pvt., Army.
Montrolo, Arcadio, Seaman, Navy.
Moore, C. E., Pvt., Army.
Morris, T. J., jr., Seaman, Navy.
Mourhess, C. A., Lieut., Army.
Mower, L. M., Second Lieut., Army.
Murray, Charles R., Pvt., Army.
Myers, Benjamin, Pvt., Army.
Nelson, K. E., Lieut., Navy.
Noblencn, Louis, Pvt., Army.
Nyland, Fritz C., Ensign, Navy.
O'Conner, T., Seaman, Navy.
Oles, Floyd, Pvt., Army.
Oscarson, P. K., Seaman, Navy.
Overton, R. C., Ensign, Navy.
Paddison, O. H., Lieut. (j. g.), Navy.
Pagenhart, Edwin H., Capt., Army.
Parker, Ernest, Pvt., Army.
Parker, H. F., Seaman, Navy.
Parker, W. E., Lieut. Commander, Navy.
Pascoal, Doreteo, Seaman, Navy.
Patton, R. S., Lieut. Commander, Navy.
Peacock, F. L., Lieut., Navy.
Pease, H. W., Second Lieut., Army.
Perrin, P. A., First Lieut., Army.
Peters, John H., Lieut. Commander, Navy.
Petterson, J., Seaman, Navy.

Pierson, C. C., Seaman, Navy.
Pigford, D. V., Pvt., Army.
Pigford, Robert, Pvt., Army.
Pinner, R., Seaman, Navy.
Pittmann, C. W., Pvt., Army.
Powell, J. D., Capt., Army.
Powell, W., Seaman, Navy.
Prenzlau, T., Seaman, Navy.
Quillian, C. G., Lieut. Commander, Navy.
Ramos, Andres, Seaman, Navy.
Ramos, Apolonio, Seaman, Navy.
Rappleye, Howard S., Lieut., Army.
Raynor, Leroy P., Lieut., Navy.
Ready, C. T., Seaman, Navy.
Reese, E. E., First Lieut., Army.
Robinson, C. B., Seaman, Navy.
Romberg, B. A., Seaman, Navy.
Rozier, B. B., Pvt., Army.
Rude, Gilbert T., Lieut. Commander, Navy.
Ruest, J., Seaman, Navy.
Ruffner, Walter S., Pvt., Army.
Ruiz, Frank S., Pvt., Army.
Rycraw, George H., Pvt., Army.
Sandoe, Nichol M., Seaman, Navy.
Schoppe, R. L., Lieut., Navy.
Seran, H. A., Lieut. Commander, Navy.
Severns, E. V., Pvt., Army.
Sewell, Leo A., Pvt., Army.
Shalowitz, A. L., Second Lieut., Army.
Shell, W. R., Pvt., Army.
Shoemaker, H. C., Seaman, Navy.
Sigales, G., Seaman, Navy.
Singleton, Cleve, Seaman, Navy.
Skare, Charles E., Pvt., Army.
Skau, Rolf, Pvt., Army.
Smith, Dean O., Pvt., Army.
Smith, E. L., Seaman, Navy.
Smith, J., Pvt., Army.
Smith, Sherman, Pvt., Army.
Smith, S. P., Seaman, Navy.
Smith, W. M., jr., Seaman, Navy.
Spills, John H., Pvt., Army.
Springle, D. D., Seaman, Navy.
Spry, H. S., Seaman, Navy.
Staeblain, T., Seaman, Navy.
States, Earl C., Pvt., Army.
Stewart, George, Pvt., Army.
Strough, R. P., Lieut. Commander, Navy.
Taylor, Dan W., Seaman, Navy.
Thompson, George, Pvt., Army.
Thompson, M., Seaman, Navy.
Thurtell, C. S., Pvt., Army.
Tolson, J. Q., Seaman, Navy.
Torres, Anastacio, Seaman, Navy.
Toulson, J. M., Seaman, Navy.
Trueblood, Paul M., Lieut., Navy.
Ulrich, L. C., Pvt., Army.
Vandewynckele, Paul, Pvt., Army.
Vess, L. J., Seaman, Navy.
Waff, F. E., Seaman, Navy.
Walker, Eustace S., Lieut., Navy.
Watkins, John T., Lieut. Commander, Navy.
Weidlich, W., Lieut. (j. g.), Navy.
Welfore, Leon, Seaman, Navy.
Wells, John M., Seaman, Navy.
Wheeler, Raymond A., First Lieut., Army.
Whidbee, N., Seaman, Navy.
White, Albert, Seaman, Navy.
Whitney, Paul C., Lieut. Commander, Navy.
Wilder, Leo C., Lieut., Navy.
Wilkey, J. M., Seaman, Navy.
Williams, Preston S., Pvt., Army.
Witherbee, Max O., Second Lieut., Army.
Witherspoon, Andrew C., First Lieut., Army.
Woolbert, A., Seaman, Navy.
Wrenn, C. A., Pvt., Army.
Young, C. H., Pvt., Army.
Youngblood, Adam, Pvt., Army.
Zeitlin, R. M., Seaman, Navy.

This Bureau also contributed five of its survey vessels to the fleets operated by the Navy. One of our vessels, the *Surveyor*, was employed on convoy duty to and from Mediterranean ports. While on one of these trips, a convoy was attacked by two German submarines, one of which was the famous *U-39* which sunk the *Lusitania*. The *U-39* fired a torpedo at the fleet which grazed the bow of the *Surveyor* and was visible from the deck of that vessel. The wake of the submarine was picked up by the *Surveyor* and she was able to get in a position for favorable discharge of the depth charge. As the *Surveyor* was unable to leave the convoy, she was unable to return and finish the submarine, but did succeed in disabling her to the extent that the submarine was compelled to enter Cartagena, Spain, and intern there. Another of our vessels, the *Isis*, was on duty at New Yrok as flagship of commandant, squadron 2, cruiser force, from November 16, 1917, to October 14, 1918, and was on duty at Yorktown and Hampton Roads as flagship of division 4, battleship force 1, from October 15, 1918, to April 1, 1919. A third one of

our vessels, the *Bache*, was assigned to squadron 5 of fifth naval district, and performed general salvage work, outside patrol, and guard-ship duties off Virginia Capes. Her primary duty was identification and passing of all inbound and outbound vessels. She was the means of communication between naval authorities and these vessels. She handled mail and gave medical assistance to passing vessels, and performed important salvage operations. Two other vessels of the Bureau were in the naval service on the Pacific coast. They were the *Explorer* and the *Patterson* (renamed the *Forward*). These vessels were assigned to patrol duty in Alaskan waters.

Besides this direct assistance to the military branches of the Government by the contribution of men and vessels, this Bureau rendered valuable aid to both these branches through the efforts of its field and office force. In the field, this assistance consisted in furnishing certain control for maps in critical areas selected by the chiefs of military mapping of the Corps of Engineers of the Army. These areas were in Texas, Georgia, Florida, South Carolina, North Carolina, and Virginia. The work was chiefly triangulation, traverse, and leveling. Special hydrographic examinations were made by means of the wire drag at points designated by the Navy Department. Among such were the wire-drag surveys in Long Island Sound and in York River (Chesapeake Bay). Quite an extensive wire-drag examination was made of the waters in the vicinity of Eastport, Me. Initial surveys included such work as the location of points for naval fire-control experiments, the reestablishment of the speed-trial course at Lewes, Del., for torpedo-boat destroyers, the location of the Port Jefferson trial course in Long Island Sound, and the Block Island (Rhode Island) trial course.

Some divisions of the office were engaged almost exclusively on work that would be of use to the Army and Navy during the war. This work consisted of the computation of precise traverse, and of several grades of triangulation and of precise leveling executed within areas selected by the division of military mapping of the Corps of Engineers of the Army. Magnetic data were supplied to various Army and Navy organizations, and to persons engaged on investigation of the submarine problem. Another important accomplishment in connection with the war was the furnishing of our nautical publications, consisting of charts, coast pilots, tide tables, for the use of our naval vessels, our Merchant Marine, and the vessels under the control of the Army, and the Railroad Administration.

This service has 103 years of active history which show that it has never failed in loyalty, no matter what the call. Its members have always given the benefit of their trained thought and well-informed judgment whenever and wherever they were needed and however they could best be used.

In the great conflict just ended these traditions have been upheld.

Admiration is due the spirit that has animated each and every member of the United States Coast and Geodetic Survey. To a man there was an instant and eager response to the country's call for help. At all times, a service which is laboring for the safety of mankind, it

stood ready to undertake new work. The kind of work needed was varied—all could not go into battle. The men in the field would have been useless without the executive work behind them at home, and all honor is due them, who, showing a steady, uncompromising moral courage, unmoved by clamor and undisturbed by outer excitement, have kept steadily at their posts, carrying on most successfully the important and necessary work here.

Those who were sent to the field were simply performing their duty in another way, and established an enviable and remarkable record, showing again their unusual adaptability and training.

The Bureau was about equally represented in both Army and Navy and performed signal valuable service in each.

Part IV.—STATEMENT FOR THE PAST YEAR OF ACCOMPLISHED FIELD AND OFFICE WORK, ACCOMPANIED BY ILLUSTRATIONS, AS REQUIRED BY STATUTE, SHOWING THE PROGRESS MADE, ETC.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The division of hydrography and topography has supervision of all hydrographic and topographic surveys executed by this Bureau, which supervision includes the determination of where surveys or resurveys are required, how they shall be conducted, the preparation of instructions for surveying parties, the organization of the parties, and the inspection of the field work, and examination of the records. It is also charged with the construction, maintenance, and repairs of the vessels and other field equipment, except instruments, the records of the personnel employed on this work, the compilation of the coast pilot in the field and office, the observation of tides and currents, and compilation of tide tables.

For administrative purposes, the division is divided into four sections, known as the section of field work, section of vessels and equipment, section of coast pilot, and section of tides and currents. Each of these sections is under the direction of a hydrographic and geodetic engineer, who is responsible for the efficient and economical administration of his section under the general supervision of the chief of the division of hydrography and topography.

The division also has supervision over the five field stations located at Boston, New York, New Orleans, Seattle, and San Francisco, respectively, and over the office at Manila, P. I. The field stations are for the purpose of maintaining close relations between the Bureau and those who have occasion to use its charts, publications, and data, and to keep the Bureau informed of the needs for further work in these general localities. They are in charge of hydrographic and geodetic engineers, but undertake no surveys unless specifically directed to do so by this office. The Manila office performs all of the functions of a field station, and in addition, has direct charge of all surveys in the Philippine Islands and much of the office work incident to these surveys. This office is in charge of a hydrographic and geodetic engineer, with the title of Director of Coast Surveys.

This report gives a general statement of the work performed during the year under the direction of the division by the various field parties, the field stations, the Manila office, and finally, a resumé of the work of the four sections. Detailed statements are given in the reports of the chief of sections attached hereto, and by the chief of parties already submitted.

MILITARY WORK.

A very large part of the topographic, hydrographic, and wire-drag work of the Bureau done during the fiscal year, was at the request of the Navy Department to meet urgent military needs. The Bureau

and its field parties, including field stations, cooperated closely with the Navy and War Departments in the matter of supplying charts and other information, the execution of surveys for the establishment of camp sites, and manufacturing plants, and to bring charts up to date, and in the marking of obstructions to navigation. Frequent consultations and correspondence were carried on at Washington with the various bureaus of the War and Navy Departments relative to the work required, and in the field, the parties cooperated to the fullest extent with local military authorities.

The steamers *Bache*, *Explorer*, *Isis*, *Patterson* and *Surveyor*, turned over to the Navy during the previous fiscal year, continued operations as war vessels until the termination of hostilities, and were then returned to this Bureau under authority of Executive order of February 26, 1919.

The same Executive order returned to duty in this Bureau all those officers who had been detailed during the war for duty with the War and Navy Departments. Some of these officers went into the Navy with the vessels on which they were serving at the time of the vessel transfer, but many of them went directly to the Navy and Army from the Washington office, the field stations, and from various field parties. The return of these officers, as well as the vessels, although designated for not later than April 1, 1919, was in many cases delayed by unavoidable conditions until near the end of the fiscal year.

NEW VESSELS AND LAUNCHES.

The Bureau has received by transfer from the Navy Department, five vessels of various sizes ranging from 100 tons to 400 tons displacement, and has the promise of two other vessels of 500 tons and 600 tons displacement, respectively, to be transferred early in the next fiscal year. The vessels received to date are the steamers *Arcturus*, *Onward*, *Ranger*, and *Wenonah*, and the motor vessel *Natoma*. The steamers *Lydonia*, and *Sialia* are to be transferred later on. All these are former yachts that were acquired by the Navy, fitted and used as patrol boats, and in the suppression of enemy submarines. On the termination of hostilities, they were no longer required by the Navy, and were, therefore, turned over to this Bureau for use as survey craft until more suitable vessels could be had.

The Navy also transferred to this Bureau eight miscellaneous motor boats, six of them of the cabin-cruiser pleasure-boat type, and two of them of the work-boat type. These launches will be used for wire-drag operations, and for chart revision, and will help to eliminate the former necessity of hiring launches.

Contracts were made during the year for the construction of four 60-foot wire-drag guide launches, and for three 30-foot wire-drag launch tenders. All of the guide launches, and one of the tenders were completed and put into service before the close of the year. A fourth tender was purchased, and equipped with a new engine.

Bids were obtained by the U. S. Shipping Board, Emergency Fleet Corporation, for the construction of two 1,000-ton surveying vessels of the *Surveyor* type. No award has been made owing to the disinclination of the Emergency Fleet Corporation to authorize the construction without further authority.

FIELD WORK, ATLANTIC COAST.

Field stations.—Field stations of the Survey, each in charge of a field officer of the Bureau, were maintained at Boston, New York, and New Orleans, where there is kept a stock of charts, and also other publications of the Survey and of the Bureau of Lighthouses for consultation and for sale. The stations cooperate with the sales agents of the Bureau by furnishing them charts and other publications to meet immediate needs. The inspectors at these stations have for their principal duty the inspection of the navigable waters within their districts, for the purpose of keeping charts and other nautical publications of the Bureau corrected to date. The routine duties of the field station are handled by a clerk. The following special assignments were made to the inspectors at Boston, New York, and New Orleans during the year, in addition to the duties of the field stations:

The inspector at Boston continued the field examination of the coast between Gloucester and Boston, preparatory to undertaking the field work of making a chart revision of this locality for use on a large-scale chart of this area, which is urgently needed, especially of the important harbor of Lynn, Mass. Also, a field revision of the topography of this section was made. A field party under an inspector revised the triangulation and topography between Manchester and Boston. The inspector also cooperated with the commandant of the first naval district in the installation of apparatus for observing currents, and furnished instructions in the method of taking and recording observations.

The inspector at New York executed a supplementary triangulation at Sandy Hook, requested by the Navy Department in connection with the proving grounds for heavy ordnance; completed the computation of triangulation on the coast of New Jersey for the Army and Navy; cooperated with the Army Engineers in the determination of the position of three towers at Fort Tilden; and completed special tidal data for Brooklyn and other newspapers. Supervision was also exercised over the permanent tidal station maintained by the Bureau at Fort Hamilton, New York Harbor.

The inspector at New York cooperated with the commandant of the third naval district in the installation of apparatus for observing currents, and furnished instructions in the method of taking and recording observations. At the close of the fiscal year the inspector was engaged on a tidal current survey of New York Harbor.

The inspector of the Bureau at New Orleans cooperated in an advisory capacity with the board of advisory engineers of the Public Belt Railroad Commission appointed to report upon the physical and financial feasibility of a Mississippi River railroad crossing at, or in the vicinity of, New Orleans, together with terminal improvements collateral thereto. The inspector verified the topography in the vicinity of Pascagoula, Miss., in October, and in January, 1919, he was at Mobile, Ala., executing the necessary field work to furnish up-to-date information for charts, and installing apparatus for observing currents on Heald Bank Light Vessel. In February, he accompanied the superintendent of lighthouses on an inspection trip from Morgan City to New Orleans, proceeding by the outside route

to Grand Pass Timbalier, and thence by the inside route to New Orleans.

Vessels.—The steamer *Bache* was returned to the Coast and Geodetic Survey on June 20, 1919, after completion of repairs by the Navy Department. No field work was in progress at the close of the fiscal year, but the necessary tall hydrographic signals were in the course of erection, and arrangements had been completed for the placing of buoys, prior to beginning offshore hydrography off the entrance of Chesapeake Bay. On authorization by the Navy Department the *Bache* was furnished with one 24-foot coast guard motor launch, in place of the motor whaleboat formerly on this vessel, and two new coast guard whaleboats, which will give her a better boat equipment than she had prior to transfer to the Navy.

The steamer *Isis* was returned to the Coast and Geodetic Survey on April 30, 1919. After receipt of the vessel by this Bureau, several tubes gave way in both boilers, and it was necessary to take the vessel to a shipyard for renewal of the tubes. No field work was in progress at the close of the fiscal year, but the necessary tall hydrographic signals have been erected, and arrangements made for the placing of buoys, for beginning the offshore hydrography off the entrance of Delaware Bay.

The steamer *Hydrographer* was employed during the first half of the year on surveys of the lower part of Chesapeake Bay, embracing the main channel of the bay, and approaches to Hampton Roads, to meet the needs of the Navy Department. On completion of repairs early in January, the *Hydrographer* left Baltimore for Key West, where she is now working in cooperation with officers at the naval station. An improved type of sounding tube was tested with marked success in the deep waters of the Florida Straits.

The schooner *Matchless* was employed on a survey of York River and approaches, continuing along the west shore of Chesapeake Bay to the vicinity of Hampton, and as far westward as Newport News. The hydrography included the area of Hampton Roads, and the inshore area between the Tail of the Horseshoe Light, and York River. This vessel also completed surveys in the vicinity of Wormley Creek, at the request of the Navy Department. After an inspection by a board appointed for the purpose, the *Matchless* was surveyed, condemned, and appraised, in accordance with authority granted on April 16, 1919, by the Secretary of Commerce. The vessel was sold on June 26, 1919.

The steamer *Onward* was received from the Navy Department on April 19, 1919, after completion of the necessary repairs, and the crew and equipment of the schooner *Matchless* were transferred to that vessel. This vessel has been employed on a continuation of the field work assigned to the schooner *Matchless.*

The steamer *Ranger* was received from the Navy on April 28, 1919. After completion of the necessary repairs she will take up offshore hydrography in the vicinity of Pensacola, Fla. A party attached to the vessel was engaged on work preparatory to the hydrographic survey of Gravesend Bay, New York Harbor. The work of building tall hydrographic signals for the surveys westward of Pensacola, Fla., was in progress at the close of the year, prior to the arrival of the steamer *Ranger* on the working ground.

Parties.—Wire-drag party No. 1 was employed on surveys, requested by the Navy Department, off the easterly end of Long Island Sound, and the westerly end of Block Island Sound, including Fishers Island Sound. Strong currents retarded the progress of the work, and it was generally necessary to plan the work so as to drag in the direction of the current. At the request of the Navy Department, this party completed a wire-drag survey of an area in the approach to New London Harbor.

Wire-drag party No. 2 continued the survey of the principal channel from the sea to Eastport, and Passamaquoddy Bay, and the survey of Passamaquoddy Bay to meet the needs of the Navy Department. The party maintained temporary buoys on the dangerous rocks found by the survey in the principal entrance to Eastport and Passamaquoddy Bay, until arrangements were made with the Lighthouse Service to establish permanent buoys. The Geodetic Survey of Canada cooperated with this party in signal building and triangulation.

On completion of surveys in the vicinity of Eastport, Me., the party was employed on surveys along the outer coast in the vicinity of Jonesport, Me., the work being designed primarily to meet the needs of the Navy Department.

Wire-drag party No. 5 continued the survey of Block Island Sound. The work at Key West, originally assigned to this party, was discontinued in order to meet the immediate requirements elsewhere of the War and Navy Departments. At the request of the War Department, this party executed a resurvey of Southwest Ledge.

A field party was employed on a triangulation and topographic revision survey of the coast between Manchester and Boston, in conformity with instructions issued to the inspector at Boston. This work is preliminary to the preparation of a chart on an adequate scale to cover this locality, including the harbor of Lynn. This party completed the shore line from Manchester to Magnolia, and the Chelsea River from Revere to Chelsea, and a topographic revision of the outlying islands.

A field officer investigated the subject of coast surveying and revision by means of airplane photography in conjunction with aviators of the War and Navy Departments. This officer executed a trigonometric control for an Atlantic City, N. J., photographic survey, and at the close of the year was studying the photographs taken by Army and Navy fliers with reference to this control.

A field officer established a trial course 1 nautical mile in length in the vicinity of Anacostia, D. C., to meet the needs of the Navy Department, that Department furnishing the necessary launches and material. During the latter part of the fiscal year this officer was employed on a tide and current survey in the vicinity of Point Judith, Block Island Sound.

A field party was employed during the latter part of the year on a tide and current survey along the coast between Portsmouth, N. H., and Portland, Me.

A field party was employed on a hydrographic and topographic survey of the Turtle River, Ga., to the picric acid plant at Crispen Island to meet the needs of the construction division of the Army.

After examination by the chief of the division of hydrography and topography, it was found that a suitable revision of Charleston, S. C., and vicinity could be made within the limits of funds available for this work, and, in conformity with instructions, a field officer completed, with the assistance of the superintendent of lighthouses and other local authorities at Charleston, the requested triangulation. Local interests and Government officials showed a gratifying spirit of cooperation and interest in this work.

A field party executed a systematic hydrographic and topographic survey of Key Biscayne Bay, and channels from the sea, to meet the need of navigators and commercial interests at Miami, Fla.

An officer inspected the tide and current survey parties working off the coast of New England, and in Block Island Sound and vicinity, and tide station at Portland, Me. He also consulted with the inspector at New York relative to the tide and current survey party being organized for work in New York Harbor.

A field party has been employed on a triangulation and topographic survey of the Virgin Islands, requested by the Secretary of the Navy on August 28, 1917. This party is cooperating closely with the governor and other naval officials of the Islands, and good progress is being made in this work. The work on St. Thomas and St. John is completed, and the party is now employed on St. Croix. The governor of the Islands has requested that a wire-drag survey be made in that vicinity as early as practicable.

FIELD WORK, PACIFIC COAST.

Field stations.—Field stations of the Survey, each in charge of a field officer of the Bureau, were maintained at Seattle and San Francisco during the fiscal year, where there is a stock of charts and other publications of the Survey, and of the Bureau of Lighthouses for consultation and for sale. The stations cooperated with the sales agents of the Bureau by furnishing them charts and other publications to meet immediate needs.

The inspector has for his principal duty an inspection of the navigable waters within his district, for the purpose of keeping charts and other nautical publications of the Bureau corrected to date. The routine duties of the field station are handled by a clerk. The inspectors at the two Pacific coast field stations had charge of the arrangements for installing current-measuring apparatus on light vessels within their districts. Tidal and current observations have been in progress at the stations maintained by the field stations.

The Seattle field station has served as the headquarters for the field parties operating in Washington and Alaska, and has rendered valuable assistance to the field parties. The inspector had charge of the preparation of plans and specifications of the vessel to replace the steamer *Taku*, and issued specifications and plans, and opened bids for the construction of the vessel. A 1-mile speed-trial course was laid out by him on Lake Washington for immediate use of vessels under construction at that point. The inspector cooperated with the Navy Department at Puget Sound Naval Station, relative to the return of the steamers *Explorer* and *Forward* (*Patterson*), and three of the launches received from the Atlantic coast.

The inspector at San Francisco, assisted by local coast guard stations, was employed on a survey of Presidio Shoal on the northerly waterfront of San Francisco, made necessary by reports of very much shoaler water than charted.

Vessels.—The steamer *Sialia* is being repaired by the Navy prior to transfer to the Coast and Geodetic Survey.

The steamer *Wenonah* was received from the Navy on April 12, 1919, after completion of the necessary repairs, and proceeded to the Pacific coast via the Panama Canal. This party will, on arrival, take up offshore hydrography in the vicinity of Cape Mendocino, and the survey of Humboldt Bay when weather conditions prevent outside work.

The motor vessel *Natoma* was received from the Navy on April 9, 1919, after completion of the necessary repairs, and proceeded to the Pacific coast, via the Panama Canal. She will be used on the resurvey of San Francisco Bay.

The steamer *Arcturus* was received from the Navy on May 5, 1919, after completion of such repairs as the Navy was willing to make. At the close of the fiscal year, she was undergoing repairs that were necessary, due to the fact that repairs previously made were incomplete.

Vessels proceeding to the Pacific coast of the United States and to Alaska, with the exception of the *Natoma*, were directed to take soundings, and make oceanographic observations while en route, and the track to be followed by each vessel in the Atlantic Ocean, Caribbean Sea and Pacific Ocean was laid out in advance so that each would develop an unexplored track.

The steamer *Explorer* was returned to the Coast and Geodetic Survey on May 1, and the *Forward* (*Patterson*) was returned on May 24. These vessels have been condemned, and will be sold.

Parties.—A field party was employed on a systematic hydrographic and topographic revision survey of the Tacoma waterfront, to show the extensive improvements which have been made at that point.

A field officer has been employed in arranging for repairs to the launches received from the Navy, and shipped to the Pacific coast on Naval colliers to fit them for wire-drag and revision work on the Pacific coast. He is, also, preparing to begin wire-drag work in Lake Washington and Lake Union after July 1.

A field officer was employed on a revision survey of Los Angeles Harbor to bring our charts up to date.

A field party was employed on a hydrographic and topographic revision survey of Morro Bay, requested by local interests. After completion of the Morro Bay work, the party proceeded to Eureka, Calif., and took up the work of recovering and re-marking triangulation stations in that vicinity, and building the necessary signals for the offshore work which will be done by the vessels of the Bureau on their arrival from the Atlantic coast.

A field party completed a wire-drag survey of Lake Tahoe to meet the needs of the United States Reclamation Service. This survey was limited to the shores where numerous bowlders and uncharted rocks were found.

FIELD WORK, ALASKA.

Vessels.—A field party with the launch *Cosmos* completed a survey of the north end of Wrangell Strait in order to locate certain bowlders that have been reported in this important fairway. The improvised harbor sweep used on the *Cosmos* was carried away several times owing to the very strong currents, but lead-line development was checked by the sweep at critical points, enabling the party to complete the work in a satisfactory manner. This party also made a survey of Keete Inlet, Cordova Bay, Alaska.

The steamer *Surveyor* was returned by the Navy on April 1, 1919, after completion of the repairs necessary to place the vessel in condition for survey work, and proceeded to Alaska, via the Panama Canal. At the close of the fiscal year the vessel was at Seattle, repairing and outfitting for work on the south coast of the Alaska Peninsula.

Parties.—A field party completed a survey of Port Chatham, Kenai Peninsula, to enable the Chrome Mining Co. to ship their product. From local reports, and information received from the Bureau of Mines, it appeared that the chrome-iron deposits in this locality are important, and that their production was a necessity for certain war products. Surveys were also completed by this party in Seldovia to locate the uncharted rock which had been reported by local interests in the vicinity of the wharf. A survey was made of Halibut Cove, Kachimak Bay, to enable fishing interests to ship their product, and Knik Arm in the approaches to the railroad terminal at Anchorage, Alaska, was surveyed. This work was done at the urgent request of the Alaskan Engineering Commission.

An automatic tide gauge was established at Anchorage, to be operated by the Alaskan Engineering Commission, and tides were observed at that point.

FIELD WORK, PHILIPPINE ISLANDS.

The director of coast surveys, acting under the authority of the superintendent, makes plans for the work of the Survey in the Philippine Islands, issues detailed instructions to the field parties, and has charge of the field station at Manila.

The expenses of the work are met by the Coast and Geodetic Survey and Philippine Government, which also furnished three vessels for surveying purposes during the fiscal year. The steamer *Pathfinder* is furnished by the Coast and Geodetic Survey.

During the fiscal year, the *Pathfinder*, *Romblon*, and *Fathomer* were employed on surveys in the Philippine Islands. Work was done on the east coast of Palawan, and in the vicinity of Cuyo Islands in the northerly part of the Sulu Sea. While these vessels were undergoing repairs, launch parties were engaged on a survey of Laguna de Bay.

The steamer *Marinduque* is temporarily in the service of the insular government, but will be returned to the jurisdiction of the Coast and Geodetic Survey about July 1. The officers for this vessel left San Francisco for Manila on May 25, 1919.

The epidemic of influenza which occurred in the fall of 1918 seriously hampered the work of the Coast and Geodetic Survey. A num-

ber of officers, and many of the crews of the vessels were stricken with the disease, seven deaths having occurred on the steamer *Pathfinder* alone.

MISCELLANEOUS FIELD WORK.

The question of aerial surveying is under consideration, and it is believed useful service may be obtained in such localities as follows:

Florida reefs (for the purpose of locating coral heads).

Ten Thousand Islands, west coast of Florida between Cape Sable and Big Marco Pass. (These so-called Ten Thousand Islands are embraced within an enormous swamp where little or no solid land may be expected.)

Delta of the Mississippi. (Aerial photographs could be used to fill in the details of the interior of the delta.)

Suggestion has been made that the topographer should work with an airplane, and photograph the country as needed to put in the changes. Triangulation could then be done as necessary to put in the landmarks for charts and other control points that might be needed to make full use of the photographs. Photographs could be taken of bodies of shallow water in order to determine the direction of the slues or channels leading between the extending shoals, and thus verify and, if necessary, correct the charts. The above suggestions cover points where airplane hydrography can unquestionably assist in bringing our charts up to date.

At the invitation of the British Admiralty, the chief of the division of hydrography and topography, and the chief of the section of field records, attended an international hydrographic conference at London, England, during the latter part of June. In a letter from the charge d'affairs ad interim dated June 4, 1919, the object of the conference is stated as follows:

> To consider the advisability of all maritime nations adopting similar methods in the preparation, construction, and production of their charts, and all hydrographic publications; of rendering the results in the most convenient form to enable them to be readily used; of instituting a prompt system of mutual exchange of hydrographic information between all countries; and of providing for consultations and discussions to be carried out on hydrographic subjects generally by the hydrographic experts of the world.

SECTION OF FIELD WORK.

The principal duties of this section are the supervision of topographic and hydrographic surveys, and coordination and standardization of the work of the various field parties, with a view to having a complete and continuous survey of the coast. All data pertaining to the locality in which work is to be done are assembled, compared, and studied, and instructions prepared accordingly. Close touch is kept with the field work through reports and sketches from the field party.

Data were collected, and itemized memoranda prepared for 23 sets of instructions for field work. This embraced a careful study of existing surveys. Original field sheets covering areas where changes frequently occur, and where preliminary surveys only have been made, were reviewed in order to formulate plans for performing the necessary field work to bring the charts up to date. Com-

pleted field sheets were reviewed, as time permitted, preparatory to recommending them for the approval of the superintendent.

Owing to the unusual conditions that have prevailed, and the requirements of war work, and surveys that have been made a part of the National defense, the duties of the chief section have embraced many matters not heretofore performed. The chief of the section of vessels and equipment was transferred to the Navy Department for the period of the war, and during his absence the chief of this section acted as chief of the section of vessels and equipment. The principal items of work were in connection with the construction of the 60-foot wire-drag launches, and 30-foot tenders, proposals for the steamer to replace the *Taku*, and revision of specifications for the new 1,000-ton steel surveying vessel.

SECTION OF VESSELS AND EQUIPMENT.

This section is charged with the preparation of plans and specifications for new vessels and equipment, the care, maintenance and repair of existing vessels, and the records of seamen personnel. This latter includes the examination of nearly all reports and returns, except pay accounts and reports of survey work, required to be submitted by parties afloat. The section also examines and passes for approval of the chief of division and the superintendent the estimates of field expenses submitted by all parties afloat and ashore, and all contracts for lease and charter.

A considerable part of the work of the section is inspection of vessels and equipment, and an effort is made to inspect thoroughly every vessel in the Survey, except those in the Philippine Islands, at least once annually, and the vessels on this coast at least twice annually. Supervision of the Philippine vessels is maintained by means of reports from the director of coast surveys.

Until April 1, this section was under the direction of the chief of field work during the absence on Naval duty of the chief of section.

COAST-PILOT SECTION.

During November, 1918, the manuscript of the Philippine Coast Pilot, Part 1, was read and sent to the printers. To the end of the fiscal year, the work of the section included the reading of the page proofs of the Philippine Coast Pilot.

Reprints were obtained during the year of Atlantic Coast Pilots, Sections D and E. Supplements for three volumes, and correction sheets for Sections C, D, E, California, Oregon, and Washington, and Alaska, Part 1, were issued.

The record of the issue of coast pilots in recent years is interesting as indicating the usefulness of these publications. As these volumes are sold at a price sufficient to defray the cost of printing (50 cents), it is obvious that the number sold furnishes an accurate measure of the public demand. The following is the record of the issue for the fiscal years from 1912 to date:

1912	3,792	1916	5,602
1913	3,797	1917	7,952
1914	4,148	1918	12,913
1915	4,016	1919	13,315

SECTION OF TIDES AND CURRENTS.

Tidal observations were made throughout the year at seven permanent tidal stations along the Atlantic coast, two on the Gulf of Mexico, and three on the Pacific coast. In addition to these, observations were made in connection with hydrographic surveys in the United States, Alaska, and the Philippines. Tides were observed at 58 stations during the year, the total combined length of observations being 41 years, 6 months, 16 days.

During the year all permanent tidal stations have been inspected at least once, the inspection in all cases including the connection of the tide staff of the station with the permanent bench marks by spirit levels.

The work of making comprehensive tide and current surveys of our coasts, which was begun in the summer of 1916, was continued during the fiscal year 1919, and parties were employed on the coast between Portsmouth, N. H., and Portland, Me., and off the entrance to Narragansett Bay.

The purpose of the tidal party is to obtain tidal information at important points along the coast, and the establishment of permanent tidal bench marks at all principal points along the coast, which will serve the public in all cases where a knowledge of tidal planes is required to furnish hydrographic parties with standard data, and afford starting and checking points for lines of precise levels.

The tidal survey is carried on by means of two automatic tide gauges, and several subsidiary staffs; current measurements are made by means of current meters, the velocity being obtained at various depths at each station, and, also, by means of a vertical pole float.

The purpose of the current survey is to obtain definite information concerning currents in navigable channels, entrances to bays, rivers, passages, and at points along the coast, for the benefit of navigators.

Current observations were made at 57 stations (other than light vessels), the total combined length of observations being 5 months 18 days.

The manuscript for the tide tables for 1920 was prepared and submitted for printing in three separate parts, namely, the Atlantic Coast Tide Tables, which are already issued; the Pacific Coast Tide Tables, the proof of which has been read; and that part of the General Tide Tables which is not included in either of the two reprints, proof of which has not yet been received. These tables are similar to those for the past two or three years.

The following table of issues shows the increased demand for these tide tables in recent years:

Fiscal year.	General Tide Tables.	Atlantic Coast Tide Tables.	Pacific Coast Tide Tables.	Total.
1915	1,665	1,994	10,481	14,140
1916	1,166	2,367	10,034	13,567
1917	1,548	3,526	12,704	17,778
1918	2,818	3,496	13,635	19,949
1919	4,176	4,043	14,644	22,863

DIVISION OF GEODESY.

FIELD WORK.

The geodetic work of the Coast and Geodetic Survey, almost from the day that the United States entered the war until the armistice was signed, may well be called war work. All the resources of the division of geodesy were placed at the disposal of the division of military mapping of the Corps of Engineers of the Army immediately after the United States entered the war.

The assistance of the division of geodesy was accepted by the engineers, and plans were made to furnish certain control for maps in critical areas selected by the chief of the division of military mapping. These areas were in Texas, Georgia, Florida, South Carolina, North Carolina, and Virginia.

Shortly after November 11, 1918, the division of military mapping of the Office of the Chief of Engineers lessened its support to the division of geodesy, and by the end of the fiscal year 1919 the assistance from the Army consisted of only a small fund from whi h to pay several computers making special computations of value to the division of military mapping.

NEED FOR GEODETIC CONTROL.

It is difficult to overestimate the ne essity of having a proper amount of horizontal and vertical control in this country for the use of map makers and other engineers. There is not the demand for our geodetic control that there should be, and this is almost entirely due to the fact that the work of the Survey has not, in years past, been brought to the attention of those who could use the results. It has been the policy of the superintendent, for the last four years, to get the work of the Survey before the public in order that the surveyors, engineers, and others might know what is being accomplished by the Bureau. This plan will be continued, and, in addition, literature will be distributed to the public which will show how the results of the Survey's work might be best utilized.

This relates particularly to the matter of the geographic positions of triangulation stations. These are of great value to the private surveyor and engineer, and it is planned to have a pamphlet prepared which will show them to what extent they may utilize the latitudes, longitudes, and azimuths of the triangulation and traverse work. It is noteworthy that the engineering colleges are emphasizing the need of control for surveys, and this will have a marked effect in increasing the demands on the Bureau for geodetic work.

NEED FOR MAPS.

The Army has been using maps as never before in its work, both in this country and abroad, and the Coast and Geodetic Survey can look forward to a greater utilization of its products as a result of the numbers of men who were in the Army going back to civil life, and demanding good maps.

Aside from the value of these results in mapping for military purposes, there are many other needs for accurate control, and accurate

maps. The principal use of these is probable for the Federal, State, city, and highway engineers. Hundreds of millions of dollars will be spent each year in the United States in building new roads, and in maintaining and improving old ones. It is reasonably certain that this road work could be done at a considerable saving, if the country through which the road work is carried on were properly mapped. The total coast of mapping the country topographically will be not more than about $100,000,000, and this is the amount which will be spent on roads every three months for, probably, 10 years. It would certainly be good policy to have the maps precede the building of roads, rather than to have them follow such operations.

The railroad engineers are, also, particularly interested in good maps, and it is reasonably certain that, with the development of our railroads in the future, to meet the needs of industry and commerce, good topographic maps would be of great value in enabling the work to be accomplished in an efficient manner.

AIRPLANE SURVEYING.

There has been much talk, in recent months, in regard to surveying the country from airplanes. This is a subject in which the Coast and Geodetic Survey is much interested, because it seems probable that the airplane can be used to a great extent in revising the topography along the shores of the country, and in some parts of the interior, and also in making original surveys. The Coast and Geodetic Survey is not directly interested in airplane surveying of the interior of the country, but the Survey will certainly be expected to have control extended over the interior of the country, that airplane maps can be properly made, and located at many places.

EXTENSION OF GEODETIC CONTROL.

It has been the plan of the Coast and Geodetic Survey for some years to extend its geodetic work so as to have control available for all Government, State, city, and private engineers and surveyors. There are many cities to-day whose maps will be placed on the wrong datum, both for elevation and position, as a result of lack of primary triangulation and precise leveling in the interior of the country. Every city of any size, and every State of the Union should be furnished by the Federal Government with the fundamental control on which can be based the surveys and maps of detailed character in any particular locality.

There can be no question that triangulation and precise leveling bench marks should be placed within 50 miles of each place in the United States. With the Federal control carried to this extent, it would be a very simple matter in the future to have detailed control placed in many areas just ahead of the surveyors and engineers who are to make the surveys and maps. This main control should be extended as rapidly as equipment and personnel of the Survey will permit, and within say five or six years should be practically completed as far as the main part of the work is concerned. It is, of course, difficult to give exact figures as to how much leveling and triangulation will be needed to finish the minimum that is essential,

because plans must be changed from time to time to meet the needs of the topographic engineers; but it is reasonably certain that the primary triangulation and precise leveling which should be done within the next five years will cost about $1,000,000. With this distance of 50 miles as a criterion, it can be seen that lines of precise leveling, and arcs of primary triangulation should be approximately 100 miles apart. When it is considered that this distance is equal to that between Philadelphia and Baltimore, or Philadelphia and New York, it is realized that this is not an excessive amount of control. This estimate of fundamental control is made with a view to covering all of the country with a fair distribution of the control, and later to filling in the intermediate areas as the demands of surveyors and engineers arise.

Nothing is more conducive to proper commercial and industrial development of the country than good maps, and money spent in making them should be considered by the Nation as an investment rather than as a running expense.

This country adopted a broad plan, based on sound scientific and engineering principles, in the manner of controlling its maps. The only thing lacking is support in the way of money, and personnel to put the plan into operation.

ADOPTION OF STANDARD GEODETIC CONTROL.

The plan is to have all public surveys and maps based on some one initial point. The decision to have the single system of coordinates for the United States was adopted by the Survey about 20 years ago, and it is looked upon as a matter to be imitated by the geodetic surveys and map makers of other countries. The system seems to have worked out so well that the same initial point, used in the United States for its surveys and maps, has been adopted by the Governments of Mexico and of Canada. We shall, therefore, see the whole North American Continent placed on a single datum. This is far ahead of the condition of affairs in any other part of the world. But while the general plan adopted has been of such splendid character, there are few countries in the world that claim to be highly developed, that have less control per square mile than the United States. In this matter, the United States is really far behind all of the European countries, except, possibly, Russia and the Balkan States. Japan, for instance, is entirely covered by triangulation of a very high standard of accuracy, and the leveling is very much more extensive in proportion to the area than in the United States.

With a good plan adopted as far as control is concerned, it is most earnestly hoped that Congress will come to the relief of the Survey, and make it possible to have the minimum amount of control that seems justified, done within the next few years.

It has been found that other organizations of the Government have needed control much ahead of the ability of the Coast and Geodetic Survey to supply it. It is not considered a good plan to allow this control work to drag. It would really be better if all survey funds used in the interior of the country were concentrated for at least a year on geodetic work, in order that control might be furnished. This money would bear good results in the way of making

it possible to have surveys and maps made in a more efficient manner than is now possible.

CONTROL ALONG THE COASTS.

The Corps of Engineers, United States Army, has, as one of its functions, the preparation of special military maps for the defense of the country and for other purposes. Most of the maps made for that organization will be close to the shores of the country. The control that will be used on those maps will be largely the tertiary triangulation along the coast done by the United States Coast and Geodetic Survey. That triangulation is, in some cases, in bad condition due to the loss of station marks from the erosion of the shores, and the works of man. It is therefore desirable that parties be sent along all of the coasts of the United States to make an inspection of the triangulation data. It is believed that at least once in 10 years the triangulation should be visited and supplemented. During such an inspection the position of any permanent object that can be used in surveying work by the navigator should be determined.

GRAVITY WORK.

During the past two fiscal years no gravity work was done by the Coast and Geodetic Survey. The pendulums are considered to-day to be of some importance in connection with the possible location of oil-bearing rocks. In cooperation with the United States Geological Survey, it was planned, just before the war, to make certain gravity campaigns in Texas, Oklahoma, and parts of Kansas, with a view to testing whether or not the pendulum could be used in detecting oil-bearing rocks. It is hoped that this investigation will be resumed in the very near future, and for this purpose two sets of nickel-steel or invar pendulums are now being made in the instrument section of this office. With these pendulums it will be possible to observe the intensity of the gravity at any place. At present it is necessary, on account of the high coefficient of expansion of the old pendulums, to locate the gravity station in a room of constant temperature. This is usually the basement of some public or private building. On account of the necessity of having to swing the pendulum in a constant-temperature room it has been found that the points at which gravity can be observed, using the old pendulums, are very limited in number. It is intended to resume the gravity observations soon after the beginning of the fiscal year 1920.

WAR RECORD.

The war record of the division of geodesy is a most excellent one. Those of its members who did not actually enter the military service of the Government were engaged continuously on work called for by the Army and Navy.

At the end of the war all except two of the permanent employees of the Coast and Geodetic Survey, engaged either in the field or the office work of the division of geodesy, returned to the Survey.

Men of the type engaged in the field force of this Survey, and the computing and drafting forces of the office, form a suitable body of

men from whom the Army and Navy can draw officers for technical work in time of war. It is, therefore, expedient that these forces be kept up to a high standard of efficiency, both as to the number and the quality of the men, in order that they may be of the greatest value when called to military service.

FIELD WORK ACCOMPLISHED.

Below is given a list of the pieces of work which were done during the fiscal year 1919.

At the beginning of the fiscal year 1919, a precise traverse party was working in South Carolina, on a line which extends from Savannah, Ga., to Norfolk, Va.

A line of precise traverse was executed southward in North Carolina, to meet the above work in the vicinity of Sanford, N. C.

When the Savannah-Norfolk line was completed, at Sanford, an arc of primary triangulation was begun in northeastern North Carolina, to extend from the oblique arc to Sanford. A line of precise traverse was extended from Wilmington, N. C., to a junction with the triangulation near Sanford.

Owing to the fact that there are some inconsistencies in the precise traverse in Georgia, South Carolina, and North Carolina, which was done during the war in many cases by unskilled observers, it was found necessary to make an inspection of some of these lines. This work was done between July 1, 1918, and June 30, 1919.

After the completion of the work in the Southeastern States, requested by the division of military mapping, Office of the Chief of Engineers, work was begun in Texas on an arc of primary triangulation which extends eastward from Waco, Tex., to a junction with the Mississippi River. This work was also requested by the division of military mapping.

A reconnoissance was made from the vicinity of Waco, Tex., eastward to the vicinity of Mansfield, La., and at the end of the fiscal year 1919, the reconnoissance and the erection of the towers necessary to elevate the theodolite during the observations had been completed.

A party began observations for primary triangulation in the vicinity of Waco, Tex., and at the end of the fiscal year the work had been completed nearly to the vicinity of Mansfield, La.

A line of precise leveling was begun in the spring of 1919, in the vicinity of Hillsboro, Tex., which follows in a general direction the arc of primary triangulation that is being run eastward from Waco.

A precise leveling party was engaged on a line of levels along the Rio Grande from the vicinity of Harlingen westward to Eagle Pass, Tex. That leveling was done along the country roads close to the river, and the work was difficult on account of poor roads, and the crossing of numerous streams, swollen by excessive rainfall. The party was transported by two motor trucks belonging to the Survey.

Just before undertaking the leveling along the Rio Grande, a line of levels extending from Corpus Christi to New Orleans was completed.

In the spring of 1919, the chief engineer of the Forest Service made a request on the Coast and Geodetic Survey, that certain con-

trol work be done by this Bureau in some of the forest reservations in Utah, Arizona, Oregon, and California. After consultation with officials of this Survey, and of the Forest Service, it was decided that, on account of the lack of Coast and Geodetic Survey funds which could be utilized to carry on the control in question, the Forest Service would place at the disposal of the Coast and Geodetic Survey an amount sufficient to start the control surveys before July 1, 1919.

After plans had been perfected at this office a party was organized in Arizona, and made the necessary reconnoissance. At the end of the fiscal year, observing for triangulation was in progress.

An officer took the field in Utah early in May, and made the necessary reconnoissance for the location of control stations for the Forest Service, and, at the end of the fiscal year, was ready to begin observing.

Valuable assistance was received from the members of the Forest Service in the reservations within which the work was done, in preparing and marking stations whose positions were to be determined.

Late in the fiscal year instructions were issued for a line of precise levels to extend southward from Kirk, Oreg., to Roseville, Calif., in the vicinity of Sacramento. At the end of the fiscal year the party was being organized and equipped. A subparty was organized to operate under the general direction of the chief of party.

Late in the fiscal year precise leveling was begun along the line between Troy and Whitehall, N. Y. By the end of the fiscal year this line was completed, and leveling had been begun in the vicinity of Rouses Point, N. Y., working westward along the international boundary. The completion of the leveling between Troy and Whitehall finished a new line of levels from Rouses Point to Troy. This line was begun several years ago, but the work was interrupted by the war.

A field party was engaged on the upper Chesapeake Bay during nearly the entire fiscal year in making a triangulation for the use of the officers of the ordnance department, United States Army, for the purpose of locating towers from which observations are made to determine the range of guns. This work was done at the request of officers at the Aberdeen Proving Ground, Md. During the progress of the field work, the chief of party was assisted by details of men and the assignment of transportation from the Aberdeen Proving Ground.

In the spring and early summer of 1919, a triangulation was made in the lower Potomac River for the purpose of determining geographic positions of range towers on a torpedo trial course. When the work was completed, this Bureau was requested to extend the triangulation to include the determination of the geographic positions of a number of stations which would be of value to the ordnance department of the Navy in determining the range of its guns.

At the request of the office of the Supervising Architect of the Treasury, a survey was made of the grounds in the rear of the hygienic laboratory, October 19 to 22, 1918. The work consisted of taking elevations at 20-foot intervals.

In July, 1918, at the request of the officer in charge of the rifle range at Congress Heights, D. C., the eastern boundary line of the rifle range reservation was surveyed and marked.

During the first half of the fiscal year 1919, two officers were engaged on the determination of the differences of longitude in Georgia, South Carolina, North Carolina, Virginia, and the District of Columbia. This work was done in connection with the precise traverse for the purpose of furnishing corrections to observed astronomical azimuths resulting from deflections of the vertical.

Late in the spring of 1919, the same officers began the determination of certain differences of longitude along the Rio Grande arc of primary triangulation, and were engaged on that work at the end of the fiscal year.

The chief of the division of geodesy was in the Army, with rank of major of engineers, from August 17, 1918, to February 28, 1919. During that time he was assigned to the division of military mapping of the Office of the Chief of Engineers. While with the Army his principal work was devising a special grid system for use in progressive mapping of the United States, and specifications for the special defense maps which, it is expected, will be needed by the Army at critical points along the coasts of the country.

When the chief of the division of geodesy returned to the Survey from the Army, he resumed his usual duties at this office. In addition he did considerable work with an interdepartmental committee on aerial surveying and mapping, and, also, the American sections of the proposed International Astronomical Union, and the International Geophysical Union. He was selected acting chairman of the American section of the proposed Geophysical Union and, on June 30, 1919, headed the geophysical delegation from the United States to the meeting of the International Research Council at Brussels, which was held, beginning July 18.

DIVISION OF TERRESTRIAL MAGNETISM.

The duties of the chief of division include preparation of plans, estimates, and instructions for the field work; the inspection of the records as they are received; recommendations regarding the purchase, construction, and repair of instruments, and the construction and alteration of observatory buildings; supervision of the office computations, and preparation of results for publication; and discussion of results.

MAGNETIC SURVEY.

As a result of conditions due to the war, the field work was very much curtailed. In the continuation of the magnetic survey of the United States, observations were made during the year at 77 stations in 11 States, of which 34 were new primary stations, 17 auxiliary stations, 22 repeat stations for the determination of secular change, and 4 new stations in old localities. Meridian lines were established, when they were requested by the local authorities.

MAGNETIC OBSERVATORIES.

The observatories at Cheltenham, Md.; Vieques, P. R.; Tucson, Ariz,; Sitka, Alaska; and near Honolulu, Hawaii, were in operation

throughout the year. Continuous photographic records were secured of the variations of declination, horizontal intensity, and vertical intensity. Absolute observations were made at least once a week, and scale-value determinations once a month. A week's observations usually consisted of four sets of declination, two sets of horizontal intensity, and two or more sets of dip.

The magnetic instruments used in the field work were standardized at Cheltenham. At Tucson comparisons were made with magnetometers Nos. 17 and 40, thus furnishing additional data regarding the relation between the Cheltenham and Tucson observatory instruments. A redetermination was made of the moment of inertia of the long magnet of the Tucson magnetometer, which explained the observed difference between the two standards. Upon the return of a magnetic observer from his field work in the interior of Alaska, he stopped at Sitka, and compared his instruments with those at that observatory. Advantage was taken of this comparison to secure additional data regarding the relation of the magnetic elements at the old and new sites of the absolute building.

A seismograph was operated continuously at each observatory, and earthquakes were recorded as follows: Cheltenham, 53; Tucson, 41; Porto Rico, 76; Sitka, 23; Honolulu, 157. Most of the large number recorded at Porto Rico were slight shocks following the great disturbance of October 11, 1918. This earthquake was so severe as temporarily to put out of adjustment some of the instruments, and, apparently, changed slightly the level of some of the piers.

The construction of a new building for office and quarters at Cheltenham was deferred, because of labor conditions. Some damage was done to the variation building by high winds, the force of the wind being sufficient to blow the boards off the eaves on the north side of the building.

Plans were prepared for the erection of a building for garage, shop, and pump house at Tucson, but the estimated cost was found to be too great to warrant its construction, and it was, therefore, decided to install a shop in the present garage, and erect a separate building for the storage of gasoline and kerosene.

APPROPRIATIONS AND DISBURSEMENTS.

The appropriation made by Congress for the United States Coast and Geodetic Survey, in the sundry civil act for the fiscal year ended June 30, 1919, was $1,317,960, divided as follows:

Field expenses	$382,600
Repairs and maintenance of vessels	36,000
Officers and men, vessels	225,000
Pay of field officers	223,500
Pay of office force	253,860
Office expenses	80,000
Offset attachment for lithographic press (reappropriated)	3,000
Two motor-driven lathes, at $750	1,500
One new vessel to cost $354,000	50,000
Four or more new launches	62,500
Total	1,317,960

For the fiscal year ending June 30, 1920, the total amount appropriated is $1,614,280, and the items of appropriation are as follows:

Field expenses	$494,600
Repairs, vessels	56,000
Officers and men	460,000
Salaries, field	256,900
Office	266,780
Office expenses	80,000
Total	1,614,280

DETAILS OF FIELD OPERATIONS.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, ATLANTIC COAST.

MAINE.

[J. H. HAWLEY.]

SUMMARY OF RESULTS.—Triangulation: 35 square miles of area covered, 1 signal pole erected, 5 stations in supplemental schemes occupied for horizontal measures, 10 geographic positions determined. Leveling: 2 permanent bench marks established, 1 mile of levels run. Hydrography: 220.6 square miles of area dragged, 410.9 miles run while dragging, 2,911 positions determined (double angles), 42 soundings made (on shoals), 1 tidal station established, 4 hydrographic sheets finished, scales 1:10,000, 1:20,000, 1:30,000, and 1:40,000.

On July 1, 1918, wire-drag party No. 2 was located at Eastport, Me., and engaged in the survey of Passamaquoddy Bay, having completed in June the survey of Western and Head Harbor Passages which form the approach to this bay. The work was carried on during July and August, and was completed on August 29. When there was an opportunity, without interfering with the drag work, triangulation and signal building were carried on in Friar Roads so that the party was prepared to drag this area as soon as the work in Passamaquoddy Bay was completed.

Drag work in Friar Roads was begun on August 30, and continued until September 16 when it was completed. During the course of this work advantage was taken of favorable weather to drag a strip about 2 miles wide in Grand Manan Channel from the northern limit of soundings off West Quoddy Head to a junction with the east limit of the work in Head Harbor Passage. The object of this work was to insure safe navigation for vessels along the east coast of Campobello Island in an area where very few soundings have been obtained.

The work in this region as finally completed embraces the survey of Passamaquoddy Bay and a continuous survey of its approaches from the northern limit of soundings in Grand Manan Channel, off West Quoddy Head, along the east coast of Campobello Island and through Head Harbor Passage, Friar Roads, and Western Passage. The survey covers a total area of 111.5 square statute miles.

Because of the great range of tide and strong currents in this region the progress of the work was necessarily slow. In the narrow channels forming the approach to Passamaquoddy Bay drag work could be done only at or near slack water. In the bay itself the currents were not strong enough to prevent work at any time, but cross currents due to the several small outlets of the bay resulted on several occasions in an abnormal lift which made it necessary to redrag some areas in order to obtain the drag depth desired. In the western part of the bay, for example, between Western Passage and the St. Croix River it was found that during flood tide the surface current ran to the northward while below the surface the river current continued to run south. When dragging with the flood tide, drag tests showed a lift of from 10 to 14 feet and it was finally necessary to drag this part of the bay during ebb tide when the tidal and river currents had the same direction.

An automatic tide gage was maintained at Eastport from June 28 until the survey was completed. During the course of the work in Passamaquoddy Bay secondary gages were operated at St. Andrews and Midjik Bluff, New Brunswick.

Signal building and triangulation for the work in Grand Manan Channel were executed by a party from the Geodetic Survey of Canada under the direction of H. F. J. Lambert. This party built and located signals on White Horse, Grand Manan, and Campobello Islands, and its work resulted in a valuable saving of time. The party is much indebted to Mr. Lambert for his prompt and efficient cooperation.

On September 17 and 18 the equipment was loaded on the launches, and on September 19 the party left Eastport to take up the survey of Machias Bay and approaches in accordance with instructions dated September 11, 1918. The party arrived at Jonesport, Me., on the afternoon of September 19, and established headquarters at that place. Drag work could not be started until September 25 because of weather conditions, and until that date the party was engaged in signal building and miscellaneous work.

Drag work was begun in this locality on September 25, and continued until November 9. A strip about 5 miles wide was dragged, extending from the Libby Islands westward to a point due south of Black Rock. The northern limit of this strip passes along the shore line in the vicinity of Moose Peak Lighthouse.

Whenever possible, soundings to supplement those shown on the chart were obtained by the tender which sounded at different buoys when the drag was under way. The depths in this locality are too great for the use of the hand lead, and it was, therefore, necessary to use a sounding machine. A registering sheave was furnished the party but no winding drum was available. A fairly satisfactory drum was accordingly improvised by attaching a large buoy hoist to a box and rearranging the gears to form the drum flanges. The size of the drum was enlarged to the size desired by winding rope on the shaft between the flanges. To wind this drum a buoy crank was cut down to give a short throw, and a brake was rigged to check the drum when the lead struck bottom; 390 soundings were obtained in this locality.

For the reduction of the drag work in this region, a tide gauge was established and maintained at Jonesport.

During October various members of the party were ill with the influenza which was then prevalent in Maine and the party was seriously short-handed for several weeks. Fortunately the work was in open deep water, and could be carried on with fewer men than are ordinarily necessary so that there was little delay as far as the drag work was concerned. It was necessary to work for some time without the larger tender, however, and fewer supplemental soundings were obtained than would have been secured with the normal number of men.

During the entire season a total area of 240 square statute miles was dragged, and 51 changes in the charted depths were found. These changes were reported from time to time during the season.

The launches *Pilot*, *Survey*, and *Edna M.* were used in this work. On November 9, on account of unfavorable weather, work was discontinued for the season.

In this work an improved semaphore machine was used. Improvements were also made in the method of attaching the buoys to the drag, permitting the new type of buoy to be used to advantage.

[J. H. HAWLEY.]

SUMMARY OF RESULTS.—Leveling: 14 permanent bench marks established, 2.5 miles of levels run. Hydrography: 7 tidal stations established, 6 current stations occupied.

On March 22, 1919, the chief of this party was relieved from duty in the office, and began the work of preparing for the transfer of launches from New York, N. Y., and Newport, R. I., to Norfolk, Va. This work was completed on April 27.

On arrival at Baltimore, Md., after completing the transfer of launches, he began the work of organizing a tidal and current survey party in accordance with instructions dated April 26, 1919. This party left Baltimore in the launches *Marindin* and *Mitchell* on May 6, arrived at Kittery Point, Me., and established headquarters on May 14.

On May 16 the chief of party proceeded to Portland, Me., in the launch *Marindin* and, after a delay of two days, due to stormy weather, established a current station on Portland light vessel on May 19, and then returned to Kittery Point. The launch *Mitchell* was left at Kittery Point during this period for painting and general overhauling.

On May 16, a member of the party left Kittery Point and proceeded to Camden, Me., where he installed a new engine in the launch *Edna M.*, and fitted this launch out for work. He then ran the launch to Kittery Point, arriving on May 27.

Current observations in Portsmouth Harbor and vicinity were started on May 21, and continued under very favorable weather conditions until June 12. Five stations were occupied.

A main tidal station was established in Pepperell Cove at Kittery Point on May 21, and tides were observed during the periods when current observations were in progress. Four supplemental tidal stations were also established and connected by simultaneous readings with the main station.

Bench marks were also established at the shipyard of the Atlantic Corporation on the west side of the river just above Portsmouth, and connected with the tide staff maintained by the company. Arrangements were made with the engineering division of the corporation to have observations made on the gauge in conjunction with observations at the main station.

Every effort was made to obtain tidal and current data from other organizations in the vicinity. The various gauges mentioned above were connected by spirit levels with 27 bench marks, 14 of which were standard bronze marks established by the party.

On June 12 the work in the vicinity of Portsmouth Harbor was completed, and on June 13 and 14 the wire-drag equipment in storage at Kittery Point was loaded on the launches and preparations made to change headquarters. Departure was prevented by thick fog until the afternoon of June 17, on which date the party left Kittery Point in the three launches, and proceeded to Cape Porpoise, Me.

Current observations from Cape Porpoise were prevented by bad weather until June 23, and this period of bad weather was utilized to install wire-drag equipment on the launches. On June 23, current observations were started at station No. 66 near whistle buoy "2CP" off Cape Porpoise, and continued for 51 consecutive hours until June 25. On June 26 a tidal station was established at Cape Porpoise Harbor.

The remainder of the month was taken up with office work on current and tidal records, installation of one-man control on the launches, and preparation of launches for wire-drag work to be started on July 1, 1919.

It was found to be impossible to hire tide observers for the work in Portsmouth Harbor, and the lack of an automatic tide gauge was keenly felt. Had one been available a considerably greater amount of tidal work could have been done.

The party was also somewhat handicapped when making continuous current observations by lack of quarters in the wire-drag launches that were used. As these launches have only two berths and are heated only by kerosene, they do not offer suitable accommodations for the five men that are necessary for continuous observations.

MASSACHUSETTS.

[H. P. RITTER, July 1, 1918, to Apr. 21, 1919; J. A. DANIELS, Apr. 21, 1919, to June 24, 1919; W. C. HODGKINS, June 25, 1919, to June 30, 1919.]

An officer of the Survey has continued on duty throughout the year as Inspector for the New England coast, and in charge of the field station of the U. S. Coast and Geodetic Survey with an office in the customhouse at Boston, Mass.

Through the year, the best efforts of the inspector and all the facilities of the station were given to the assistance of the military departments of the Government in the prosecution of the war and in the various activities following the armistice. For such service, 259 copies of Coast and Geodetic Survey Charts were furnished to officers of the Army and Navy, besides 18 coast pilots, and 7 tide tables.

The station was also able to be of considerable assistance to the general public, the records showing that information was furnished to 1,064 applicants, that 179 publications of the Survey were distributed, and that 84 charts, 15 coast pilots, and 10 tide tables were sold.

A somewhat important feature of the work of the station was that of assisting the local agents for the sale of our publications to supply the need of the public by the transfer of items which they did not have in stock.

In the course of the year, 267 charts, 3 coast pilots, and 2 tide tables were thus transferred.

The station has also been an agency for the distribution and sale of the publications of the Bureau of Lighthouses. During the year, 114 copies of light or buoy lists were thus disposed of.

In addition to these office duties the inspector reported a supposed new shoal in the vicinity of the eastern entrance to Nantucket Sound and made frequent trips of inspection to points in the vicinity of Boston, in connection with topographic revision work. Many triangulation points were visited and most of the stations were recovered.

Under the direction of the inspector extensive topographic revision in the vicinity of Lynn, Salem, and Marblehead was executed by officers detailed for the purpose.

In the autumn of 1918 the inspector installed apparatus for the observation of currents upon the light vessels stationed at Pollock Rip Slue, the Stone Horse Shoal, and Nantucket Shoals; and in March, 1919, upon the temporary light vessel *Easthampton*, stationed at the northern end of Stellwagen Bank.

During the winter six officers and draftsmen were furnished office space and necessary facilities for the completion of the field records of wire-drag parties Nos. 1, 2, and 5.

The topographic chart revision and the reduction of wire-drag records were under the direction of the inspector until February 1, 1919, when they were transferred to another officer, with headquarters at Salem, Mass.

During the greater part of the year a considerable part of the office space of the station was occupied by the force of the office of Inspection of Engineering Material, United States Navy, in compliance with the request of the inspector in charge of that office.

Similar assistance was given the office of the United States Civil Service Commission, whose room adjoined that of the field station.

With the view to acquainting the public with the existence and facilities of the station, most of the local yacht clubs were visited by the inspector, who furnished them with sundry publications besides general information.

[JOHN A. DANIELS.]

SUMMARY OF RESULTS.—Triangulation: 40 square miles of area covered, 2 signal poles erected, 9 stations in supplemental schemes occupied for horizontal measures, 55 geographic positions determined. Topography: 45 square miles of area surveyed, 48 miles of general coast line surveyed, 56 miles of shore line of rivers surveyed, 9 miles of shore line of creeks surveyed, 11 miles of shore line of ponds surveyed, 380 miles of roads surveyed, 4 topographic sheets finished, scale 1:10,000.

On January 24, 1919, J. A. Daniels relieved H. P. Ritter of the field work of revising the topography and triangulation of the north shore of Massachusetts Bay from the latitude of Grover's cliff northeastward to and including Manchester Harbor.

This work had been begun in July, 1918. Old triangulation points had been recovered, various plans and maps had been obtained from town and city surveyors, and these had been transferred to copies of the original sheets, and some original revision work had been done in the vicinity of Marblehead Neck. Enough had been accomplished to show that an extensive revision of the whole area was necessary.

Four sheets lettered A, B, C, and D, from south to north, were laid out upon a scale of 1:10,000, to include the area specified. During the bad weather of February and March all the previous surveys and information from various sources were transferred to these sheets in pencil. Plane-table work for verification and correction was begun as soon as weather permitted, and was pushed every good day until it was completed. A great deal of intermediate detail work was paced and sketched in notebooks and then transferred to the sheets. By following this method it was possible to work on many days when the sheets could not be taken out, and it made possible the utilization of sketchers on good days. The inking of the sheets was done as soon as the details were secured and the existing work was corrected or verified. By following this method the party was always busy regardless of weather conditions, and the office work was very nearly up to date at all times. While the sheets are revision sheets they have all the value of a complete resurvey—as to completeness and accuracy. The only exception is in the matter of contours and elevations. This phase was not touched upon, as it was concluded that the old contour system was as complete and accurate as any that could be produced and that changes of contour were not appreciable.

The objects that had been located by the wire-drag parties of 1915–16 supplied the principal control, although a few older points were recovered and used. Mr. Ritter had visited and recovered a large number of triangulation points, and had secured information that was very valuable. The control was adequate without additional triangulation, and the triangulation done was for the sole purpose of locating prominent objects for use upon the chart.

CONNECTICUT, NEW YORK, AND RHODE ISLAND.

[J. A. DANIELS.]

SUMMARY OF RESULTS.—Triangulation: 1½ square miles of area covered, 5 signal piles erected, 3 stations in main scheme occupied for horizontal measures, 13 geographic positions determined. Leveling: 2 miles of levels run. Topography: ½ mile of shore line run. Hydrography: 138.2 square miles of area dragged, 0.25 square mile of area sounded, 211 miles run while dragging, 18.4 miles run while sounding, 8,669 angles measured while dragging, 341 positions determined (double angles) while sounding, 69 retained soundings, 1,687 soundings made, one drag sheet finished; scales of hydrographic sheets, one 1:2,000, two 1:20,000, two 1:50,000.

Wire-drag work in Block Island Sound and Fishers Island Sound was in progress at the beginning of the fiscal year, and was continued until November 14.

No extensive scheme of triangulation was required for this work. One new station was established and marked on Block Island, R. I. Observations were made to locate the flagpole at the Block Island naval base headquarters, and several other natural objects were located for use as signals in the hydrographic and wire-drag work. The flagpole mentioned was located at the request of the commander of the naval base. Observations were also made to determine the north range points of the Block Island trial course. These were requested by the chief of wire-drag party No. 1. Several old stations were recovered for these purposes.

A small system of plane-table triangulation was made for the location of signals to control the hydrographic survey of the entrance to Great Salt Pond. Fourteen objects were determined for this purpose. In connection with this work the shore line at the entrance was rerun.

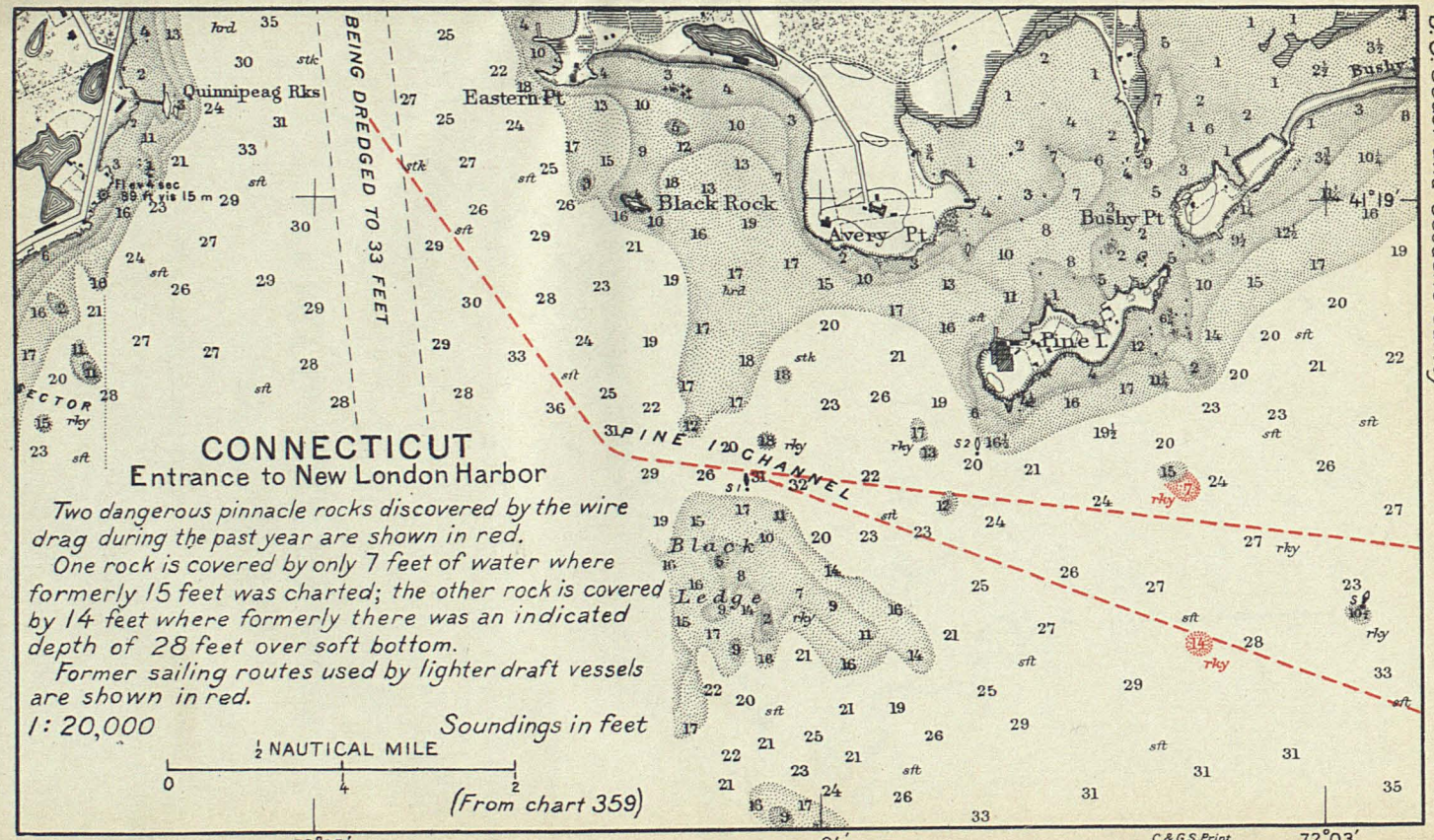
The sounding work accomplished was done at the request of the naval authorities, and consisted of a complete resurvey of the entrance to Great Salt Pond, Block Island, on a scale of 1:2,000. This survey made known the fact that the north side of the channel has shoaled considerably through the collection of sand and gravel. The safe depth in the channel has become narrowed on this account. No other difference in depth was noted.

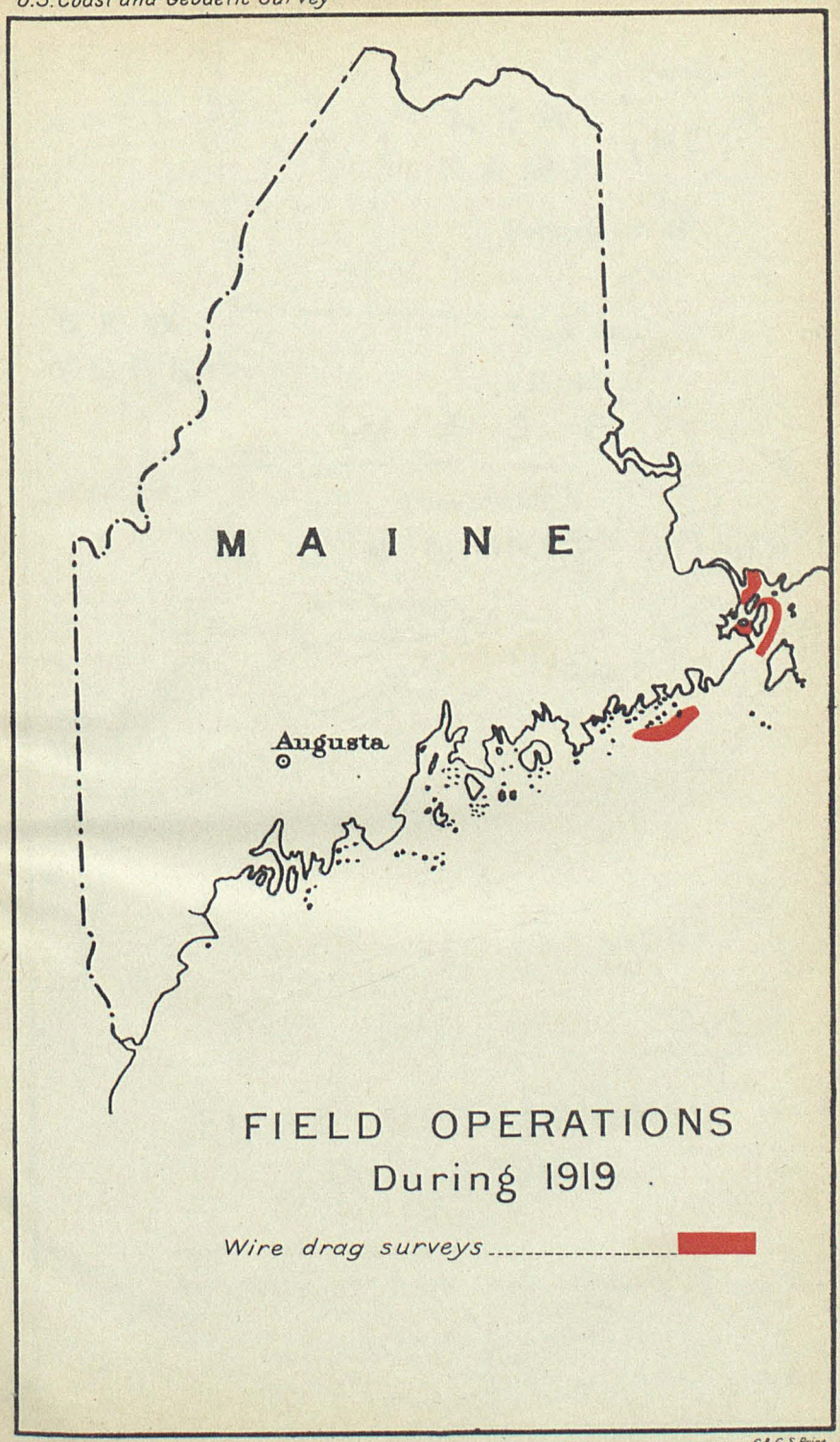
The sounding was done from a pulling boat loaned to the party for the purpose by the commander of the naval base.

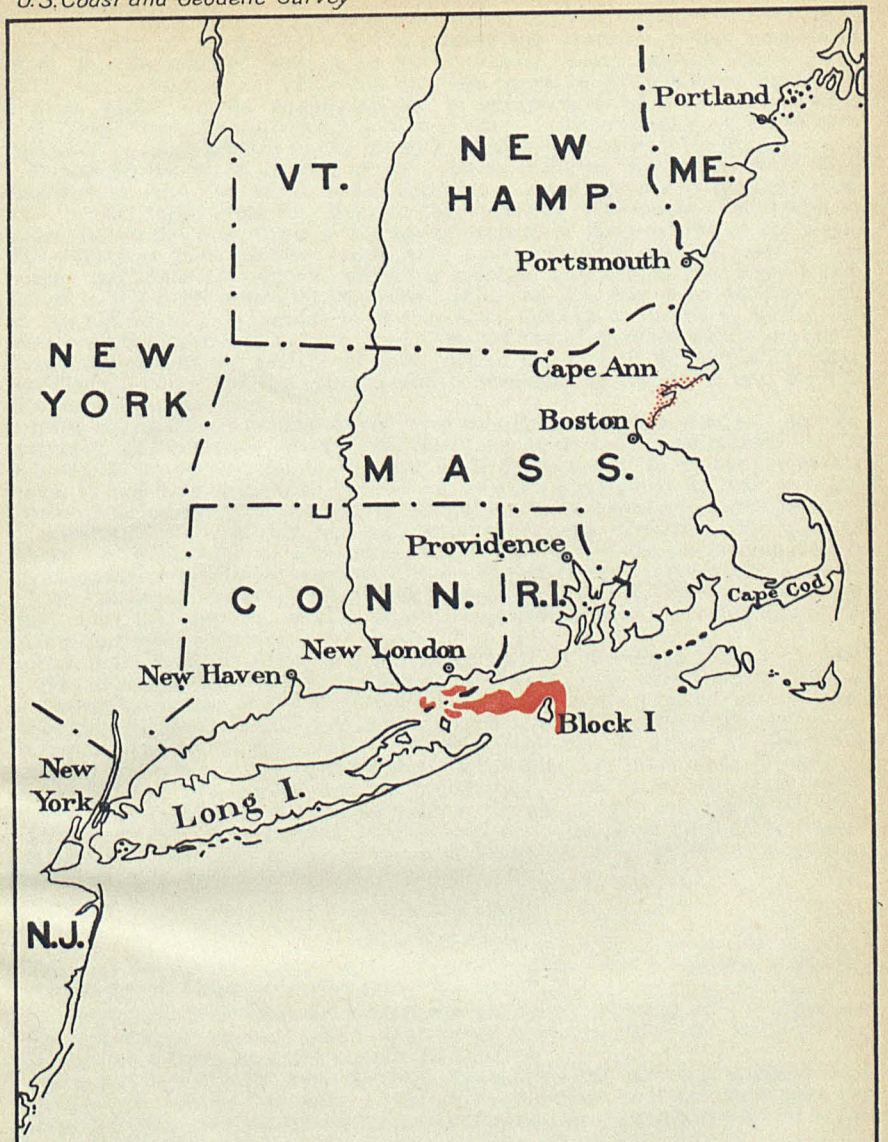
In the vicinity of Block Island, R. I., the wire-drag work begun in the first part of the summer by party No. 1 was extended to the westward and northward to join additional work that was done to the eastward of the island. In the vicinity of the Sandy Point bell buoy to the northward of the island unusually troublesome currents were encountered. Much of the irregularity was due to wind action, but counter and eddy currents were also noted. To find the current flowing normally any day and in the direction predicted was an exceptional occurrence. This handicap, together with the irregularities in depth, not shown on the chart, made this an exceptionally difficult area to drag. Approximately 100 square miles of area were covered in the immediate vicinity of the island. This area connects with areas previously dragged to the westward of the island. One dangerous shoal was located, this being a bowlder with a depth of 20 feet, found off the northeast point of the island. The work was done on a scale of 1:20,000 in the areas close to the island and 1:50,000 in the offshore areas.

In the vicinity of Southwest Ledge an examination was made in order to locate the shoal upon which the steamer *Allaquash* was reported to have struck on July 30, 1919. No shoal was found at the point indicated, and it was concluded that the steamer was in error in reckoning, or else had struck a piece of submerged wreckage that had been carried away subsequently by the tidal currents. The work in this vicinity was done on a scale of 1:20,000, but was plotted upon an existing smooth sheet which has a scale of 1:50,000.

On November 13 the party was transferred from Block Island to Noank, Conn., and the subsequent work was done in Fishers Island Sound or in the


CONNECTICUT
Entrance to New London Harbor
Two dangerous pinnacle rocks discovered by the wire drag during the past year are shown in red.
One rock is covered by only 7 feet of water where formerly 15 feet was charted; the other rock is covered by 14 feet where formerly there was an indicated depth of 28 feet over soft bottom.
Former sailing routes used by lighter draft vessels are shown in red.
1: 20,000
Soundings in feet
½ NAUTICAL MILE
0
4
2
(From chart 359)
Quinnipeag Rks
Eastern Pt
BEING DREDGED TO 33 FEET
Black Rock
Avery Pt
Bushy Pt
Pine I
PINE I CHANNEL
Black Ledge
41°19′
72°05′
04′
72°03′
C & G.S. Print


MAINE
Augusta
FIELD OPERATIONS
During 1919
Wire drag surveys



FIELD OPERATIONS
During 1919

Wire drag surveys.....

Topographic surveys.....

western part of Block Island Sound. After this transfer it was possible to work in the exposed waters of Block Island Sound during clear, calm days, and to utilize less favorable days for work in the sheltered waters of Fishers Island Sound. Approximately 40 square miles of area were covered and 7 dangerous shoals located in this vicinity. Connections were made with the work of other parties in the vicinity of New London and the Race.

It was necessary on account of the country being at war to maintain close cooperation with the naval authorities in carrying on the wire-drag work. This proved to be a pleasent duty in this instance. The naval commander at Block Island did everything in his power to further the progress of the work. The carpenter and machine shops were made available for the uses of the party. All kinds of supplies, including gasoline and engine oils, were transferred to the party whenever requested. The use of a whaleboat for sounding in the harbor and of various tools that were lacking in the party equipment were readily secured. The party was given the use of an office within the naval headquarters building for the greater part of the season—in fact, everything possible was done for the comfort and convenience of the party and for the furtherance of the work.

Close cooperation was maintained with wire-drag party No. 1 of this service, stationed at Stonington, Conn. The shortage of wire-drag equipment due to delayed deliveries because of the war made it necessary to exchange various items in order to keep both parties as completely supplied as was possible. These exchanges were made with a cordial spirit of cooperation, and resulted in increased output of both parties. An advantageous division of the work in Block Island Sound was also made, which resulted in the connection of the areas surveyed by the two parties without loss of time or duplication of work.

The *Norman 2*, chartered as guiding launch, the *Annie T. Mack*, chartered as end launch, and the *Chelsea E.*, a Block Island fishing boat chartered as tender, gave satisfactory service.

Aluminum floats, designed and purchased by J. H. Peters in 1917, were used in part throughout the season. They showed no signs of deterioration because of the action of the salt water; unless previously bruised, they readily withstood the pressure of the deeper depths dragged; and they were very convenient to handle because of light weight and small volume. If proper facilities are provided to prevent bruising these floats when they are taken aboard, there is no reason why they should not last indefinitely. This is an important point, however, as even small bruises so weaken them that they collapse or fill with water when deeply submerged. Our experience with them during the season left no doubt that they are much the best design yet used for the purpose, and their general adoption is strongly recommended.

RHODE ISLAND.

[F. B. T. SIEMS.]

SUMMARY OF RESULTS.—Hydrography: 1 automatic tide gauge established, 3 tide stations established, 5 current stations occupied.

Under instructions from the Superintendent dated May 21, 1919, a party for tidal and current surveys was organized at Baltimore, Md., for work on the coast in the vicinity of Point Judith, R. I.

Between May 21 and June 3, 1919, the newly-built launches *Rodgers* and *Ogden* were outfitted for making the trip to the New England coast, and for survey purposes, and on June 4 the party and launches left Baltimore, Md., for the field of work.

It was found impracticable to use Point Judith Harbor of Refuge as a base for survey operations, making it necessary to stop at Block Island where the party arrived June 11.

Work was begun at once, and was in progress at the close of the fiscal year.

CONNECTICUT, NEW YORK, AND RHODE ISLAND.

[F. B. T. SIEMS.]

SUMMARY OF RESULTS.—Triangulation: 4 signal poles erected, 6 stations in supplemental schemes occupied for horizontal measures, 10 stations occupied for vertical measures. Leveling: 4 permanent bench marks established. Hydrography (wire-drag work): 97 square miles of area dragged, 180 miles run while dragging, 13 rocks and shoals discovered, 247 soundings made (over shoals), 1 tide station established.

After completing wire-drag surveys and current observations off the west coast of Block Island during the early part of July, the party was transferred to Stonington, Conn., on July 6, 1918, to conduct wire-drag surveys in Long Island Sound, Block Island Sound, and Fishers Island Sound.

On account of the strong tidal currents and exposed waters of the areas named above, especially in the extreme eastern part of Long Island Sound and adjoining portions of Block Island Sound, the need of efficient launches for dragging is of primary importance. A good part of the day can be lost to field work by temporary engine failure. The drag may be swept away from the area desired to be covered, by strong currents, and make it impossible to return to the area unless the drag is taken up and again set out. Thus nothing is accomplished up to the time a second or third trial is made.

As mentioned in the previous report, the party was handicapped in the use of inefficient launches, one of which was the end launch chartered for the party at the beginning of the season, and the other was temporarily hired. It was impracticable to continue to work with the underpowered and very poorly designed end launch in the new locality, and efforts were therefore made to replace this launch and the guide launch, which the owner failed to deliver to the party, by other launches.

At this time a great many launches were turned over to the Navy, also many were being used for fishing or other occupations; therefore few, if any, suitable launches for wire-drag work could be hired. A great deal of time was consequently lost to field work during July in searching for launches.

Finally, after considerable trouble, the best two launches that could be obtained under the circumstances were accepted the latter part of July. Although of sufficient power, they were far from meeting the requirements of the work in this locality. Both of the launches later proved to be more or less unsatisfactory on account of engine trouble. It was necessary to carry nearly all the wire-drag gear on the guide launch, on account of lack of space in the end launch, losing considerable time each day in setting out and taking up the drag.

Field work was resumed on August 3, after outfitting the newly hired launches. The work in general was planned so as to take advantage, if possible, of fair currents in going to and from the working grounds, and also in dragging. Dragging was in progress in Long Island Sound and Block Island Sound during August, September, and part of October. The work in Fishers Island Sound and off New London Harbor was accomplished in October and November, when the weather restricted work in the open waters.

The area covered by the wire drag in Block Island Sound is roughly outlined by an area extending south from the 7-fathom curve on the north side of the sound from Mount Prospect, Fishers Island, to Noyes Neck, R. I., to about halfway across Block Island Sound. It forms a junction in part on the east with the work done by the wire-drag party operating westward from Block Island. The work inshore and near the Race was hampered by heavy lobster gear which owners, upon request, failed to remove. Some uncharted rocky ledges were discovered inshore; the areas offshore were found free from dangers. The supposed wreck of the steamer *Larchmont* was located off Watch Hill Point, in 20 fathoms of water, and has a least safe depth of about 72 feet over it. A shoal sand ridge about 4 miles northeast of Cerebus Shoal was found to have about 14 feet less depth than soundings obtained by former surveys.

The area dragged in Long Island Sound extended eastward from meridian 72° 13′ directly north of Plum and Gull Islands to a junction with completed work. No dangers were found in this area. The work was exceedingly difficult on account of very strong currents, and it was at times impossible to control the drag. Two small undragged areas in the Race were covered during short periods of least current.

The dragging in the approach to New London Harbor, which the Navy Department requested, and covered by supplemental instructions from the Superintendent dated August 22, 1918, was accomplished. No natural dangers were found to exist in this area, but several wrecks of vessels were discovered.

In all of the above work the maximum effective depth was in general 100 feet, and in depths of 10 to 20 fathoms the waters were dragged 5 to 20 feet off the bottom. In depths less than 10 fathoms, dragging was done 3 to 6 feet off the bottom.

An area of about 4 square miles off Stonington Breakwater, Fishers Island Sound, was dragged to a maximum effective depth of 35 feet, and within 3 feet of the bottom in lesser depths. A very short drag was used for this work, and in order to have time to maneuver the launch over the intricate channels, dragging against the current with the short drag was found necessary. Ranges, consisting of buoyed flags and placed in position so as to guide

the launches in covering certain areas, were found to be very helpful. In order to drag this area it was necessary to remove a large number of lobster pots.

The work was well controlled by numerous triangulation stations, some of which were established by the party. Practically all the signals used were located by triangulation.

Tides were read at Little Gull Island and at Stonington, Conn., for the reduction of drag depths and soundings.

NEW YORK.

[J. H. PETERS, Commanding Steamer *Ranger*.]

SUMMARY OF RESULTS.—Triangulation: 9.7 square miles of area covered, 6 stations in supplemental schemes occupied for horizontal measures, 25 geographic positions determined. Leveling: 3 permanent bench marks established, 0.1 mile of levels run. Topography: 0.3 mile of general coast line run. Hydrography: 0.4 square mile of area sounded, 22.1 miles run while sounding, 184 positions determined (double angles), 1,373 soundings made, 2 tide stations established, 1 hydrographic sheet finished, scale 1 : 10,000.

Between April 14 and June 30, 1919, a hydrographic survey and such triangulation and topography as was necessary to control the hydrography was made of the southeast side of Staten Island between the foot of New Dorp Lane and Midland Beach, in accordance with instructions dated April 12, 1919.

The triangulation necessary to control a hydrographic and topographic resurvey of Gravesend Bay and adjacent territory, New York Harbor, was done in accordance with instructions dated May 10, 1919. The hydrography covered by these instructions was not done during this fiscal year, as it was understood not to be immediately necessary and was postponed until the small boats for the *Ranger* would be available, when the hydrography could be completed at less cost.

[ISAAC WINSTON.]

Inspection duty for the region between Narragansett and Delaware Bays was continued by an officer who is in charge of a field station of the Survey with an office in the customhouse, New York City.

On July 1, 1918, the inspector was in the field on the coast of New Jersey engaged in determining the geographic positions of certain towers used in connection with range firing, which had been requested by the commanding officer of the Sandy Hook Proving Ground. This work was completed on July 10.

On July 24, 25, and 26 an inspection was made with officers of the Army Engineers of the Eastern Department of the condition of the triangulation stations on the western end of Long Island.

On August 15 and 16 the inspector determined the geographic positions of North and South Sandy Hook beacons.

Other visits to Sandy Hook in connection with this work were made on August 20 and 28.

A day was spent in September on reconnoissance at Fort Tilden, N. Y., with an engineer officer of the Eastern Department.

In the latter part of October the electric tide indicator which had been in operation for many years in the Maritime Exchange was dismantled, funds for its repair and operation not being available.

A stock of charts and nautical publications was kept on hand at the field station for reference and sale.

The number of demands upon the inspector for information covering a wide range continues to increase, and the usefulness of the field station is becoming more widely recognized. Many Army and Navy officers called for information, and numerous charts and publications were furnished to meet emergency demands.

Cordial relations and cooperation were maintained with the branch hydrographic office at New York.

Copies of tidal data and tables giving the time of sunrise, sunset, moonrise, and moonset were furnished for publication in local tide calendars, in 16 newspapers, and in Eldridge's tide book.

The inspector has acted as agent for sale of publications of the Bureau of Lighthouses and for distribution of pilot rules for inland waters.

A self-registering tide gauge was installed at the shipyard of the Submarine Boat Corporation at Port Newark, N. J., in February, and has been in operation since that time.

In March current measuring apparatus was placed on two temporary light vessels maintained by the Navy off the entrance to New York Harbor, and observers were instructed in the methods of observing currents.

In March negotiations were begun for the transfer of several vessels from the Navy to the Coast and Geodetic Survey.

On May 15 the rooms occupied by the field station were temporarily placed at the disposal of the Commissioner of Lighthouses for the meeting of a board appointed to consider the question of placing a light vessel off Barnegat Inlet, N. J.

In June arrangements were made for the transfer of the launch *Elsie III* from Boston to New York, and the launch was afterwards brought to New York by an officer detailed for the purpose.

Preliminary plans for a tide and current survey of New York Harbor and vicinity were discussed with the engineer officer in charge of the deepening of the channel through East River, and mutual cooperation and assistance were secured.

Copies of tide tables and times of sunrise and sunset for 1920, corrected to conform to the daylight-saving law, were prepared for the publishers of certain calendars.

Tidal tabulations were made for various ports.

NEW JERSEY.

[C. G. QUILLIAN.]

SUMMARY OF RESULTS.—Triangulation: 7 stations occupied for horizontal measures, 3 triangulation stations recovered, 75 geographic positions determined.

Between June 10 and June 30, 1919, a field officer was engaged in the determination by triangulation of control points for a revision of topography by aerial photography to be made by the Army. He recovered 3 triangulation points, occupied 7 stations, and located approximately 75 points for the aerial survey.

DELAWARE.

[J. S. S. JONES.]

In the latter part of August, 1918, an inspection was made at Lewes, Del., for the selection of a suitable site for the erection of an automatic tide gauge near Deleware Breakwater.

Four localities were visited, three of which proved unsuitable for the purpose intended. The site selected is on a pier under the charge of the Corps of Engineers, United States Army, on the outer end of which is a small building used as a shelter by the keeper of the lighthouse depot. This is now used to house the gauge and apparatus.

On January 9, 1919, the necessary preliminary arrangements having been made, the installation of the gauge was begun. The northwest corner of the building was chosen as the site of the gauge.

When the tide staff had been placed in position a double line of levels was run from the staff to five old and six new bench marks. The float well was placed in position, a box shelter constructed over the top of the well, the gauge set up and put in operation, and the observer instructed in his duties.

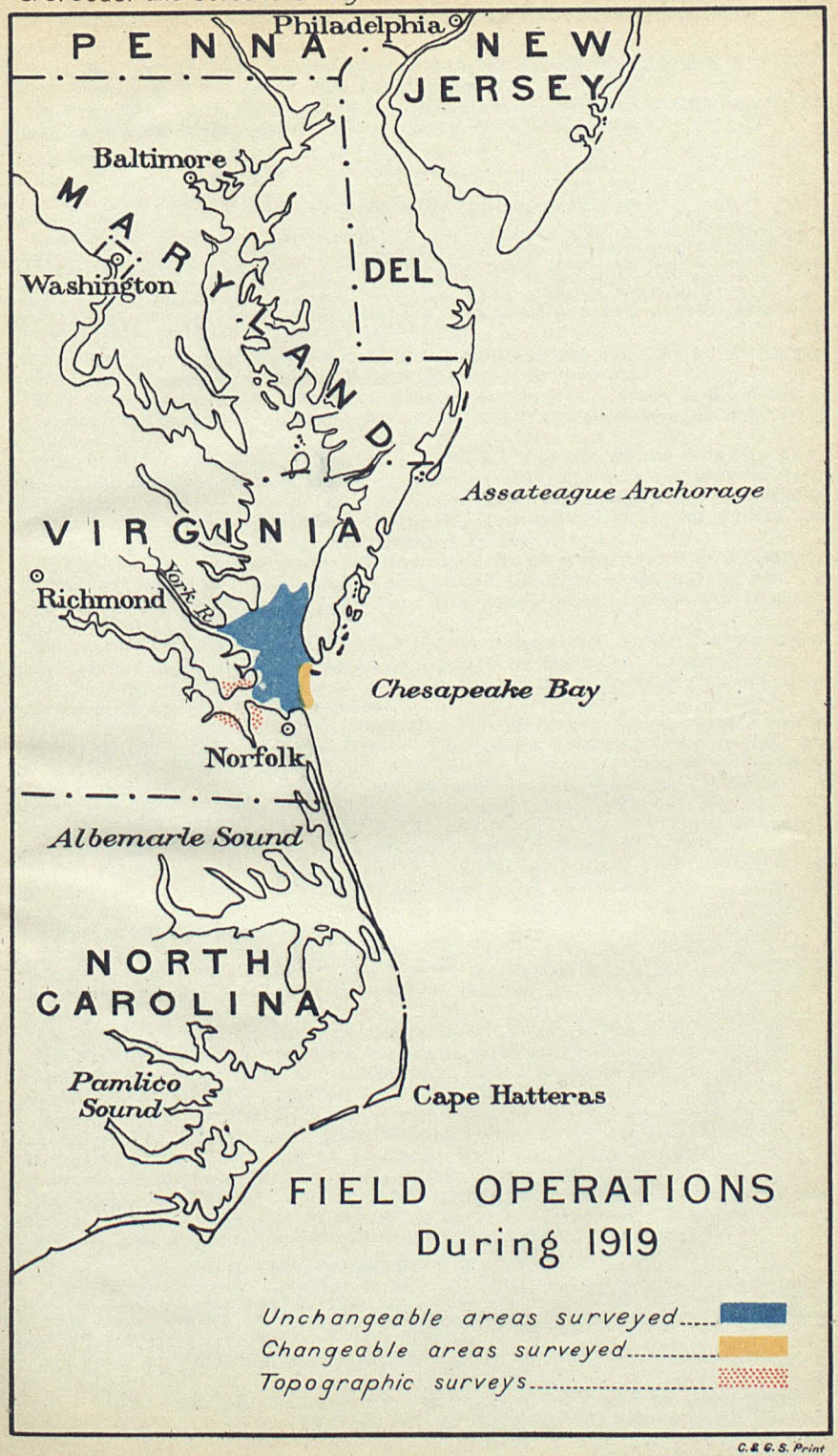
DELAWARE, NEW JERSEY, VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, AND GEORGIA.

[H. A. MARMER.]

In July, 1918, arrangements were made for installing on light vessels in the third, fifth, and sixth lighthouse districts, the apparatus necessary for a series of current observations to be made in various localities along the Atlantic coast.

The current apparatus had been shipped to the various lighthouse depots considerably in advance of the probable date of the sailing of a tender, so that no delay was caused by the nonarrival of a shipment. The various light vessels were visited by the observer on the regular trips of the lighthouse tenders, the apparatus installed and the necessary instructions given for operating it.

Apparatus was installed on the following light vessels: Diamond Shoals Light Vessel, Cape Lookout Shoals Light Vessel, Frying Pan Shoals Light


Philadelphia
PENNA.
NEW JERSEY
Baltimore
MARYLAND
Washington
DEL
Assateague Anchorage
VIRGINIA
Richmond
York R.
Chesapeake Bay
Norfolk
Albemarle Sound
NORTH CAROLINA
Pamlico Sound
Cape Hatteras
FIELD OPERATIONS
During 1919
Unchangeable areas surveyed
Changeable areas surveyed
Topographic surveys

Vessel, Brunswick Light Vessel, Winter Quarter Shoals Light Vessel, Overfalls Light Vessel, and Northeast End Light Vessel.

In February, 1919, apparatus was installed and observers instructed on the temporary light vessels *Falcon*, *Long Island*, *Owl*, and *Brant*.

VIRGINIA.

[E. B. LATHAM, Commanding Schooner *Matchless*.]

SUMMARY OF RESULTS.—Triangulation: 77 square miles of area covered, 20 signal poles erected, 11 stations in main scheme occupied for horizontal measures, 27 geographic positions determined. Leveling: 3 miles of levels run, 7 permanent bench marks established. Topography: 2 square miles of area surveyed. Hydrography: 65 square miles of area surveyed, 332.4 miles run while sounding, 1,270 positions determined (double angles), 12,553 soundings made, 4 tidal stations established, 6 current stations established, 1 hydrographic sheet finished, scale 1 : 20,000.

Between July 1 and September 18 the *Matchless* was engaged in surveys in York River, Chesapeake Bay, and Back River, all in Virginia.

The work requested by the Navy Department in York River, and soundings to verify depths, etc., indicated by previous surveys, was completed September 3, 1918.

The location of signals and other objects for the use of the Atlantic Fleet was transmitted to the commander in chief of the Atlantic Fleet and the commander of naval base No. 2. This consisted of a tracing from the confidential chart of this region (published by the Hydrographic Office), on which was shown the position of the objects requested by the Navy.

In addition to this tracing, a list was made showing the names and positions in degrees, minutes, and meters, and a brief description of each object. A copy of the latter was sent to the office. Every assistance possible was rendered by the naval authorities.

The surveys at the naval oil base afterwards requested by the Navy Department were completed within the time required by the naval authorities.

On September 3 all the work in York River and approaches, except three current stations, had been completed.

The *Matchless* was moved on September 5 from Sedger Creek to mid-channel abreast of the beacon in York River. Two of the launches were posted, one in Mobjack Bay and one in Poquoson River. Currents were observed from the ship and each of the launches, beginning at 10 a. m., Thursday, September 5. Heavy weather interrupted the observations at 7 a. m., Saturday, September 7, and the ship was put under way at 12 noon on that date for Back River. A rough passage was made with the wind northwest hauling to northeast.

After passing the bar at Back River, the tide and wind were too much for the launches to make headway against, and after four attempts to pass the turn in the channel at the lower Back River Beacon the ship was anchored to await slack water.

At 6 p. m., September 7, the ship was under way, and passed to a safe anchorage into Back River off Messick Point. Eight feet is the best water in the crossover below the Upper Back River Beacon, and the ship touched lightly in passing in.

On Monday the anchorage was shifted to off Amory's wharf, Back River.

On this date field operations were begun with two parties searching for old triangulation stations, and the commanding officer going to Langley Field headquarters to arrange for supplies, getting fresh water, and for information, etc.

Signals were erected, and the observations in the triangulation begun on September 11. This triangulation was necessary to determine signals for use off and in Back River, and to determine certain objects (landmarks, etc.) to be shown on the new editions of charts for this region.

Boat sheets, showing positions of sounding lines of previous surveys and old depths for comparison of the work of 1918 with these old surveys, were prepared, and sounding operations were begun on September 16.

[C. H. OBER, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Leveling: 10 miles of levels run. Hydrography: 435 square miles of area covered, 2,277.3 miles run while sounding, 6,560 positions determined (double angles), 34,092 soundings made, 6 tide stations established, 10 current stations occupied, 2 hydrographic sheets finished, scales 1 : 40,000 and 1 : 30,000.

On June 30, 1918, the hydrographic survey of lower Chesapeake Bay was in progress.

The work done was included on two hydrographic sheets, one extending from Lynnhaven Roads to latitude 37° 08′ between Cape Henry and Thimble

Shoal Lighthouse and the other from latitude 37° 08′ to Wolf Trap Lighthouse. From the eastern limit of longitude 76° 04′ west to the western limit of a line drawn from York River to Wolf Trap.

Field work by the vessel was closed October 31, but tidal readings were continued until November 16, 1918.

[L. A. POTTER, Commanding Schooner *Matchless*, Sept. 18, 1918, to Apr. 30, 1919; Commanding Steamer *Onward*, May 1 to June 30, 1919.]

SUMMARY OF RESULTS.—Triangulation: 142 square miles of area covered, 4 signal poles erected, 5 observing tripods and scaffolds built, 17 stations in main scheme occupied for horizontal measures, 92 geographic positions determined. Leveling: 23 permanent bench marks established, 7 miles of levels run. Topography: 46.5 miles of area surveyed, 37 miles of general coast line surveyed, 10 miles of shore line of rivers surveyed, 40 miles of shore line of creeks surveyed, 229.5 miles of roads surveyed; scale of topographic sheet 1 : 10,000. Hydrography: 82 square miles of area covered, 1,262 miles run while sounding, 6.435 positions determined (double angles), 42,880 soundings made, 13 tide stations established, and 7 current stations occupied, 3 hydrographic sheets finished; scales of hydrographic sheets 1 : 20,000, 1 : 10,000, and 1 : 5,000.

On September 18, when the command of the schooner *Matchless* was transferred, the vessel was at anchor in Back River. The signals for the triangulation in Back River were already erected, and one day of hydrography on the hydrographic sheet, extending from York River to Hampton Roads, had been done. Work was continued on the hydrography and triangulation in accordance with orders previously issued, and on October 4 the *Matchless* shifted from an anchorage in Back River to a berth in Hampton Creek, where she lay until the end of the calendar year.

The triangulation in Back River necessary to locate prominent objects and signals for the control of the hydrography was completed before leaving that locality. Observations were also taken to locate Thimble Shoal Lighthouse and several prominent objects near the entrance to Hampton Roads. Seven stations in the main scheme and 12 intersection stations were located in connection with the work from York River to Hampton Roads.

A special development of Back River entrance was made, and the positions of the aids to navigation, and a copy of the survey of the entrance were furnished to the superintendent of lighthouses, Baltimore, Md. The hydrography was extended eastward to a junction with the work done by the *Hydrographer*, and southward to the shore of Willoughby Spit, to cover the area south of Thimble Shoal Channel, which has been used as a dumping ground. Work on the sheet extending from York River to Hampton Roads was completed November 14.

In accordance with instructions dated November 1, a reconnoissance of Hampton Roads, Chuckatuck Creek, and Elizabeth River and tributaries was at once taken up to obtain information as to the necessity of further surveys. This work was completed, and a report submitted November 8, showing the necessity for complete surveys of the whole area.

In accordance with instructions dated November 14, work on a hydrographic and topographic survey of Hampton Roads was at once taken up. This work was in progress at the end of the calendar year. Signals necessary to the control of the hydrography and topography were erected, and observations made for their location and the location of prominent objects, of which many were uncharted. Three stations in the main scheme and about 25 prominent objects were located.

The commanding officer conferred frequently with the U. S. Engineers, the officials at the naval base, and others in order to coordinate the survey work and make the results as nearly complete as possible.

On January 1, work was in progress on the hydrographic, topographic, tidal, and current survey of Hampton Roads and vicinity, the party having headquarters at Hampton, Va. This work was continued throughout the remainder of the fiscal year and was in progress on June 30. A topographic sheet covering the north side of Hampton Roads and two sheets on the south side were completed. A hydrographic sheet covering the main part of Hampton Roads southward to Craney Island Flats was also completed. Seven current and seven tidal stations were occupied.

The triangulation was continued for the purpose of furnishing control for the hydrography and topography, and for the location of prominent objects for the charts. A special effort was made to make the list of prominent objects for the charts complete, and the legends selected were such as to make the objects easily distinguishable. A special effort was also made to verify the descriptions of old stations, and furnish descriptions, not only of all new stations determined, but of all old stations recovered for which no descriptions exist. Three

main-scheme stations and 42 prominent objects were determined by triangulation. All new stations were described, and recovery noted for 90 old stations prepared.

A large part of the time of the party was devoted to miscellaneous work in connection with transfer of vessels and launches from the Navy Department to the Coast and Geodetic Survey, shipment of launches to the Pacific coast, care and overhauling of vessels and equipment, and work in connection with condemnation and sale of the schooner *Matchless*.

The steamer *Onward* was received from the Navy Department on April 18, and brought from Norfolk to Hampton April 19. Work was at once started on cleaning, painting, and overhauling the vessel, to fit her for receipt of the personnel and equipment and to fit her for survey purposes. The vessel was placed in commission May 1, but work on her was continued, simultaneously with the field work, and was still in progress on June 30.

The launch *Almax II* was taken over from the Navy Department April 28, and the *Scandinavia* May 21. In addition to these, five others—the *Helianthus*, *Wildcat*, *Lydia III*, *Mikawe*, and *Audwin II*, taken over from the Navy by other officers—were turned over to the commanding officer of the steamer *Onward* for shipment to the Pacific coast. The *Helianthus*, *Audwin II*, and *Almax II* were shipped before the close of the fiscal year.

The commanding officer served as a member of the board of appraisal of the schooner *Matchless*, the report of which was submitted April 26. The *Matchless* was placed out of commission April 30, personnel and equipment being transferred to the steamer *Onward*. She was advertised for sale May 19, sold June 16, and delivered to the buyers June 30.

Under orders dated March 22, the commanding officer was instructed to cooperate with the commanding officer of the *Isis* in making arrangements for the shipment of launches to the Pacific coast on a Navy transport. Arrangements were successfully made, and three launches—the *Helianthus*, *Almax II*, and *Audwin II* were shipped on the U. S. S. *Huston*, leaving Norfolk April 12.

[H. A. SERAN, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Hydrography: 6 tall hydrographic signals built, total height 324 feet.

During the period from March 31, 1919, to June 20, 1919, the steamer *Bache* was being repaired at the Coast Guard station, Arundel Cove, Md., Speddins Shipbuilding Co., Baltimore, and at the Norfolk Navy Yard. An officer was assigned to act as the representative of the Survey while these repairs were in progress.

On June 22 the vessel was turned over to the Survey, although the Navy Department had yet to finish certain items of repairs and furnish a sounding machine.

From June 20 to June 30 the vessel was at the navy yard, Norfolk, Va., obtaining supplies, preparing buoys for use as signals on the offshore hydrography, and installing a sounding machine.

Arrangements were made with the superintendent of lighthouses of the fifth lighthouse district for the loan of six second-class, tall-type can buoys to be used as offshore signals in accordance with previous Coast Survey practice. As the Lighthouse Service could not furnish the necessary chain and anchoring gear, arrangements were made with the Bureau of Ordinance, Navy Department, for the loan of such mooring material as was necessary to take the place of chain, etc. This material had been used in connection with the defense net across the Capes of the Chesapeake.

As the buoys for offshore signals were to be placed in the fairway to the channel at the approaches to Chespeake Bay, it was decided to equip each of the buoys with a light similar to the temporary light established at times by the Lighthouse Service. Specifications were drawn up, advertised, and a contract let with the Alexander Millburn Co., of Baltimore, Md., to furnish six such lights. The lights consist of a marine lantern, with fresnal lens, equipped so as to show a steady white light about 8 feet above the top of the buoy and inside the superstructure. The gas for the light is furnished by a Prest-O-Lite tank and reduced to suitable pressure. The lantern and tank are securely fastened to a frame which is to be fastened to the superstructure on the buoy with eight braces.

In order to start field work with little delay after the transfer of the vessel from the Navy, a subparty was organized. This party built the signals necessary for the work while the vessel was being repaired at Baltimore and Norfolk.

Two 100-foot signals were erected, one near the site of Ship Shoal 3, 1915, about 5 miles north of Cape Charles and at the northern limit of the work, and the other on the site of Mink Hill, 1915. It was the intention to build a third 100-foot signal at or near the site of Bel, 1915, but as this part of the island is suffering greatly from inroads from the sea, anchors for the guys could not be placed. This part of Smith Island is entirely under water at high tide at the present time. To have built a tall signal at this point would have required more money than was available at that time. A 40-foot signal without far-reaching guys was erected instead.

In addition to the two tall signals and the 40-foot signal mentioned in the preceding paragraph, the subparty built three more 40-foot signals on Smith Island at or near the sites of previous signals.

The officer in charge of the subparty left Baltimore on May 15, and reported on board the *Bache* at Norfolk, Va., at the completion of the signal building on June 20. The greatest difficulty experienced by the subparty was the transporting of the materials for the signals to the various sites.

SOUTH CAROLINA.

[A. C. WITHERSPOON.]

SUMMARY OF RESULTS.—Triangulation: 21.9 square miles of area covered, 3 signal poles erected, 12 stations in supplemental schemes occupied for horizontal measures, 31 geographic positions determined.

Between February 26 and April 22, 1919, a revision was made of the triangulation in the vicinity of Charleston, S. C., in order to make available for use on a new edition of Chart 445, the results of a number of recent surveys by the United States Engineers and others, and to locate prominent points of a permanent nature that could be used as landmarks for navigation purposes.

Copies of surveys and maps by the United States Engineers, naval authorities, transportation companies, and local municipal officers showing the most recent soundings and changes in shore line due to new construction or natural changes, were obtained.

Eleven prominent points were determined by triangulation for use as landmarks.

GEORGIA.

[W. H. KEARNS.]

In accordance with a request from the construction division of the War Department a hydrographic survey was made of the Turtle River, Ga., from a point near the Southern docks, which was the limit of a recent survey, to a point beyond Crispen Island.

The constructing quartermaster of the picric acid plant at Brunswick furnished quarters for the chief of party and his assistant, and supplied the necessary laborers and material, and a launch for the transportation of the party.

The picric acid plant was situated near Southern Junction railroad station about 8 miles north of Brunswick, and about 2 miles west of the Turtle River. It occupied about 6 square miles of woodland and swamp land between Turtle River on the southwest and Southern Junction on the northeast.

Crispen Island is a low lying, sparsely wooded island on the east shore of the Turtle River about 3½ miles north of the Southern Railway docks. On this island were to have been placed warehouses and docks, and a roadway was to have been built over the marsh from the plant to the docks.

In the Turtle River between this island and the Southern Railway docks the chart showed depths of 25 feet with places of 15 and 18 feet, and it was requested that since the previous survey, which was made in 1856, was more or less preliminary, that a complete survey of the river be made from Southern Railway docks to beyond Crispen Island so that the amount of dredging could be ascertained, and that ships drawing 25 feet of water could proceed up to Crispen Island.

The launch *Polaris* furnished by the constructing quartermaster was found unsatisfactory. Another boat was hired from the fishing fleet at Brunswick which proved more satisfactory.

The work was begun with all possible dispatch, and an attempt was made to bring the triangulation up from Brunswick and sound out the shoal area lying off Little Crispen Island as rapidly as possible so that dredging could be done immediately. However, shortly after the signing of the armistice,

orders were received from the War Department to close down the plant, and the work of building the road to Crispen Island was stopped. The preparations for the building of the docks at Crispen Island were also stopped, and therefore the immediate need for the survey ceased. The constructing quartermaster, however, still thought it advisable to survey the river, and continued to finance the work.

It was necessary to extend the triangulation up from Brunswick, and therefore stations Bly, Buz, and S. E. Base, which were old established stations, were recovered. The scheme of triangulation consisted of five quadrilaterals. Nine new stations were established as the main-scheme stations and were marked. Five stations were marked by standard disk stations and reference marks, namely, Road, Tel, Hen, Dil, and Creek. Four other stations were marked by a copper nail in a 2 by 4 post sunk flush into the marsh, namely, Marsh, Bog, Herm, and Dil. Two other stations were cut in and marked by 2 by 4 posts sunk into the marsh, namely, Flag and Isle. Cuts were taken from the different stations to the various natural objects in the vicinity, such as the tank at the Southern docks, dolphins in the river, and the stack at the picric acid plant.

A tide gauge was established at the Southern Railway docks, and also one at Crispen Island, and tidal observations were made at these points. There was no tide gauge at Brunswick, and so a gauge was established there, and simultaneous observations were made with the stations at the Southern docks and Crispen Island, so that a plane could be established from the bench marks at Brunswick.

Bench marks were established at Southern Railway docks and at Crispen Island, and were connected by levels to the tide staffs.

The topography of the Turtle River included the entire river from above the Southern docks to a point above Crispen Island.

J. S. Caruthers, inspector in local charge, United States Engineer Department at Brunswick, assisted in the work in every way possible, and loaned his launch to the party on several occasions.

Several buildings in Brunswick which have been located by previous triangulation were listed as useful aids to navigation.

The construction of a float pipe for an automatic tide gauge which was being built by the Brunswick Marine Construction Co. at Brunswick, Ga., was inspected. Specifications for the construction and installation of this pipe were furnished by the Washington office, and the work was afterwards completed according to the specifications.

On January 4, 1918, when the survey at Brunswick was completed, the chief of party proceeded to Fernandina, Fla., and installed this float pipe at the tide station there.

FLORIDA.

[H. LEYPOLDT.]

Between January 1 and March 31, 1919, a resurvey was made of Key Biscayne Bay from its head to latitude 25° 35′, about the latitude of Fowey Rocks and Soldier Key, and the outside coast between the same northern and southern limits, extending just beyond the 10-fathom curve.

A tertiary scheme of triangulation had been executed during December, 1918, which gave good control of the work in the bay, and sufficient points, visible from the outside coast, were located, enabling the topographer to traverse between positions located topographically from prominent objects located by triangulation.

The coast and other land features are low and flat, wooded where not under cultivation, or else cleared for towns and townsites.

The topography was done on two 1:20,000 projections. A 1:10,000 sheet was completed. This sheet embraced the improved sections of this vicinity, namely, the city of Miami and the town of Miami Beach.

Extensive improvements in channels, buoyage, water front, viaducts, and towns necessitated a resurvey to keep the chart in proper relations to actual conditions. Large concrete water towers, conspicuous on the flat coast, were located so that mariners, in the steamer track through Florida Strait, could determine their position with accuracy when the new chart becomes available. A number of groundings by deep-draft vessels along this coast resulted in an 18-foot (position doubtful) sounding being placed on the chart. Unsuitable weather conditions prevented a thorough search for this feature, but the ac-

complished work is sufficient to show that the position given for this shoal is erroneous, due no doubt to the fact that no coastal features, either natural or artificial, were available for a better location except by estimating the distance from shore which, in hazy weather, is highly misleading.

Tidal stations were maintained at Miami, Cape Florida, Cutler, and Government Cut. It was impossible to establish a staff on Fowey Lighthouse, as a constant breaker washes the bottom of the structure. Soldier Key was also impracticable, as there was no one on the island to observe tides. The station at Miami was an automatic tide gauge; the other were staffs.

The old work was preliminary in character, and hydrography shown on the chart was insufficient for safe navigation.

The wind effect on the tides in Key Biscayne Bay is considerable, and a reference plane for sounding is unsatisfactory unless mariners are cautioned to make proper allowance for the variation of depths due to this cause.

[CHESTER A. OBER, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Triangulation: 56.7 square miles of area covered, 31 signal poles erected, heights from 10 to 14 feet; 5 buoy signals with superstructures constructed, heights 12 to 14 feet; 4 observing tripods and scaffolds built, heights 64 and 48 feet; 3 stations in main scheme occupied for horizontal measures, 5 stations in supplemental schemes occupied for horizontal measures, 7 geographic positions determined. Leveling: 4 permanent bench marks established, 7.2 miles of levels run. Magnetic work: Ship swung at one sea station. Topography: 2.5 square miles of area surveyed, 14.3 miles of general coast line surveyed, 2 topographic sheets finished, scales 1:15,000. Hydrography: 72.2 square miles run while sounding, 6,833 positions determined (double angles), 48,251 soundings made, 2 tide stations established, 3 current stations occupied, 1 hydrographic sheet completed, scale 1:15,000.

On January 1, the *Hydrographer* was at Baltimore, Md., having completed the season's repairs, and made the necessary preparations for proceeding to Key West, Fla., to take up work requested by the Navy Department.

The vessel reached Key West safely on January 21. Consultations were had with naval officials; arrangements were made for obtaining coal, water, and certain supplies from the Navy; bids were put out, boilers cleaned, and on January 29, field work was begun.

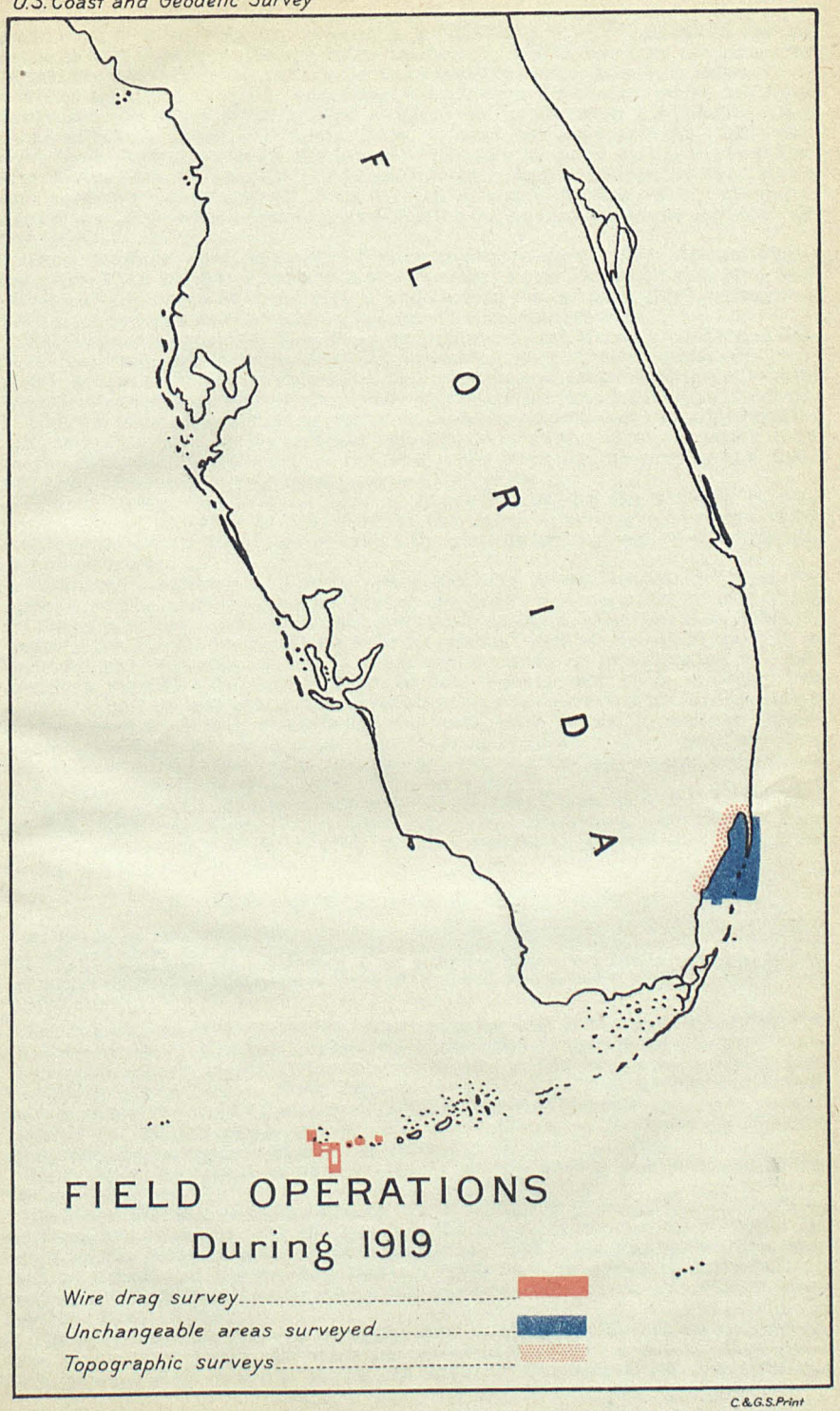
Twenty-two hydrographic signals, from 10 to 14 feet high; five hydrographic signals (tripods), 20 feet high; four triangulation signals (tripods), 24 feet high; four scaffold signals, 48 and 64 feet high, were erected. Five water signals (buoys) were placed in position by the Lighthouse Service; on two bell buoys superstructures or cagings were built, 12 and 14 feet high.

Observations were made with a 6-inch Berger repeating theodolite. Two bases were used; one from Sand Key Lighthouse to Key West Lighthouse, the other from Sand Key Lighthouse to Vote, (on Woman Key). There were necessarily a number of eccentric stations. It was intended that all measurements be remade, but as there was no opportunity for such work and as the differences in length found in the double determination of each distance came within the allowable maximum error, the observations were accepted as made.

Because the Navy had made several noticeable changes at Woman Key, the shore line and topographical features of this island were revised. Use was also made of the plane table to locate hydrographic signals. At Boca Grande Key, the small opening in the southwest side no longer exists. This was not noted until after the location of hydrographic signals had been accomplished, and when the command was transferred to G. C. Mattison, a memorandum was made of the need for revision of shore line at Boca Grande.

Three new tidal bench marks were established on the north part of the first island south of the large crescent-shaped key forming the northeastern half of the Marquesas group. These were connected by levels with the tide staff of 1919. One new bench mark was established at Sand Key Light, and all bench marks there connected by levels with the tide staff. At Key West the automatic tide gauge staff was connected by levels with the numerous bench marks in Key West and at Fort Taylor.

In the areas covered by the ship hydrography, 100-meter north and south lines were crossed by one-fourth-mile east and west lines, and shoal indications were developed. Sheet 2, which extends from Key West to Boca Grande, has all its ship work completed. A junction was made with sheet 3, which extends from Boca Grande to the western side of Marquesas, and work on sheet 3 was in a favorable state of progress at the date of the transfer of command. No splits or detached areas were left. Sheet 1, to the southward and east-


FLORIDA
FIELD OPERATIONS
During 1919
Wire drag survey
Unchangeable areas surveyed
Topographic surveys

ward of Key West, was left untouched, as the Navy has no immediate use for work in that locality. Sheet 4, offshore sheet, 1:40,000, has only the lines run in making the test of the new Coast and Geodetic Survey sounding tubes.

Work with launch *BBB*, and later with launch *Mandalay*, made favorable progress. On sheet 2 all except a very few areas were completed. One-hundred-meters north and south lines, crossed by one-fourth-mile east and west lines were also run by the launch. Through the keys to the westward of Key West, there is a small-boat channel, which was developed by the launch and used for running from Boca Grande Channel to Key West, whenever heavy seas prevented or endangered small-boat navigation north or south of the keys.

Three stations were occupied for current observations: Boca Grande Channel; Key West Harbor (just south of Frankfort Bank Beacon); and Man Key (about 1 mile south of the southern and eastern end of Man Key). Complete data were entered in the record book for current observations.

The automatic gauge at Key West was placed in satisfactory running condition, and frequent inspections made, to insure an unbroken series of readings. A new staff was furnished for this station, and samples of the old staffs were forwarded to the office. A report on this station was made early in April.

Computations, description of stations, work on sheets and records, reports, and accounts, take up no inconsiderable portion of the *Hydrographer's* time in the field, and voluntary overtime and night work on the part of the chief of party, officers, and crew deserve especial mention.

Several minor repair items were accomplished during the working season, with little or no delay to the work in the field. The first officer and chief engineer deserve a good deal of credit for the efficient upkeep of their respective departments.

Whenever possible, the *Hydrographer* left Key West Monday morning, remained on the working grounds during the week, and returned to Key West at the end of the week for water, coal, and supplies. For work on sheet 3, water signals were used. These floating signals were located each day; it is believed, however, that an ebb or flood tide position, or certain wind and sea positions, may be determined. High scaffold signals were used, in order that control might be had out to the 100-fathom curve. A few small hydrographic signals, used for launch work inside the reefs, were located by sextant angles. Plane table location could have been made only after a great deal of work and loss in time, because the mangroves overhang the shore, and a depth of 3 to 5 feet of water is found close to the mangroves.

Close cooperation was maintained with the Navy and with the Lighthouse Service. The latter placed five buoys to be used as floating signals, and also granted permission for the placing of cross targets on several of the beacons in the vicinity of Key West.

[G. C. MATTISON, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Triangulation: 1 scaffold built, height 63 feet. Topography: 2.3 miles of shore line of rivers surveyed. Hydrography: 45.6 square miles of area covered, 590.4 miles run while sounding, 3,192 positions determined (double angles), 20,072 soundings made, 1 current station occupied; scale of hydrographic sheets 1:15,000 and 1:40,000.

On June 4, the command of the *Hydrographer* was transferred from Chester H. Ober to G. C. Mattison. The vessel immediately proceeded to Marquesas Keys, and rebuilt triangulation station South, a 63-foot scaffold, which had previously blown down. Three days were spent in rebuilding this signal, and as it required the whole available deck force, the ship occupied a current station latitude 24° 30′, longitude 82° 04′ 45″ for a period of 52 hours, the launch being used to transport the working party to and from the ship.

Practically the whole of the remainder of the month was spent in doing hydrographic work.

Hydrographic signals on Marquesas were relocated by plane table. A previous traverse had been run, but the traverse did not close on stations formerly located by the party under Assistant Hodgkins. The error was found, however, and the signals are now properly located. This work was done on hydrographic boat sheet No. 3, it not being considered necessary to make a topographic sheet for this short traverse.

The only sounding done by the ship was on sheet No. 3. No indications of new shoals were found, nor were any shoals developed. A few offshore lines were run on sheet 4, south of Coalbin Rock. The new Coast and Geodetic

Survey sounding tubes were used, but a weakness was found to develop after several days' use in that the collar which holds the pivoted clamp works loose, owing to the great pressure; otherwise these tubes are apparently satisfactory.

The areas in the vicinity of Boca Grande, Man, or Woman Keys were completed by the launch. However, there remain a few shoal indications to be developed. It was necessary for the launch to do this work, as unfavorable weather conditions made it impossible to work in more exposed waters. A little sounding was done by the launch south and west of Marquesas on sheet 3.

Tide observations were made at Sand Key Lighthouse during this period by the lighthouse keepers. Marquesas tidal station was occupied for a period of 50 hours. This was done during a period of bad weather, and the launch was anchored at the tide station with three men using it as quarters. During this time it would have been practically impossible for the launch to do any sounding. Tides were read during the day at Marquesas for work on sheet 3, a seaman from the *Hydrographer* being used for that purpose. Automatic tide gauge at Key West was in operation during this period. A new tide staff was installed at Sand Key to replace the old one in use there.

Orders were received on June 12 to cooperate with the naval air service in experimental work to ascertain whether or not it is feasible so to photograph the coral heads that areas so photographed will not have to be wire dragged. The naval air station at Key West did not receive instructions until June 27. The first work done was on June 30. A series of 24 photographs were taken, and it was the intention to take more, but the plane had developed engine trouble, and found it necessary to return to Key West.

The results were not very good on this day owing to the high range of tide, the current running in and out of the channel near Key West keeping the water in clouded condition. A great many of the charted shoals did not show at all on the photographs. These photographs were taken at elevations varying from 2,300 to 4,300 feet. A high-power camera was used, and those shoals which did show on the photographs were as clear at an elevation of 4,300 as at 2,300 feet.

[E. E. REESE.]

SUMMARY OF RESULTS.—Signal building: 3 main points selected for erection of signals, 1 hydrographic signal built, height 103 feet.

On June 2 instructions were given for the erection of signal towers for offshore hydrography on the Gulf coast from a short distance east of Pensacola, Fla., to Mobile Bay. From June 2 to 8 the time was spent at the Washington, D. C., office preparing for field work, including ordering wire at Washington, and sending out proposals for hire of launch. June 9 and 10 were spent en route to Pensacola, Fla.

Field work began June 11, and the period June 11 to 22 was spent in getting outfit together, organizing party, and hiring launch. Much difficulty was encountered in getting a launch.

Actual signal building began June 23, and one tower was completed by the end of the month. This is 103 feet above ground, and 120 feet above sea level. This is the second tower from the east end of the work. In order to save time, the signal farthest east was left until after the larger and faster launch was available.

LOUISIANA.

[J. B. BOUTELLE.]

During the fiscal year an officer has continued on duty at New Orleans as inspector for the Gulf of Mexico, during the greater part of the time engaged in the usual work of the office, attending to official correspondence, distribution and sale of charts and publications, supplying information in reply to requests from officials and from the public, and collecting information required for the correction of the charts.

From September 7 to 9 the inspector was at Pascagoula, Miss., engaged in revising the topography of that harbor.

In August the board of commissioners of the Public Belt Railway of New Orleans requested data and instruments in order to make surveys on the Mississippi River to show the practicability of building a bridge over or a tunnel under the Mississippi River at that place.

Information was furnished, and the necessary instruments were loaned to the engineer of the commission, and the inspector aided him when he was unable to obtain other expert assistance.

Blue prints, maps, and information for the correction of charts, obtained from the United States Engineers, and from other sources, were forwarded by the inspector to the Washington office.

Charts, publications, and information relating to surveys were furnished in reply to numerous requests from officials or others.

A stock of charts, and nautical publications was kept on hand for reference.

In January, and again in June, topographic information in reference to harbor improvements was collected at Mobile, Ala., and current apparatus was installed on Heald Bank lightship. In February repairs to the tide gauge at Fort Morgan, Ala., were supervised, and an inspection trip was taken with the superintendent of lighthouses from Morgan City to New Orleans, by way of the Gulf of Mexico and inland routes.

[F. H. HARDY, Commanding Steamer *Surveyor*.]

SUMMARY OF RESULTS.—Hydrography: 62 deep-sea soundings made, 29 observations of bottom temperatures made, 43 observations of surface temperatures made, 57 bottom specimens preserved.

The steamer *Surveyor* left Norfolk, Va., April 21, 1919, under instructions to proceed to the Pacific coast by way of the Panama Canal. Deep-sea soundings were made during the voyage, beginning on April 22, from latitude 34° 00′, longitude 71° 40′ to San Salvador, and across the Caribbean Sea, and thence to a point off the coast of Lower California, the last sounding being taken on May 18.

[R. R. LUKENS, Commanding Steamer *Wenonah*.]

SUMMARY OF RESULTS.—Hydrography: 39 deep-sea soundings made.

The steamer *Wenonah* left New York for the Pacific coast by way of the Panama Canal on May 22, stopping at Norfolk, Va., to install a deep-sea sounding machine, and also stopping at Kingston, Jamaica, for coal and supplies.

Deep-sea soundings were begun off Cape Hatteras, and 37 soundings were made between Cape Hatteras and Colon where the vessel arrived June 26.

The vessel left Kingston, Jamaica, at 7 a. m., June 21, and proceeded to take up the sounding line to Colon.

Just outside of Kingston Harbor, a very heavy southeasterly sea was encountered, accompanied by a fresh breeze from the same direction. Although it was very rough, three soundings were attempted without success, due to the excessive pitching and rolling, and it was considered that to continue operations would only mean a loss of material, which was already running short.

Accordingly sounding was discontinued, and the vessel proceeded on her course, making very bad weather of it rolling 30 to 42 degrees, with the alleyways filled with water. Neither officers nor men could sleep below, and there was spray over the decks constantly, making sleep there impossible.

At daylight, June 23, the wind moderated enough so that two soundings, one of 1,700 and the other of 1,900 fathoms were made. The ship passed through the breakwater at 10.30 p. m., June 23, and anchored in Colon Harbor.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, PACIFIC COAST.

CALIFORNIA.

[ARTHUR JOACHIMS.]

SUMMARY OF RESULTS.—Hydrography (wire drag): 23 square miles of area dragged, 69.2 miles run while dragging, 298 positions determined (double angles), 1,129 soundings made, 2.3 square miles of area sounded, 25.5 miles run while sounding, 4 hydrographic sheets finished, scale 1:12,000.

Between May 5 and June 3, 1919, a wire-drag survey was made around the entire shore of Lake Tahoe to discover dangers to navigation. The survey was made at the request of and in accordance with the requirements of the United States Reclamation Service.

It was only after a careful study was made of the hydrographic sheets by the Reclamation Service and of the lake itself, that a definite conclusion could be reached as to the logical effective depth to drag. This matter was discussed with the project manager of the Reclamation Service at Fallon, Nev., who emphasized the importance of dragging in close to shore, as it was here only that obstructions could be expected, since with few exceptions deep water could be found within 500 yards of the shore. A definite conclusion was reached by the assistant engineer, United States Reclamation Service, assigned to

cooperate in the wire-drag work, and the chief of the drag, that they could drag completely around the shore of the lake carrying an effective depth of 16 to 17 feet for the present height of the lake, which, if corrected to a datum of 6,223, would be about 12 feet effective depth. For the purpose of getting in close to shore it was agreed that they should hook up the two inshore buoys to 12½ and 13 feet.

The hydrographic sheets of the Reclamation Service show two-thirds of the shore of Lake Tahoe to be rather bold and dropping off into deep water, and the other one-third consisting of shoal shelves covered in most cases with large bowlders, and in a few instances, clear sand. These shelves run out from 200 to 500 yards, except in two or three instances where they extend out about three-fourths of a mile. At their outer edge they drop boldly into deep water. Considering the type of navigation to ply on the lake, namely, boats drawing from 3 to 7½ feet, it was important to drag these shoal shelves, over which it was in general only practicable to carry 16 to 17 feet. Also, the time allotted for the work was so limited that attention was given only to the most important parts. From the outer limits of these shoals extends blue water which, owing to the clearness of the lake, signifies that it is quite deep. It was requested that all the time be spent on work over the shoal areas, as the whole purpose of the survey was to locate any obstructions to navigation which had been missed on these shoals by the previous hydrographic survey of the Reclamation Service.

A drag strip of from 1,700 to 1,900 feet was run with an effort to keep as closely inshore as possible. A number of shoals, in most cases bowlders, were located with one-half foot to 7 feet of water over them.

There were four sheets covering the work of this survey, which include the complete area of the lake. They were made on a scale of 1 inch to 1,000 feet, which was requested by the Reclamation Service. The soundings taken on drag shoals were plotted in ink.

Sheet No. 1 begins at Sugar Pine Point, on the California coast, and extends to Tahoe Vista, which is about 1 mile west of State Line Point.

Sheet No. 2 starts where No. 1 ends and extends around the Nevada shore to a point about three-fourths mile south of Glenbrook. A drag strip of 1.700 to 1,800 feet was run completely around the shore line and inshore as close as it was possible to drag. The two important points on this sheet by way of shoal are at State Line Point and off the point marking the southern limits of San Harbor.

Sheet No. 3 continues from sheet No. 2 and extends to a point 1.5 miles west of Tallac.

Sheet No. 4 continues from sheet No. 3 and overlaps on sheet No. 1, making a closure of the drag survey around the lake.

Bowlders off State Line Point are exceedingly dangerous, as it is natural for vessels to stand in close to this point when enroute from Crystal Bay to the city of Tahoe. They are also deceiving in that blue water can be found only a few yards out board from them.

The bowlder shoal off the southern point of Sand Harbor, the one just south of Glenbrook, and also off Zephyr Cove, since they offer no warning to vessels, deep water surrounding them, are dangerous.

The entrance to Emerald Bay is bordered on both sides by bowlder reefs that on the north side extend about half way across the entrance and contain very dangerous bowlders. The south side does not extend very far out from shore, however, it also is very foul with bowlders. So the channel is only 85 yards in the narrowest place and has a sand bottom. It is a level bottom with an average depth of about 8 feet at 6,223 elevation of the lake. Emerald Bay was dragged, and no dangers discovered after passing the entrance.

Off the city of Tahoe a number of dangerous bowlders were discovered, which are of importance in that this place at present is most frequented by vessels.

A number of minor shoals were discovered a knowledge of which is important to vessels skirting the shores of the lake.

If the elevation of the lake was lowered to 6,223, the results of this survey would show definitely the conditions of the areas bordering the shore, since the survey was made on that datum. So far as the bowlders are concerned, it would in most cases be a benefit, since a number of them would be awash and could be seen more readily. It is true, however, that the shoals off the cities of Tahoe and Bijou, having less water, would make docking at these places difficult for vessels drawing over 7 feet. The docks, on the other hand, could be lengthened, and in that way meet the requirements. The important factor is not so much the elevation as is the range. A large range would vary conditions so

that those navigating the lake would have to build their docks to meet the conditions of extreme low water, and at the same time they would always be subjected to figuring out the depths carried at various elevations of the lake. Any misunderstanding in this regard might lead to disaster.

Previous years of observations have shown that the lake never has reached an elevation lower than 6,223. In 1864 it reached the lowest of any known record which was 6,223.5. In 1862 it attained its maximum elevation of 6,231. That shows a natural range of 7.5 feet. For vessels drawing only 2 to 7.5 feet, which is the case with all vessels to consider on the lake, this range is of vital importance. The tendency would be to err in allowing for the height above the datum. To minimize the range and make it as near a constant as possible would be an aid to navigation. The ideal condition would be to keep the lake at a constant elevation. That condition is impracticable owing to the rapid rising of the lake during the early summer months when the snow begins to melt; also, during the year there is an annual evaporation of from 30 to 36 inches. These to a certain extent compensate, and there is no doubt that the elevation of the lake can be held more nearly a constant than its natural range would allow, by regulating the overflow at the Truckee River.

The commercial navigational interests of the lake are at the present time almost solely centered in the Bliss Transportation Co. which has one steamer and two launches plying on the lake. The steamer is the *Tahoe*, which is 172 feet long, and draws 6 feet. The launches are the *Meteor*, drawing 7 feet, and the *Nevada*, drawing 6 feet.

The *Tahoe* makes one trip a day around the lake during the summer, and one of the other two launches makes a round trip twice a week during the rest of the year.

The remainder of the navigation on the lake is that of pleasure launches owned by property owners, and run for their own use. These launches are, in the majority, boats which draw about 3 or 4 feet, and are from 25 to 50 feet in length.

Previously there had been a small amount of lightering on the lake when the Carson Tahoe Lumber & Fluming Co. was engaged at logging on the Nevada shore. This company has not operated for several years past.

True to the general understanding, Lake Tahoe is used almost solely as a summer resort. The people who make their homes here carry on industries which maintain the place as such. The total number of people remaining at the lake during the winter of 1918-19 was about 40, while it is estimated that about 6,000 are here during the middle of the summer season.

Along the California coast of the lake it is estimated there are at least 150 large summer homes, owned in the most part by wealthy people who spend their summer vacation at the lake. In addition to these homes there are 16 hotels, which accommodate from 50 to 500 guests each.

Along the Nevada shore there are few resorts, Incline and Glenbrook being practically all the settlements. These two places were originally started when the Lake Tahoe Lumber & Fluming Co. was operating on the lake.

The topographic features of the shores of the lake are of two classes. On the California shore there is a tendency to even mountain slopes leading down to the lake, while on the Nevada side the irregular granite mountain slopes quite frequently are steep and rugged. The lake appears to be locked in by mountains ranging from 1,500 to 5,000 feet above the level of the lake. There are, however, a number of draws through the mountains to the lake, the principal one of these being between Truckee and Tahoe, where the Truckee River flows.

These high mountains furnish large watersheds for Lake Tahoe, and during the early summer the water from melting snow feeds the lake by eight fairly large mountain streams. Truckee River, on the other hand, is the only outlet.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 8 miles, 18 square miles of area covered, 12 points selected for scheme. Triangulation: 20 square miles of area covered, 15 signal poles erected, 12 stations in main scheme occupied for horizontal measures, 19 geographic positions determined. Leveling: 25 miles of levels run. Topography: 10.5 square miles of area surveyed, 30 miles of detailed shore line surveyed, 7 miles of roads surveyed, 1 topographic sheet finished, scale 1:10,000. Hydrography: 4 square miles of area surveyed, 136 miles run while sounding, 1,389 positions determined (double angles), 8,856 soundings made, 2 tidal stations established, 2 current stations occupied, 1 hydrographic sheet finished, scale 1:5,000.

Between January 24 and April 2 a resurvey was made of Morro Bay, Calif., including topography and hydrography and the triangulation necessary for control.

Triangulation stations—White 1881, Black Hill 1881 and 83, and Cass 1883 and 1916—were recovered, the necessary signals erected, and the observations for the triangulation made between February 5 and 17.

Preparation was made to take advantage of favorable conditions for obtaining soundings in the entrance to the bay, but there were only two days on which it was possible to venture on the bar between February 12 and April 2. On these two days the necessary soundings outside the bay and on the bar were obtained.

The soundings taken indicate the width and depths in the approach to the bay on the south side of Morro Rock, and the width and depths to a limited extent on the north side of the rock. There is no practicable entrance on the north side of Morro Rock.

A large part of the area of the bay was covered by leveling instead of sounding from a boat. It was impracticable to pass over the higher flats in a boat.

At the southern end of the bay there is some area that is not covered by soundings. It was impracticable to pass over this area in a boat, and the mud flats are too soft to walk on.

The weather conditions are most unfavorable at this time of the year for surveying operations at Morro. Only one boat ventured outside the bay between January 24 and April 3. It was reported that she narrowly escaped swamping on her return.

An automatic tide station was operated at Morro during the progress of the work. A tide staff was read near the head of the bay when sounding operations were in progress, and a 48-hour series of readings were observed while the current observations were being made.

Two current stations were occupied for a series of 25 hours each.

[E. B. LATHAM.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 72 miles, 242 square miles of area covered, 45 points selected for scheme. Triangulation: 242 square miles of area covered, 35 signals erected, 25 stations in main scheme occupied for horizontal measures, 110 geographic positions determined.

After collecting data at San Francisco and making necessary arrangements, parties were organized at Eureka, Calif., in the early part of April, 1919, to search for old triangulation stations, and erect signals for use in offshore hydrography from Punta Gorda to the mouth of the Klamath River.

At the close of the fiscal year this work was approaching completion.

[F. WESTDAHL.]

SUMMARY OF RESULTS.—Hydrography: 0.5 square mile of area covered, 12.6 miles run while sounding, 394 positions determined (double angles). 761 soundings made, 1 hydrographic sheet finished, scale 1 : 5,000.

In July, 1918, instructions were issued for a resurvey of the Presidio Shoal, San Francisco Bay.

The field work was done between August 13 and 30, working only when the tide and wind were favorable.

The soundings were reduced and plotted, and the original sheet was forwarded to the Washington office on September 17.

A boat and crew were furnished by the Presidio Life Saving Station, and the assistant supervisor of the twelfth naval district detailed two officers of the naval reserve to assist in the work.

The resurvey indicates that the shoal has shifted its position by about its own width to the southward. It also indicates that the shoal has no rocky basis, being in fact formed by the meeting of the ebb currents from the northern and southern arms of San Francisco Bay, and the consequent release of the material carried in suspension by these currents. The greater amount of suspended material is carried from the northern arm of the bay, and where this current is reinforced by the volume rushing through Raccoon Strait and meeting the current from the southern arm, the greatest amount of material is dropped, forming the Presidio Shoal.

The shoalest water, 21 feet, was found in two places about 130 meters apart.

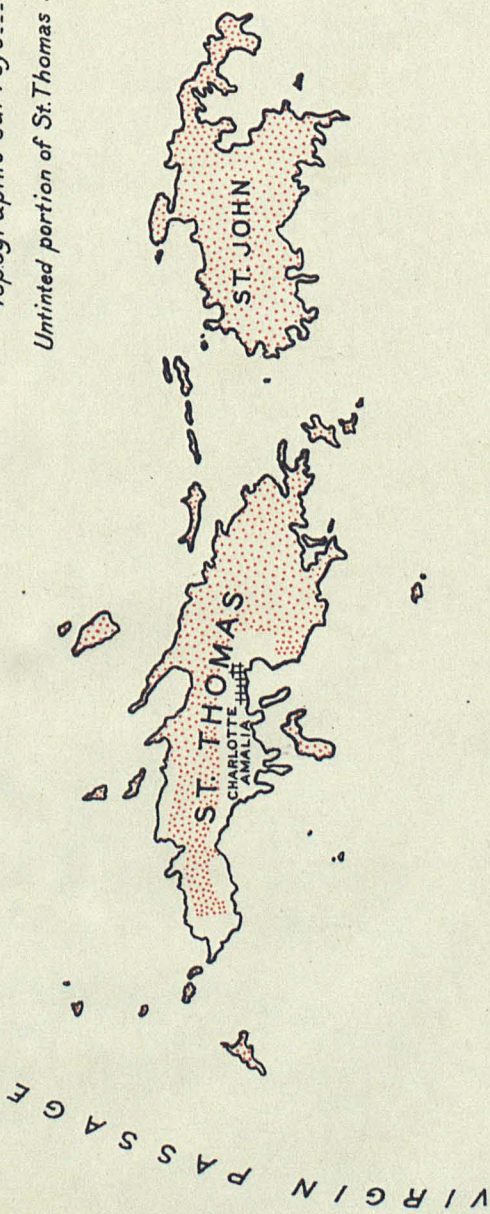
[E. F. DICKINS.]

An officer of the Survey has continued to serve as inspector of the Bureau for the coast of California, and in charge of the field station at San Francisco, Calif.

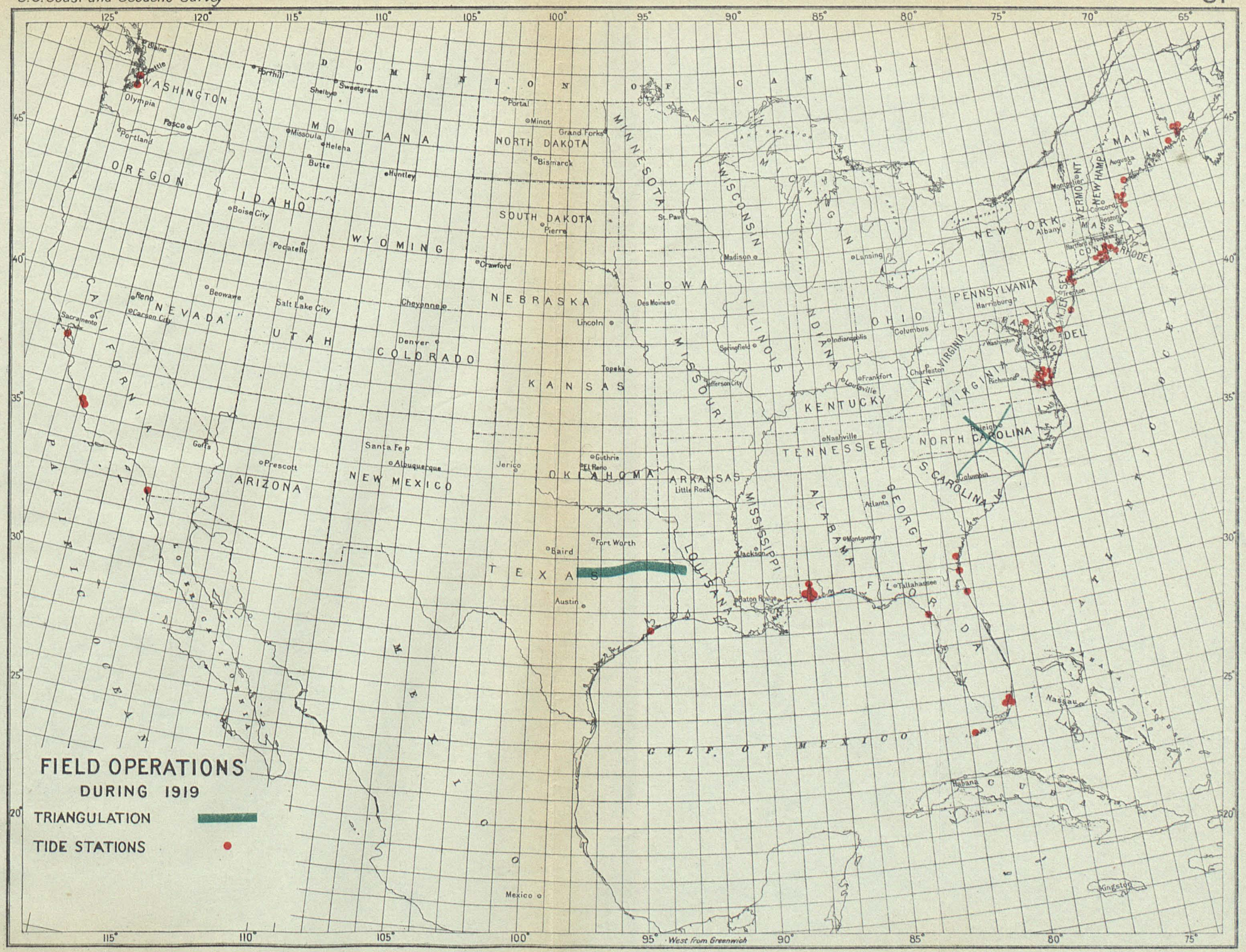
VIRGIN ISLANDS
FIELD OPERATIONS
1919

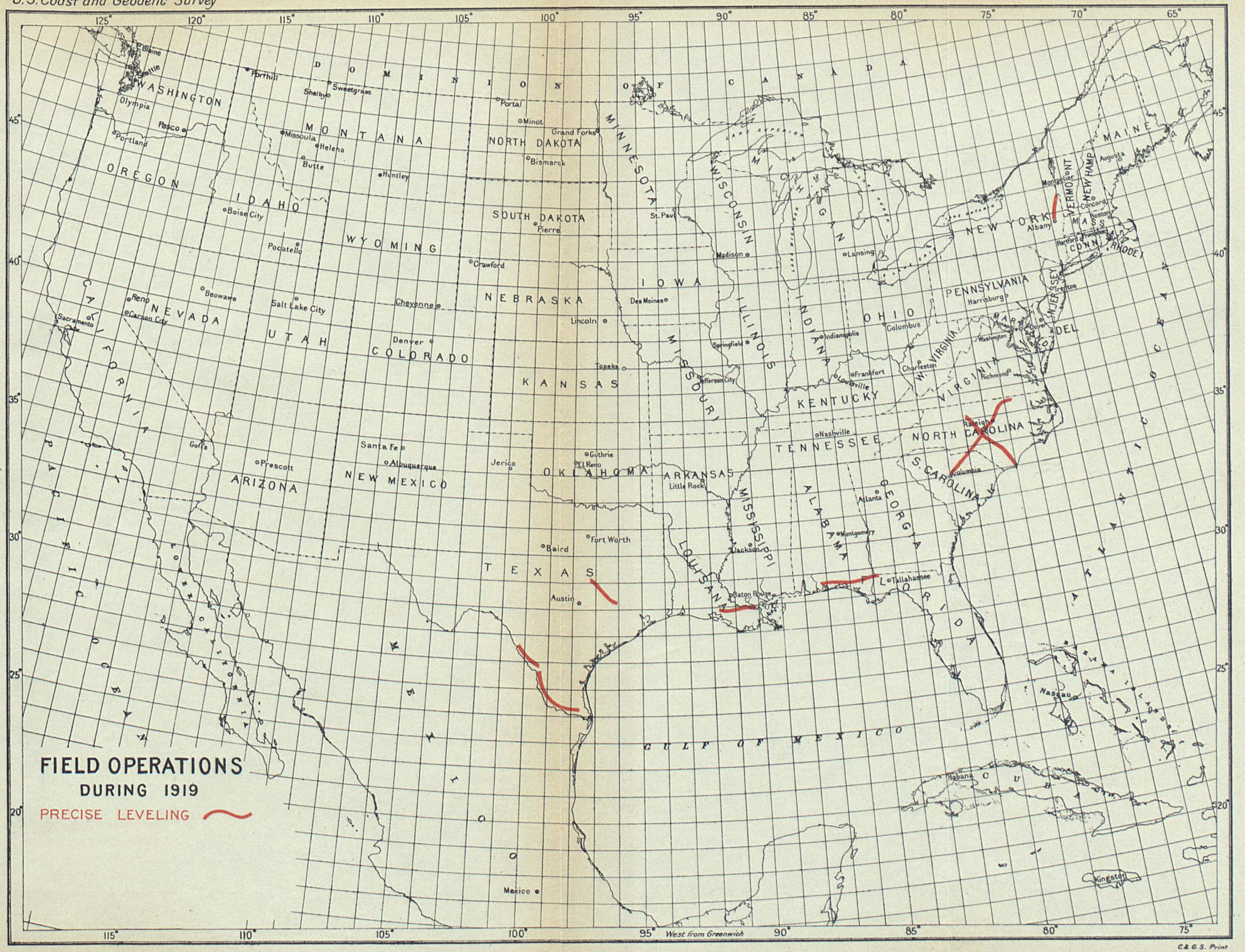
Topographic surveys.....

Untinted portion of St. Thomas surveyed in 1918



C. & G. S. Print


FIELD OPERATIONS
DURING 1919
TRIANGULATION
TIDE STATIONS
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMP.
MASS.
CONN.
RHODE I.
NEW JERSEY
MARYLAND
DEL.
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
CUBA
Blaine
Seattle
Olympia
Pasco
Portland
Forthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Goffs
Prescott
Santa Fe
Albuquerque
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Jerico
Guthrie
El Reno
Baird
Fort Worth
Austin
Mexico
St. Paul
Madison
Des Moines
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Charleston
Richmond
Raleigh
Columbia
Atlanta
Montgomery
Tallahassee
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Trenton
Harrisburg
Washington
Dover
Nassau
Habana
Kingston
West from Greenwich
C.&G.S. Print


FIELD OPERATIONS
DURING 1919
PRECISE LEVELING
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
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WISCONSIN
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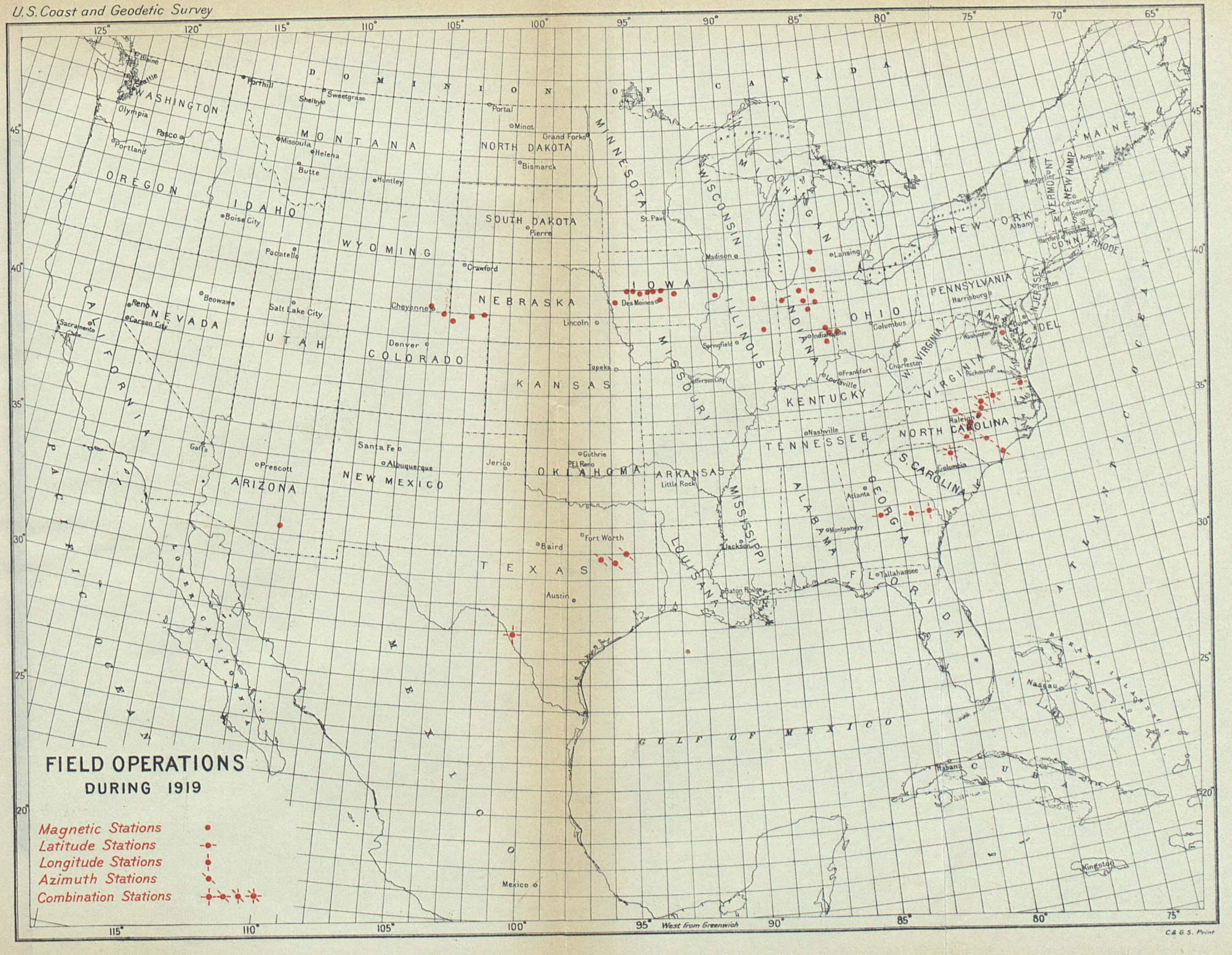
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
RHODE
NEW JERSEY
DEL.
MARYLAND
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
West from Greenwich


FIELD OPERATIONS
DURING 1919
Magnetic Stations
Latitude Stations
Longitude Stations
Azimuth Stations
Combination Stations
DOMINION OF CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
S. CAROLINA
NORTH CAROLINA
VIRGINIA
W. VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VERMONT
NEW HAMP.
MASS.
CONN.
RHODE I.
NJERSEY
MARYLAND
DEL.
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
CUBA
LOWER CALIFORNIA
Seattle
Olympia
Pasco
Portland
Bloine
Porthill
Sweetgrass
Shelby
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Beowawe
Reno
Carson City
Sacramento
Salt Lake City
Cheyenne
Denver
Goffs
Prescott
Santa Fe
Albuquerque
Portal
Minot
Grand Forks
Bismarck
Pierre
Crawford
Lincoln
Topeka
Jerico
Guthrie
El Reno
Baird
Fort Worth
Austin
Mexico
St. Paul
Des Moines
Madison
Springfield
Jefferson City
Little Rock
Jackson
Baton Rouge
Lansing
Indianapolis
Columbus
Frankfort
Louisville
Nashville
Charleston
Richmond
Raleigh
Columbia
Atlanta
Montgomery
Tallahassee
Albany
Augusta
Montpelier
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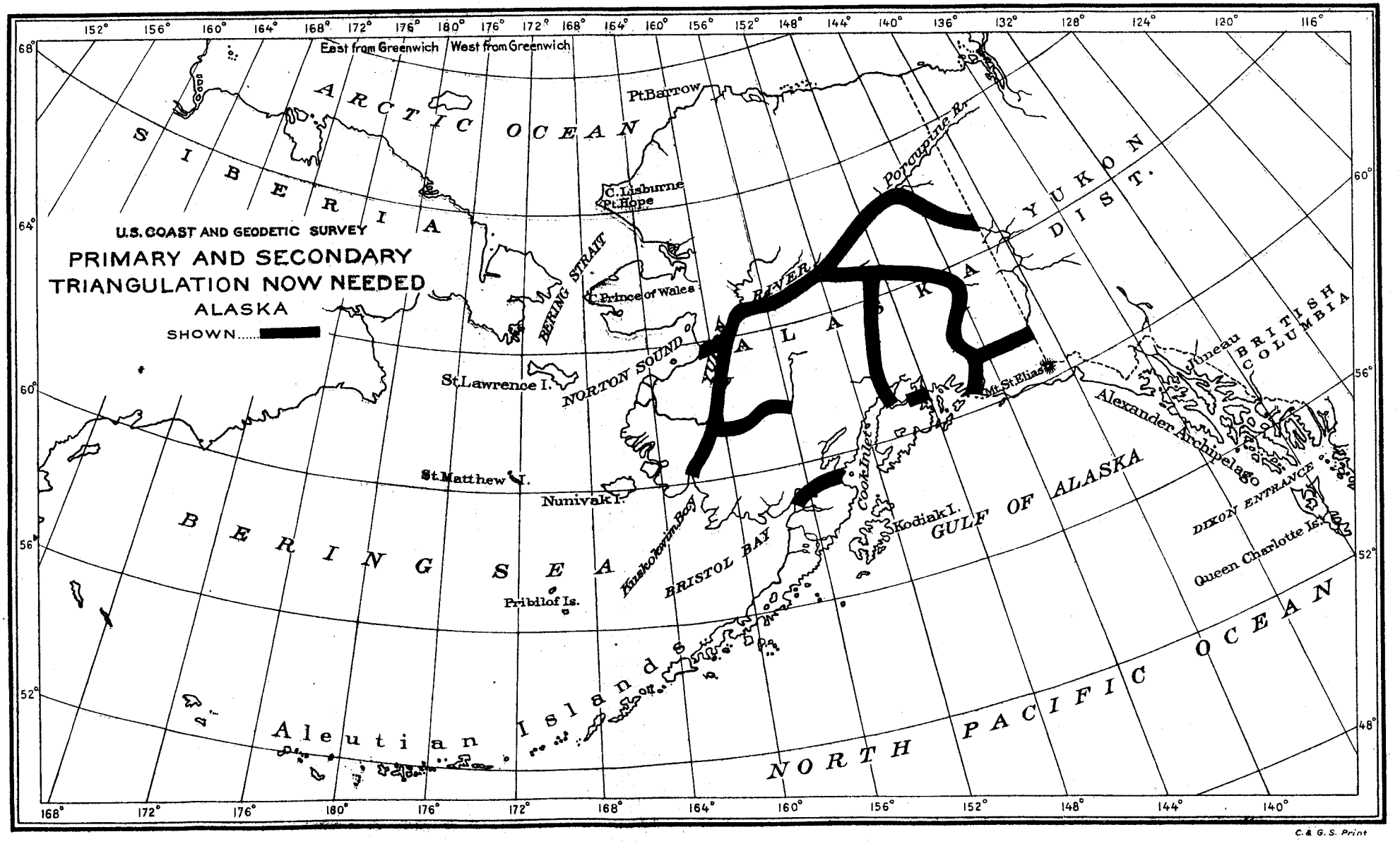
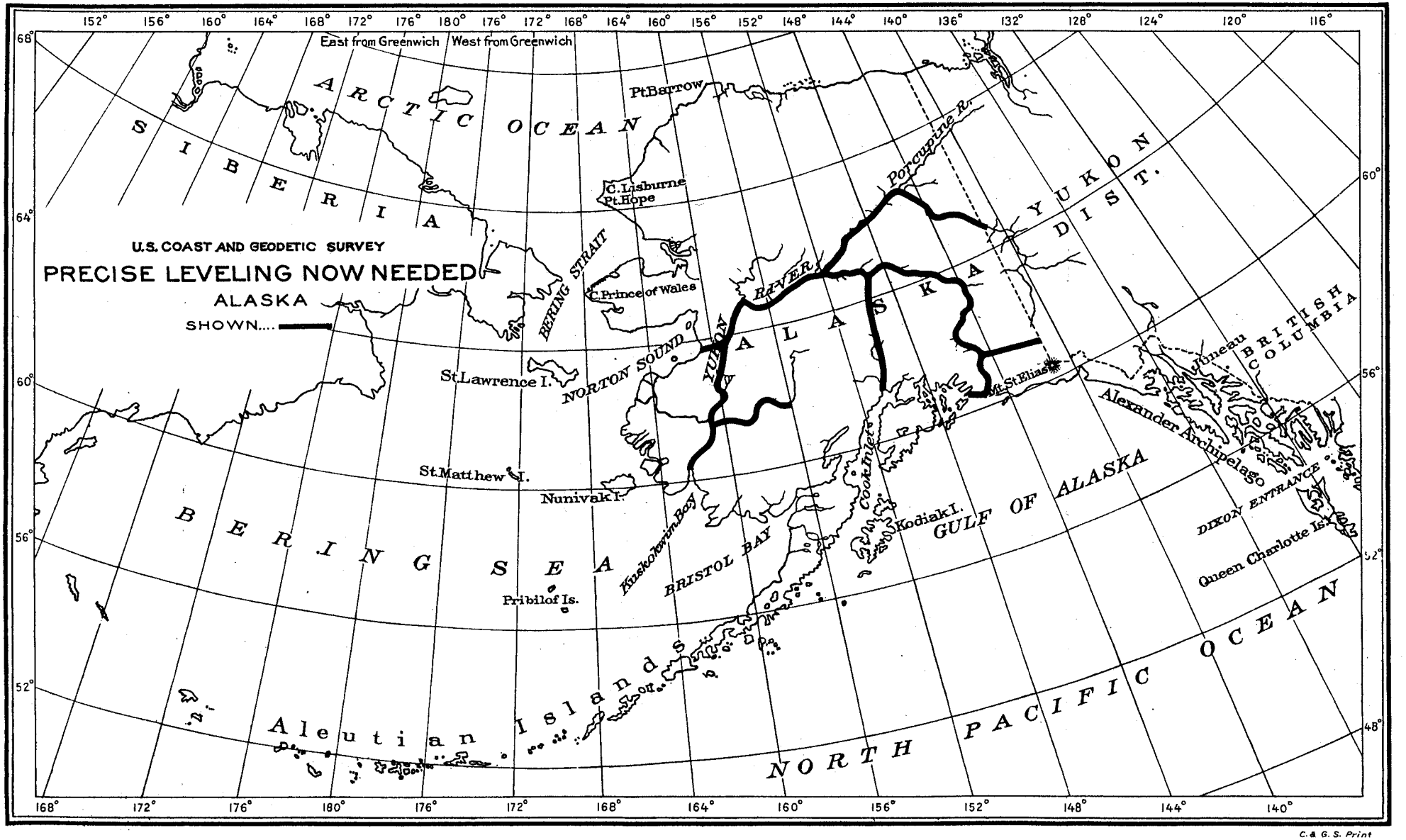
Washington
Dover
Nassau
Habana
Kingston
West from Greenwich
C & G S. Print


U.S. COAST AND GEODETIC SURVEY
PRIMARY AND SECONDARY TRIANGULATION NOW NEEDED
ALASKA
SHOWN.....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
BERING SEA
Pribilof Is.
Kuskokwim Bay
BRISTOL BAY
Aleutian Islands
NORTH PACIFIC OCEAN
Porcupine R.
YUKON DIST.
ALASKA
Mt. St. Elias
Cook Inlet
Kodiak I.
GULF OF ALASKA
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.

C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PRECISE LEVELING NOW NEEDED
ALASKA
SHOWN....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt.Barrow
C.Lisburne
Pt.Hope
BERING STRAIT
C.Prince of Wales
NORTON SOUND
St.Lawrence I.
St.Matthew I.
Nunivak I.
Kuskokwim Bay
YUKON RIVER
Porcupine R.
ALASKA
YUKON DIST.
BRITISH COLUMBIA
Juneau
Mt.St.Elias
Alexander Archipelago
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
BERING SEA
BRISTOL BAY
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
152° 156° 160° 164° 168° 172° 176° 180° 176° 172° 168° 164° 160° 156° 152° 148° 144° 140° 136° 132° 128° 124° 120° 116°
68° 64° 60° 56° 52°
60° 56° 52° 48°
168° 172° 176° 180° 176° 172° 168° 164° 160° 156° 152° 148° 144° 140°

C.& G.S. Print

The chief duty of this officer is the inspection of the navigable waters within his district, the collection of information necessary for the correction of the charts, coast pilots, and tide tables, and to furnish to the public information relating to the coasts of the United States.

Under the supervision of the inspector an automatic tide gauge was maintained throughout the year at the Presidio station, San Francisco, by means of which a continuous record of the time and height of the tide was obtained.

The field station has kept on hand a stock of charts and nautical publications for sale and reference; obtained information required for the correction of the charts and coast pilots; furnished information and charts to Government officials and others on application; supplied tidal information and advance notices affecting navigation for publication in the newspapers; attended to forwarding instruments and supplies to the field station of the Survey at Manila, P. I., and furnished transportation to officers of the Survey upon request.

A revisionary survey for the correction of charts was made in the vicinity of San Pedro, Calif., and an inspection was made of changes and corrections at Port Richmond and Ellis Creek to obtain information for the same purpose.

WASHINGTON.

[JOHN W. MAUPIN.]

SUMMARY OF RESULTS.—Reconnoissance: 5 square miles of area covered, 56 lines of intervisibility determined, 4 points selected for scheme. Triangulation: 14 square miles of area covered, 13 signal poles erected, 6 stations occupied for horizontal measures, 18 geographic positions determined. Leveling: 2 bench marks established. Topography: 8.4 square miles of area surveyed, 27.6 miles of general coast line surveyed, 11.8 miles of creeks surveyed, 11.3 miles of roads surveyed, 1 topographic sheet finished, scale 1:5,000. Hydrography: 1.7 square miles of area covered, 7,317 miles run while sounding, 993 positions determined (double angles), 3,063 soundings made, 1 tide station established, 1 hydrographic sheet finished, scale 1:5,000.

In compliance with instructions dated November 5, 1918, a party was organized for a revision of the chart of Commencement Bay, Tacoma Harbor, Wash., and the actual field work was begun on December 23, 1918.

The Tacoma city engineers were interviewed and a thorough reconnoissance was made of the entire water front before laying out the work which was considered necessary. One week was spent in signal building and searching for the old triangulation station before the triangulation observations were started. The weather proved so thick and adverse for triangulation that it was decided to locate sufficient points for beginning the plane-table work, and to complete the triangulation observations at a later date when weather conditions should improve.

With a few exceptions the methods employed were the usual Coast Survey procedure. Although the instructions called for chart revision work, so many changes were found in the Tacoma water front it was found necessary to make a resurvey of the water front, waterways, etc. Upon the advice of the inspector at Seattle, and with a view to future chart corrections, it was decided to do the hydrographic and topographic work on a scale of 1:5,000. All prominent objects which were considered essential to the construction of a new chart were located by triangulation. Two blue prints were obtained, showing all railroad tracks and other topographic features, and enough points were located on these prints for transferring to the chart. At several places the waterways were choked with logs, and it was found necessary to walk over the log rafts, taking many detached soundings, which proved to be slow and tedious work. A photostat copy of the previous work on a scale of 1:10,000 was used as a revision sheet for the topography outside the limits of the topographic sheet on which the present work was done. All the topographic features along the water front falling within the limits of chart No. 6451, were corrected on this sheet, and the hydrography was tested at a number of different places, but no changes could be found. With the exception of taking left angle, practically all the instrument work was done by the chief of party.

The tide flats at Tacoma are surrounded by highlands in most directions. It is due to this fact that the smoke from the many factory chimneys settles down over the tidelands, making the atmosphere extremely thick and unfavorable for field instrument work. For the same reason the wind does not readily carry the fog away. In general the weather conditions were extremely adverse, and field work could be accomplished only on an average of about one-third of the working time. Southerly storms, lasting several days at a

time, often accompanied by hail or snow, were frequent. The weather conditions improved to some extent during the last two weeks of the season.

The work was done in close and accurate detail, and is believed to be entirely sufficient for the construction of a new chart. A number of triangulation stations were substantially marked for use in the future revision work. The season's work was closed on March 31, and in accordance with instructions, the chief of party was ready to take over the steamers *Patterson* and *Explorer* on April 1 in compliance with the executive order for the retransfer of these from the Navy.

From April 1 to June 30, 1919, the chief of party was in command of the steamers *Explorer* and *Patterson.*

An inspection was made of one of the chart agencies of the Survey at Seattle, and various duties were performed relating to the transfer and shipping of property, caring for wire-drag launches and property, and preparation of inventories.

GEODETIC WORK.

UTAH.

[GEORGE D. COWIE.]

SUMMARY OF RESULTS.—Reconnoissance: 11 stations selected for primary triangulation. Triangulation: 11 observation stands erected for primary work, 80 stands erected for supplementary stations, 2 stations occupied for observations.

In May, 1919, work was begun on the extension of primary and secondary triangulation in Utah over an area indicated by the Forest Service.

On May 7 the observer arrived in Ogden, and after conference with the Forest Service officials there, made final preparations for field work at Richfield, Utah.

About May 17 reconnoissance for primary triangulation was begun, and by June 9 eleven stations were established, and observation stands were erected. During this time several parties comprised of men from the Forest Service, running expenses paid by the Coast and Geodetic Survey, were in the field, erecting supplementary stations to give immediate control over the Fish Lake, Dillmore, and Manti Forest Reserves.

These parties set up about one pole, with banners, per day while in the field. In all nearly 80 supplementary stations were erected.

On June 17 the observing party and light keepers left Richfield for their various stations, and on the 19th observations were begun at the old 1882 Tusher triangulation station of the United States transcontinental line. This station was completed and observations half completed at Station Monroe by June 30.

One United States motor truck and one rented car were used in addition to horses.

ARIZONA.

[C. V. HODGSON.]

SUMMARY OF RESULTS.—Reconnoissance: 8 points selected for scheme. Triangulation: 16 observing tripods built (all stands except one 12-foot signal), 1 observing scaffold built, height 12 feet, 2 stations in main scheme occupied for horizontal measures, 2 stations occupied for vertical measures, 1 elevation determined trigonometrically.

On April 11 Mr. Hodgson left the office to take up the work called for in the instructions of the superintendent, dated April 7, 1919, which provided first for a reconnoissance for control stations over portions of the Arizona national forests for the benefit of the Forest Service topographers, and later for an extension of primary triangulation from the Texas-California arc over the areas to be controlled, and thence eastward along the El Reno-Needles arc, the reconnoissance for which was done in 1916.

On the way out a stop was made at Albuquerque to consult with the district forester and with the topographer in charge of the work. A reconnoissance trip in conjunction with Mr. Daves, the topographer, was arranged for, and a small amount of outfit obtained from the district office.

The time from April 21, on which date the chief of party arrived at Prescott, until the early part of June was taken up in the preliminary reconnoissance, in making arrangements for the building party under the charge of Signalman Lutz to take the field, and in securing light keepers,

Six of the eight light keepers were finally secured by June 2, and since they had been leaving as rapidly as they could be secured, the chief of party decided to leave with only a couple of days training of the new arrivals. The light keepers left for their stations on June 4, and the observing party started to the first station at Harquahalla. From that time to the end of the month the work was actively prosecuted.

TEXAS AND LOUISIANA.

[J. S. BILBY.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 245 miles, 3,520 square miles of area covered, 53 points selected for scheme. Base lines primary (selected) Jacksonville, length 4½ miles. Traverse (reconnoissance), length 185 miles. Triangulation: 48 observing tripods built, total height 2,193 feet, 48 observing scaffolds built, total height 2,797 feet.

In October, 1918, a party was organized for the purpose of making a reconnoissance from the ninety-eighth meridian triangulation in the vicinity of Waco, Tex., eastward to the Mississippi River. This work had been requested by the Chief of Engineers, United States Army, to furnish data to be used in military mapping.

The chief of party arrived at Waco, Tex., October 24, and began the preliminary work of collecting and repairing the automobile trucks to be used in transporting the party.

The work of selecting stations for the primary triangulation was then taken up, and by January 3 the reconnoissance had been completed, and stations selected from points in the ninety-eighth meridian triangulation eastward to the vicinity of Jacksonville, Tex., and a preliminary reconnoissance had been made for the purpose of selecting the best route for triangulation from Jacksonville eastward to Robeline, La.

On account of the heavy rains and bad condition of roads, it was not practicable to continue the reconnoissance to the river at that time. On January 3, the chief of party returned to Waco, Tex., to organize a building party, and start building signals.

At Waco the outfit and trucks were overhauled, a party organized, and on February 1 the party and outfit were ready for the field. Building signals and preparing the stations were extended from the ninety-eighth meridian triangulation stations eastward, and by April 12 the building was completed to the vicinity of Jacksonville. From Jacksonville east the stations were selected during the process of building. Heavy continuous rains kept the roads in bad condition, and added considerably to the difficulties of the work.

Stations were selected and signals built for primary triangulation to Mansfield, La. It was not practicable to extend triangulation to the eastward of Mansfield, on account of the high timber, flat low country, bad roads, and unfavorable conditions. A reconnoissance was made for primary traverse from Mansfield to the Mississippi River at Vidalia. Stations were selected and signals built for primary traverse from Station Field to the Texas & Pacific Railroad.

During the progress of work, descriptions of stations, and progress sketches were furnished the chief of the observing party, and to the office.

By June 30 the actual field work of reconnoissance and building had been completed for the triangulation, and the party was preparing to move to Oklahoma, and take up work in the execution of instructions dated June 23, 1919.

The total length of the scheme for primary triangulation from the ninety-eighth meridian triangulation to Mansfield, La., is 245 miles. There are 44 stations in the main scheme, 2 LaPlace stations, and 1 base line. Three primary traverse stations were selected at which signals were built, and the stations marked to make the connection from a station of the triangulation to a station on the Texas & Pacific Railway track at Mansfield. This traverse connection was made by staking about 450 meters from Station Field to a station on the Kansas City Southern Railway, then along the Kansas City Southern Railway track northward to the Texas & Pacific Railway, crossing at South Mansfield, a distance of about 1½ miles.

The total length of the scheme selected for primary traverse from Mansfield to Vidalia is about 185 miles. The route selected is from Mansfield to Alexandria, on the Texas & Pacific Railroad, Alexandria to Georgetown, Georgetown to Vidalia, on the St. Louis, Iron Mountain & Southern Railway.

DELAWARE.

[GARDINER LUCE.]

SUMMARY OF RESULTS.—Triangulation: 10 square miles of area covered, 13 triangulation stations visited or recovered, 7 stations occupied for horizontal angles, 4 geographic positions determined. Signal building: 2 tall hydrographic signals built.

On May 9 instructions were given for the organization of a party and the erection of tall hydrographic signals on the coast of Delaware for the use of the steamer *Isis*, and later instructions were given for the location of prominent land marks. Supplemental instructions were afterwards issued for the running of a traverse, for the recovery of old triangulation stations, and the location of new stations, if necessary, within the requirements of tertiary triangulation.

On June 23 instructions were issued at the request of the Navy Department, for determining the positions of the Navy radio compass stations at Bethany Beach, Cape Henlopen, and Cape May, and then to close work.

On May 12 headquarters were established at Lewes, Del., and bids for supplies obtained in Lewes and Wilmington, Del. The necessary hands were hired.

From May 12 to May 22 the chief of party was occupied at Lewes, Del., in reconnoissance, triangulation, obtaining supplies, and organizing party.

On May 23 the party was moved to Ocean View, Del., where a tall type of hydrographic signal was constructed over the triangulation station on Cotton Patch Hill, reaching to a height of 115 feet above high water. This signal was erected on a sand hill 40 feet in elevation.

The signal was completed on May 30 and the party returned to Lewes, Del.

On June 2, 1919, the lumber, wire, and signal-building outfit were hauled to triangulation station, Midway, 2½ miles south of Rehoboth, on the narrow strip of land between Rehoboth Bay and the ocean. The next day construction of a tall-type signal was commenced over this station by the chief of party and four men, and completed to a height of 120 feet above high water on June 13, two and one-half days being lost by bad weather.

From June 14 to June 30, inclusive, the chief of party was occupied on triangulation, locating all prominent objects useful to navigation and the survey work of the steamer *Isis*.

NORTH CAROLINA.

[C. L. GARNER and MAX STEINBERG.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 120 miles. 1,260 square miles of area covered, 37 lines of intervisibility determined, 17 points selected for scheme. Triangulation (primary): 1,260 square miles of area covered, 27 observing scaffolds and tripods built (heights 4 to 80 feet), 16 stations in main scheme occupied for horizontal measures, 16 stations occupied for vertical measures, 30 geographic positions determined, 25 elevations determined trigonometrically. Leveling: 30 permanent bench marks established, 50 miles of levels run. Azimuth: 1 station occupied for observation of azimuth.

On September 28, 1918, instructions were issued to Mr. Garner to carry a scheme of primary triangulation or primary traverse from the eastern oblique arc triangulation in the vicinity of Madison to the Norfolk-Savannah line of primary traverse in the vicinity of Sanford, N. C. The instructions also called for a line of precise levels which should extend from the vicinity of Greensboro to Sanford, N. C.

Reconnoissance for this work began about October 15, and was finished about November 18. It was decided that it was best to have triangulation from the oblique arc to Sanford. The observations for the work began shortly after November 1. Considerable difficulty was encountered in getting off the large figures of the old triangulation to connect with the new work on account of haze.

That part of the scheme of triangulation which makes a connection with the primary traverse which extends from Savannah, Ga., to Norfolk, Va., was done by the party of Max Steinberg. This connection was made, and the two parties completed the work at the end of December, 1918.

GEORGIA.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Primary traverse: Length of traverse check-measured 550 miles (measured once) and 67 miles (measured more than once). 20 stations occupied for check horizontal measures. Azimuth: Stations occupied for approximate azimuth.

The revision of the primary traverse on the line from Macon to Griffin, Ga., was begun August 16 at Macon, Ga., where an azimuth was measured on the night of August 30.

Azimuth was observed at numerous points between stations Southern and Forsyth, and all lines were remeasured and errors located. This section was finished October 2.

Between October 3 and 8, all measurements in and near Macon were checked, and several stations were occupied for horizontal angles, in order to detect and correct errors.

On the completion of this work check measurements were made on the lines from Macon to Columbus, and Macon to Brunswick.

The checking of the measurements on the line from Macon to Columbus was begun October 9, and completed November 10. The remeasurement of the line from Macon to Brunswick was begun November 10, and completed December 14.

The measurement of the line from Macon to Savannah was next taken up, and the line was completed and field work closed on February 16, 1919.

On February 17 an investigation was made of the traverse base at Dublin, and on February 26 the observer reported at the Washington office.

[E. D. BROMLEY.]

On June 2, 1919, instructions were received to remeasure the angles on the primary traverse line, Macon to Forsyth, Ga.

Up to June 30, 1919, 45 of these stations had been recovered, 39 signal tripods built, and 16 had been occupied and the angles remeasured with a 12-inch direction instrument, using eight positions at each station.

In remeasuring these angles, tripod signals were built to give clearance above the track and ground of not less than 6 feet, and in most cases the line of sight was 15 to 20 feet above the ground. The tripods were built rigid, and great care was exercised in the centering of the signal pins and the instrument over the station mark.

An auto truck was used for transportation along the public highway, which is in most cases near the Central of Georgia Railway tracks. This, probably, was the cheapest means of transportation for this particular piece of work, as the employment of conductors when motor cars are used is very expensive.

While the hire of the truck was a little greater than ordinary, owing to the unusual demand, the truck proved very efficient. In case there was much rain, the Georgia red-clay roads would be almost impassable with a truck.

TEXAS AND LOUISIANA.

[C. L. GARNER.]

SUMMARY OF RESULTS.—Triangulation: 3,400 square miles of area covered, 38 stations in main scheme occupied for horizontal measures, 38 stations occupied for vertical measures, 126 geographical positions determined, 126 elevations determined trigonometrically. Azimuth: 4 stations occupied for observations of azimuth (including 2 La Place stations).

On February 27, 1919, instructions were issued to Mr. Garner to begin observations for a scheme of primary triangulation and primary traverse extending from the ninety-eighth meridian in the vicinity of Waco, Tex., eastward to the Mississippi River. The reconnoissance for this work had been completed as far as Mansfield, La., by the end of December, 1918. The signal building was started shortly after January 1, 1919. The work was requested by the Chief of Engineers, U. S. Army.

Mr. Garner arrived at Waco, Tex., on March 24, 1919, and began organizing his party for the work and overhauling the trucks which were to be used on the work. These trucks were used in hauling the outfit and light keepers to the various triangulation stations. The actual observing started on April 15. By the end of the fiscal year the work had been completed nearly to Mansfield, La. There remained only seven stations to be occupied.

There were a number of high towers in the scheme of triangulation, and at times the wind made them unsteady. Nevertheless, the closures of the triangles averaged only about one second. The work was made difficult at times by heavy rains.

Electric signal lights with dry-cell batteries were used throughout the season and proved most satisfactory.

NORTH CAROLINA AND SOUTH CAROLINA.

[MAX STEINBERG.]

SUMMARY OF RESULTS.—Primary traverse: 253 miles of traverse run, 197 observing tripods and scaffolds built, heights 4 to 40 feet; 197 stations in main scheme occupied for horizontal measures, 150 stations in supplemental schemes occupied for horizontal measures. Triangulation: 350 square miles of area covered, 3 observing tripods and scaffolds built, heights 40 feet each; 6 stations in main scheme occupied for horizontal measures, 6 geographic positions determined. Precise leveling: 277.8 miles of levels run, 358 permanent bench marks established; 7 stations occupied for determination of azimuth.

During the season beginning July 1, 1918, and ending December 29, 1918, the following work was accomplished:

Lines of primary traverse and precise leveling were extended from the vicinity of Seaboard, N. C., to Moncure, N. C., where connection was made with the traverse from Savannah, Ga., over the tracks of the Seaboard Air Line Railway, and from Wilmington, N. C., to Sanford, N. C., over the Atlantic Coast Line Railroad. From Sanford northwestward the character of the country was more favorable for triangulation than for traverse. A scheme of triangulation was started from two adjoining lines of the Norfolk-Savannah traverse as a base and carried 25 miles toward the oblique arc, and connection was made with the triangulation carried down from the oblique arc by C. L. Garner.

On July 1, 1918, the work had been completed to Seaboard, N. C. It was continued from there to Moncure, N. C., where connection was made October 10 with the line run from Savannah northward, a total distance of 136 miles. The entire party and outfit were moved to Wilmington, N. C.

[CLEM L. GARNER.]

SUMMARY OF RESULTS.—Reconnoissance (for primary traverse): Length of scheme 140 miles; 180 points selected for scheme. Primary traverse: 50 square miles of area covered, 180 signal poles erected, 83 observing scaffolds and tripods built, heights from 4 to 70 feet, average height 12 feet, 54 stations in main scheme occupied for horizontal measures, 126 stations in supplemental schemes occupied for horizontal measures, 200 geographic positions determined. Precise leveling: 140 miles of levels run. Azimuth: 3 azimuth stations occupied.

On July 8, 1918, the charge of the primary traverse and precise leveling party of M. E. Lutz was transferred to Clem L. Garner, at Camden, S. C.

During the period between July 12 and October 7, the line of primary traverse and precise leveling was continued from Camden, to which point the work had been carried by M. E. Lutz, to a junction with the work of Max Steinberg at a point about 2 miles to the southward of Moncure, N. C. The traverse followed the Seaboard Air Line Railway for the entire distance.

The field work on the traverse and leveling was done between July 12 and October 7, 1918, a period of two and three-fourths months, during which time the progress was 139 miles, or an average of 50 miles per month. The work was over a very crooked road where the curves were long, and averaged only about three-quarters of a mile apart.

The progress of the leveling was necessarily held down to the same amount of mileage, since the traverse stations were used as bench marks, and the leveling could not be done before the marks had been set and the concrete seasoned at least one day.

Practically all of this work consisted of short traverse lines connected to main-scheme stations several miles apart, thus forming so-called loops. This system increased the cost of the work somewhat, but furnished a valuable means of checking the accuracy of the work.

Several improvements were made in the methods of operation with the object of eliminating some of the errors occurring in traverse work.

During the season a number of photographs were taken to illustrate the operations of the party.

Motor velocipede cars were used for the transportation of the party and instruments.

GEORGIA, FLORIDA, ALABAMA, AND SOUTH CAROLINA.

[EARL O. HEATON.]

SUMMARY OF RESULTS.—Traverse: 754 miles of traverse line remeasured. Leveling: 4 miles of check levels run.

Between February 15 and March 6, check level work was done by this party at Theodore and Alabama Port, Ala.

On March 7 the observer proceeded to Columbus, Ga., to check the measurements on the traverse line between Columbus, Ga., and Jacksonville, Fla., 266 miles.

Between April 20 and May 13, check measurements were made along the traverse between Callahan, Fla., and Albany, Ga., by way of Valdosta, Ga., a distance of 198 miles; May 16 to May 24, between Everett and Savannah, Ga., a distance of 60 miles; and May 25 to June 30, on the Norfolk-Savannah traverse, between Savannah, Ga., and Cheraw, S. C., a distance of 230 miles.

NEW YORK.

[O. W. FERGUSON.]

SUMMARY OF RESULTS.—Precise leveling: 88.22 miles of levels run. 57 permanent bench marks established.

In the latter part of April, 1919, a party was organized to run a line of precise levels from Troy, N. Y., to Whitehall, N. Y., and then to proceed to Rouses Point, N. Y., and continue a line of levels westward over the Rutland Railroad.

The party arrived at Troy on May 13, and leveling was begun on the morning of May 19.

Beginning at the old bench marks in the southern part of Troy, the line was run to Whitehall, a distance, including sidelines, of 78.42 miles, finishing there on June 24.

Connection was made with four old bench marks in Troy and three in Whitehall, and with water gauges at Waterford, Saratoga Lake, and Fort Edward. Forty-five old bench marks were recovered and connected with the line of levels, although many others had been destroyed in the construction of the new canal and destruction of the old canal. There were also established, on this line 22, bench marks of the new type, consisting of brass disks set in cement posts and other masonry, and 35 other bench marks cut on stone work.

On June 25 the party was moved to Rouses Point to start the line westward.

At Rouses Point an old bench mark of 1882 in the Chapman block was recovered and connected with the gauge used for construction of the terminal of the barge canal, with bench mark Q–1, 1916, established by Mr. Powell, and with two bench marks established by the Canadian engineers. Twenty-four new cement-post bench marks were constructed, and 9.8 miles of line run to the westward connecting with nine railroad bench marks recovered on the way, thus completing 88.22 miles of line by the end of the fiscal year.

TEXAS.

[CASPER M. DURGIN.]

SUMMARY OF RESULTS.—Precise leveling: 43 permanent bench marks, 99 miles of levels run.

Between May 4 and June 30, 1919, work was in progress on the line of precise levels from Hillsboro, Tex., to Natchez, Miss. This line begins in the vicinity of Hillsboro, Tex., and follows the Trinity & Brazos Valley Railway to Mexia, Tex. From Mexia it follows the Houston & Texas Central Railway to Mexia Junction, and from Mexia Junction, the Mexia-Nelleva Junction Cut-off of the Houston & Texas Central Railway to Jewett, Tex. Work was progressing on this latter railroad on June 30, 1919.

Hired automobiles and the interurban railway were used to transport the party while doing the leveling from Abbott, Tex., to Schofield, Tex. On the remainder of the work motor velocipede cars were used.

One pilot was necessary to pilot the motor cars over the Houston & Texas Central Railway. The Trinity & Brazos Valley Railway did not require a pilot.

[CASPER M. DURGIN.]

SUMMARY OF RESULTS.—Precise leveling: 335 miles of levels run, 135 permanent bench marks established.

Between September 13, 1918, and March 19, 1919, a line of precise levels was run from Harlingen, Tex., to Eagle Pass, Tex., following as closely as possible

the scheme of triangulation along the Rio Grande, and connecting with bench marks of the Coast and Geodetic Survey at Laredo and Eagle Pass, Tex.

Two motor trucks were used for the transportation of the party.

The line of precise levels followed the St. Louis, Brownsville & Mexico Railroad from Harlingen to Samfordyce, Tex., thence along the military road along the Rio Grande to Laredo, Tex. At Laredo it was found advisable to follow the wagon road from Webb, Tex., to Asherton via the Tiendas Ranch, and then follow the main road from Asherton through Carrizo Springs and Cometa to Eagle Pass. In this way, although it meant following a route in some places 30 miles from the Rio Grande, leveling was eliminated from Laredo to Webb, and many creeks and arroyos were avoided. Spur lines were run to several triangulation stations to connect them with the main line of levels and to give a control to the elevations of the triangulation stations determined by vertical angles.

The country over which this line of levels followed was nearly level from Harlingen to Samfordyce. North of Samfordyce the line passed over numerous ridges from 3 to 5 miles apart, and separated by steep valleys, at the bottom of which were deep arroyos.

The total number of bench marks was 135 in a distance of 335 miles, or an average of one permanent bench mark to 2.5 miles.

FLORIDA.

[DOUGLAS KARR.]

SUMMARY OF RESULTS.—Precise leveling: 150 miles of levels run, 66 permanent bench marks established.

The work in progress at the end of the last fiscal year on the line from Biloxi, Miss., to River Junction, Fla., was continued after July 1, 1918, from a point 15 miles east of Pensacola, Fla., and field work was completed September 23.

Two motor cars were used for the transportation of the party.

LOUISIANA.

[CASPER M. DURGIN.]

SUMMARY OF RESULTS.—Precise leveling: 158 miles of levels run, 121 permanent bench marks established.

Work on the line of levels extending from Sinton, Tex., to New Orleans, La., was in progress on July 1, having been carried to Jeanerette, La., during the month of June.

At the end of August the line was completed to New Orleans, La., with the exception of the crossing of the Mississippi River, and connecting with some of the bench marks in New Orleans. Two spur lines were run from Baldwin, La., to Weeks Island, La., and from Bayou Sale to South Bend, La.

On September 3 and 6 observations were taken for carrying the levels across the Mississippi River. In this work simultaneous observations were taken from both sides of the river. The length of sights across the river between Avondale and Harahan, La., where the crossing was made, was 1,630 meters.

Connection was made with three bench marks previously established in New Orleans, La.

Transportation for the greater part of June and July was by motor truck. During August and September trains were used entirely, as the truck was in poor condition, and the roads were in many cases unfit for travel owing to heavy rains.

On this line permanent bench marks were established on an average of one to every 1.3 miles. For temporary bench marks lag screws in telegraph poles, squares in abutments of bridges, or the concrete bases of block-signal towers were used.

OREGON.

[C. A. EGNER.]

In June a party was organized at Klamath Falls, Oreg., to run a line of precise levels from that place into California.

The chief of party arrived at Klamath Falls June 17. From that date until June 24 the time was spent in organizing the party, establishing bench marks, and reconnoissance. Leveling was done on June 26 and 30.

Permanent and temporary bench marks were set from Lelu, Oreg., south to Ady, Oreg., a distance of 26 miles.

The work was in progress at the close of the fiscal year.

GEORGIA, NORTH CAROLINA, SOUTH CAROLINA, VIRGINIA, AND DISTRICT OF COLUMBIA.

[W. B. FAIRFIELD AND J. E. MCGRATH.]

SUMMARY OF RESULTS.—Latitude and longitude: 6 primary latitude stations established, 8 differences of longitude (telegraphic) determined, signals exchanged on 27 nights.

During the period between July 1, 1918, and January 20, 1919, differences of longitude were determined between the following points: Riley, Ga., and Fort Valley, Ga., on July 5, 11, 13, and 14; Fort Valley, Ga., and Norris, Ga., August 8, 12, and 14; Norris, Ga., and Turner, Ga., September 14, 15, and 17; Turner, Ga., and Bethune I, S. C., October 8, 10, and 11; Bethune I, S. C., and Lee, N. C., November 3, 4, 5, and 6; Lee, N. C., and Littleton, N. C., November 20, 23, and 25; Littleton, N. C., and Suffolk, Va., December 16, 19, and 26; Suffolk, Va., and Coast and Geodetic Survey Pier, Washington, D. C., January 11, 12, 13, and 15.

Latitude was determined at the following stations: Fort Valley, Ga., August 4, 1918; Norris, Ga., August 21, 1918; Bethune I, S. C., October 15, 1918; Littleton, N. C., December 4, 1918; Suffolk, Va., January 4, 1918.

Between July 1 and 3, 1918, one of the officers engaged in the longitude work was detailed to revise certain work done in connection with the primary traverse in the vicinity of Macon, Ga.

In the latter part of the season the weather conditions were extremely unfavorable for longitude work.

TEXAS.

[W. B. FAIRFIELD AND J. E. MCGRATH.]

SUMMARY OF RESULTS.—Latitudes and longitudes: One primary latitude station established, one difference of longitude (telegraphic) determined, signals exchanged on 4 nights.

The difference of longitude (telegraphic) between Laredo and La Place (Eagle Pass) was determined on June 4, 6, 11, and 12. Latitude was determined at La Place on June 14.

The Western Union Telegraph Co. rendered every assistance in the use of their lines, and making the necessary connections.

MAGNETIC WORK.

MARYLAND (CHELTENHAM MAGNETIC OBSERVATORY).

[GEORGE HARTNELL.]

During the year the work of the Cheltenham Magnetic Observatory was continued in accordance with the usual program.

The two magnetographs were in continuous operation. The Z No. 1 variometer rendered continuous service over a period of 31 months, from April, 1916, to November, 1918, without a shift, the longest record made during the operation of this observatory. The explanation is that the agate knife-edges were very carefully reground by the instrument division in April, 1916. The recording spot was raised in the early part of November of this year by balancing the magnet.

At the time of this adjustment, the magnet was oscillated in situ, both with the damping box in place, and also when removed. The observations were repeated later in the month. The magnet was also removed and oscillated in a horizontal plane. The general conclusion reached was that the scale values derived from the method of oscillations and from deflections were in practical agreement.

The performance of the seismograph has been satisfactory. It is recommended by the observer that a better type of circuit-breaking clock for marking the time be provided. It is also recommended that a new seismograph house be built, or at least the present one be improved or remodeled, so as to obviate the intense humidity of the air that prevails in the room where

the seismograph is situated, as the clocks and all the delicate parts of the seismograph are being badly injured by rust.

The special work during the year was the development of the theory of the balanced magnet Z variometer. The application of the theory to the designing of vertical intensity variometers was outlined, and it was shown how a vertical intensity variometer could be made free from drift due to the weakening of the magnets, and to the secular change in the vertical intensity.

W. H. Cullum, magnetic observer, was assigned to Cheltenham Observatory from August 1 to August 20, for training preparatory to taking charge of the Tucson Observatory. In other respects the personnel of the Cheltenham Observatory remains as heretofore.

After September, 1919, although frequently overhauled at the office, earth inductor No. 26 failed to furnish satisfactory observations, and after February 25, earth inductor No. 22 was substituted for it.

The high winds in March caused some damage to the roof of the variation building. This was repaired, and other minor repairs were made.

The chief of the instrument section of the Survey visited the observatory on March 11, for the purpose of testing earth inductor No. 26.

ILLINOIS.

[WM. WALTER MERRYMON.]

STATIONS OCCUPIED.—Illinois: Urbana.† Michigan: Kalamazoo.†

Between June 23 and 30, 1919, the three magnetic elements were observed at the two stations named above, both of which were old stations indicated by dagger (†).

ARIZONA (TUCSON MAGNETIC OBSERVATORY).

[H. E. MCCOMB, July 1, 1918, to July 31, 1918; WILLIAM H. CULLUM, Aug. 1, 1918, to June 30, 1919.]

At the magnetic observatory at Tucson, Ariz., the magnetic instruments have been in almost continuous operation recording variations in declination, horizontal and vertical intensity.

Scale value observations were made at least once a month, and whenever readjustment of instruments made them necessary.

Absolute observations were made once a week except in July.

The Bosch Omori seismograph was in continuous operation except on one day, August 14. Nineteen earthquakes were recorded during the year.

Meteorological observations were made as usual.

Contracts were let near the end of June, 1919, for a new 2,000-gallon water tank, and the erection of a shed to house gasoline and kerosene tanks. These were necessary improvements. The several buildings of the observatory are in good condition.

ILLINOIS, INDIANA, IOWA, AND MICHIGAN.

[W. W. MERRYMON.]

STATIONS OCCUPIED.—Illinois: Seneca.‡ Indiana: Cambridge City,‡ Milford,‡ New Castle, and five auxiliary stations, North Manchester,‡ Richmond,* Rochester,* and five auxiliary stations, Schneider,‡ and Walkerton.‡ Iowa: Cambridge,‡ Coon Rapids,‡ Davenport,† Des Moines,* Grinnell,† Herndon,‡ Manning,‡ Madrid,‡ Neola,‡ Peru,† Perry,‡ Rushville.† Michigan: Grand Rapids,‡ and seven auxiliary stations.

Between July 1 and September 14, the three magnetic elements were determined at the places named. Old stations were reoccupied at the places marked by an asterisk (*). New stations were established at places marked by a dagger (†). Stations were occupied, but not permanently marked, at the places marked by a double dagger (‡).

At Davenport, Iowa, the old stations could not be found, and a new station was established.

Auxiliary stations were occupied as follows: Five in the vicinity of Rochester, Ind.; five in the vicinity of New Castle, Ind.; seven in the vicinity of Grand Rapids, Mich.

A meridian line was laid out and marked at the new station at Grand Rapids. This was done at the request of the superintendent of parks and the county surveyor and engineer.

Requests from many surveyors, engineers, and others for magnetic data were received and forwarded to the Washington office.

ALASKA.

[J. W. MAUPIN, Commanding Steamer *Cosmos*.]

SUMMARY OF RESULTS.—Triangulation (tertiary): 28 square miles of area covered, 18 signal poles erected, 16 stations in main scheme occupied for horizontal measures, 18 geographic positions determined. Topography: 16 square miles of area surveyed, 21 miles of coast line surveyed, 4 miles of creeks surveyed, 1 topographic sheet finished, scale 1 : 10,000. Hydrography: 1 square mile of area covered, 34 miles run while sounding, 696 positions determined (double angles), 2,847 soundings made, 3 tidal stations established, 2 hydrographic sheets finished, scale 1 : 2,500.

A party was organized in July, 1918, to make a hydrographic survey of the north end of Wrangell Narrows in vicinity of Petersburg, southeastern Alaska. The steamer *Cosmos* was assigned for the transportation of the party.

Field work began July 25, and closed August 28.

The work contemplated was a close development by sounding, and with the harbor sweep of an area extending from a point opposite Petersburg to the north end of Wrangell Narrows, where the latter empties into Frederick Sound. The harbor sweep was used for the purpose of locating possible bowlders.

Most of the old triangulation stations were recovered, and by the addition of two new stations located by sextant cuts, sufficient control for the work was obtained.

The soundings were taken very close together, and in addition to the depths shown on the sheet, many hours were spent in feeling over the bottom for possible bowlders. The very large scale on which the work was done, and the strong currents running in whirlpools and eddies which would set the launch in all directions at times, made an accurate development extremely difficult.

The harbor-sweep work was attended with so many difficulties that at times it seemed an impossibility to cover the ground by this method. In order to withstand the force of the current it was necessary to use 2-inch pipe on the sweep, which made it very heavy, and it was operated with great difficulty by the few men who could work in the contracted space on the stern of the launch. With a maximum current of 5 knots, the sweep extending 30 feet below the surface of the water, the difficulties in maneuvering the launch to cover accurately an area with a sweep pipe only 6 meters wide were extreme. Each day the party continued work as long as the current would permit, when the pipes would break and make it necessary to lay off for repairs. During the work the sweep broke 12 times, and much time was consumed in repair work. Buoys were planted and located, which helped to keep the launch within the area which was being developed, and by continued effort the ground was covered as closely as possible. The several small spaces between the recorded sweep lines were also covered in maneuvering the launch back and forth during the process of starting a line.

The results obtained agree very closely with the original survey made in 1910. At a point 180 meters N. 60 W. (true) from signal boat, a depth of 12 feet was obtained where 14 feet was previously shown. This is considered one of the crucial spots of the work, and from all reports (including eyewitnesses) it is where several vessels have grounded. After the completion of this survey the superintendent of lighthouses at Ketchikan, Alaska, stated his intentions of placing a buoy on this spot, and a blue print was furnished him by this party for use in locating same.

On August 31 the *Cosmos* left Petersburg for Ketchikan, arriving the same day. After making necessary preparations, including a trip to Metlakatla to obtain equipment needed for work required at Keete Inlet, the vessel left Ketchikan on September 5, arriving at Keete Inlet the same afternoon. On the next day the *Cosmos* was unloaded, a camp, tide staff, and bench marks were established, and on the following day the *Cosmos* proceeded to Craig, Alaska, to remove the automatic tide gauge which had been in operation there. Three days' tidal observations were made simultaneously at Craig and Keete Inlet, and after leveling to the bench marks and removing the tide gauge the *Cosmos* returned to Keete Inlet on September 11.

The season's work at Keete Inlet opened September 11 and closed September 30, during which period there were but 16 working days.

In this time a scheme of triangulation consisting of 18 stations and 8 figures in the main scheme was completed, and 1 topographic sheet was completed.

Keete Inlet was found to extend about twice as far inland as shown on the chart, which proportionately increased the work required to be done.

The *Cosmos* returned to Ketchikan October 6, where a site was selected for a proposed boathouse. Three days were spent in establishing an automatic tide gauge, bench marks, and tide staff at Ketchikan, and two days in laying up the *Cosmos* at Metlakatla.

The party sailed for Seattle on October 19, arriving October 21.

[E. R. HAND.]

SUMMARY OF RESULTS.—Topography: 1 square mile of area surveyed, 5 miles of general coast line surveyed, 1 topographic sheet finished, scale 1:5,000. Hydrography: 1.3 square miles of area covered, 79.7 miles run while sounding, 1,603 positions determined (double angles), 3,763 soundings made, 2 hydrographic sheets finished, scale 1:5,000. Hydrography (wire drag): 24.8 square miles of area dragged, 59.8 miles run while dragging, 2,139 positions determined (double angles), 3 wire-drag sheets finished, scales 1:2,000 and 1:5,000.

The wire-drag survey at Anchorage, Knik Arm, Alaska, in progress at the beginning of the fiscal year, was completed July 28.

On account of the rapid currents in this locality the use of the drag was possible only at the time of slack water, and to insure accuracy, it was necessary to supplement the work of the drag by sounding with the lead over places where the depths appeared doubtful. So far as conditions permitted the drag was set to within 3 to 5 feet of the bottom, and to a depth of about 30 feet. Inside the 30-foot curve the water shoals rapidly, and is not to be regarded as navigable.

No dangers were found of importance to shipping. In the area immediately south of a point midway between Woronzof and Mackenzie, the drag often caught on spots with less water than indicated by the soundings. The drag passed over them all when set at 35 feet. This locality is not in the steamer track of vessels.

The drag was passed a number of times over the previously reported shoal that lies northwestward and a half mile from the proposed wharf. Sounding developed a least depth of 33 feet; the wire brought up at 30 feet but cleared at an effective depth of 27. Vessels should be careful when maneuvering around the new wharf at low tide, but at present it is well up beyond the fairway.

On July 30 the party left Anchorage for Port Chatham, arriving on August 1.

At Port Chatham quarters were found with the Whitney & Lass Mining Co., which is developing valuable chrome ore holdings in the vicinity of Claim Point. Since this company was having difficulties through the refusal of the steamship companies, on account of inadequate surveys, to send vessels to their wharf, and as the immediate need for this ore in munitions making was the determining factor in sending the party to this place, an investigation was first begun of the bight between Kelp and Claim Points where the mine dock is located. A detailed topographic and hydrographic survey was made on a scale of 1:5,000, without finding any hidden obstructions. A beacon and a range were established, and blue prints of the survey made, and on August 23, 23 days after the arrival of the party, vessels began to come to the wharf for ore.

After issuing the chart, operations with the drag showed that shoal water extends farther off Claim Point than previously shown, though nothing dangerous was found. Tracings were made showing the additional soundings off Claim Point, and furnished to those to whom the blue prints had been sent, and one was forwarded to the Seattle field station, that the data might appear on future prints from the original tracing filed there.

No sounding was done at Port Chatham except for the above-mentioned survey, and the plane-table work outside of these consisted in locating signals for the wire-drag operations. The drag work was carried up to the head of Port Chatham over all the navigable area and anchorage ground. The dragging was extended from outside Chatham Island through all the waters of less than 20 fathoms depth across to Elizabeth Island, and over all of the area in the west entrance between this island and the mainland to the 20-fathom curve, running into the bight between Kelp and Claim Points where the mining camp is situated. Spots off the west end of Elizabeth Island and off Koyoktolik Bay, designated in the instructions for this work, were swept over. A group of irregular soundings on chart 8,580 on the east side of the channel between Elizabeth Island and the mainland, and east of the north end of that island, and directly in the steamer track, was dragged over without result.

For the reduction of soundings simultaneous observations of tides were made, and referred to a bench mark established at the head of the port by H. W. Rhodes in 1906. Three permanent tidal bench marks were established on the cliffs at the end of the mine wharf opposite the tide staff.

A small drag handled by a motor dory and a pulling boat was devised for the purpose of sweeping close to the bottom in areas where the longer drag and the launches could not be used to advantage,

About the middle of September the party proceeded to Seldovia to investigate a reported rock near the Anderson wharf. This rock, with 9 feet of water over it, was found 180 feet off this dock. The water front was revised while locating signals.

Work at Seldovia and Port Chatham was completed September 24, and on the 27th the party left for Seattle, Wash., arriving October 13.

Work at Halibut Cove, Kachemak Bay, for which orders had been issued, was not undertaken owing to the lateness of the season.

[J. W. GREEN.]

STATIONS OCCUPIED.—Alaska: Alitak Bay, Anchorage, Chicaloon, Chitina, Cordova, Fairbanks, Fort Liscum, Fort Yukon, Holy Cross, Hot Springs, Kokrines, Matanuska Junction, Montana Creek, Nenana, Nulato, Rampart, and Seward.

Field magnetic observations in Alaska begun in June, 1918, were in progress at the beginning of the fiscal year, two stations, Eagle and Circle, having been occupied.

Between July 1 and the close of the season on October 12 observations of the three magnetic elements were made at the stations named above. Of the Yukon River stations established in 1908, which were reoccupied during this season, only one, that at Circle, could be found. Observations were secured in the immediate vicinity of the old station, and a new station was established nearly a mile south of the former station.

At Fort Yukon, the station which in 1908 was placed about 150 feet from the river bank, was found to be only 20 feet away from the bank, due to the river undermining and cutting away the bank. At this place repeat observations were obtained at the old station, and then a new station was established about one-fourth mile back from the river, in order to insure a determination of the annual change at a future date.

All other stations along the Yukon River were found intact, and most of them in a fair state of preservation.

New stations were established on the Tanana River at Hot Springs, Nenana, and Fairbanks. Stations were established at Chitina and McCarthy along the Copper River Railway; at Cordova, Fort Liscum, and Seward in the vicinity of Prince William Sound; at Anchorage, Matanuska Junction, Chicaloon, and Montana Creek along the new Government railway, and at Alitak Bay at the southern end of Kodiak Island.

After the return of the observer to Sitka comparison observations were obtained with the set of field instruments and the observatory instruments.

SITKA MAGNETIC OBSERVATORY.

[F. P. ULRICH.]

The usual observations were recorded during the year with practically no interruption.

The magnetic variation instruments have continued in satisfactory operation.

Absolute observations were made each week.

Comparison observations necessary on account of the change in location of the absolute observatory, and for instrumental comparisons, were made in October.

Time corrrections were obtained each week at the local cable office of the United States Signal Corps. Time signals are received each day by cable from Mare Island.

The seismograph was kept in almost continuous operation, and 20 shocks were recorded, all of small magnitude.

A new fence was put around the office lot, a new walk put down, and the grading of the lot was completed. A new azimuth mark was set, and the azimuth determined by angular measurements from the old azimuth mark.

Meteorological observations consisting of temperature and barometer readings, state of the weather, and other meteorological phenomenon were continued.

Necessary repairs were made to the office buildings.

PORTO RICO.

VIEQUES MAGNETIC OBSERVATORY.

[WALLACE M. HILL.]

At the magnetic observatory at Vieques, P. R., a practically continuous record was obtained with the magnetograph and seismograph. The usual absolute observations were made of the declination, dip, and horizontal intensity.

Adjustments were made of the D and H variometers, the seismograph, and the earth inductor. Scale-value observations were made once each month, and more frequently when the necessity arose on account of the adjustment of an instrument.

On October 11, a severe earthquake shock occurred at the west end of Porto Rico, and during the remainder of the month a constant succession of tremors of varying intensity were recorded on the seismograph. On November 12 a strong shock was recorded from the same region, and then the tremors practically ceased.

At the beginning of the first severe shock the recording needles were jarred from the pivots of both components, but a good record of the second strong shock was obtained upon the E–W component, although the needle of the N–S component was jarred from the drum.

The two experts, Prof. Reid and Prof. Jagger, who were sent by the Government to investigate the cause and results of this earthquake, visited the observatory, and examined a good typical record made on November 12.

The only instrument disturbed by the earthquake was the D variometer, which was slightly jarred out of level.

Several other strong earthquake shocks, apparently from South America, were also recorded.

Tremors of slight intensity were noted occasionally which had the same general appearance as those occurring during the large disturbances of October, 1918, in Porto Rico.

It was found necessary to make a readjustment of the long magnet of the magnetometer.

Readings of the meteorological instruments were taken each day.

Two compass declinometers were standardized, and special scalings were taken from the magnetograms for the period of the eclipse of May 29, 1919.

VIRGIN ISLANDS.

[O. W. SWAINSON.]

SUMMARY OF RESULTS.—Reconnoissance: Length of scheme 13 miles, 81 square miles of area covered, 11 lines of intervisibility determined, 7 points selected for scheme. Base lines: 2 secondary base lines measured, lengths 1 mile and 1.77 miles. Triangulation: 506 square miles of area covered, 117 signal poles erected, 5 observing tripods and scaffolds built (heights 6 to 30 feet), 4 observing scaffolds built (heights 10, 12, 14, and 16 feet), 48 stations in main scheme occupied for horizontal measures, 2 stations in supplemental schemes occupied for horizontal measures, 46 stations occupied for vertical measures, 155 geographic positions determined, 48 elevations determined trigonometrically. Leveling: 2 permanent bench marks established, 1.8 miles of levels run. Magnetic work: 5 land stations occupied for magnetic declination. Topography: 53 square miles of area surveyed, 128 miles of detailed shore line surveyed, 10 miles of shore line of ponds surveyed, 86 miles of road surveyed, 9 topographic sheets finished, scale 1:10,000.

On July 1, 1918, the topographic survey of the Virgin Islands, begun in February, 1918, at the request of the Navy Department, was in progress.

The work contemplated included a complete scheme of triangulation extended from the line "East End, Vieques Island to Savana Island," established in 1900; the measurement of a base line on each of the islands of St. Thomas and St. John, detailed topography of the shore line and entire area of the islands on a scale of 1:10,000, with contour intervals of 20 feet, and the determination of magnetic declination with the compass declinometer.

As the survey was undertaken at the request of the Navy Department, the governor of the islands, the civil engineer of the Navy in charge of engineering operation on the islands, and the commanding officer of the naval vessel stationed at St. Thomas were consulted from time to time.

As the result of these consultations several pieces of work were done for the Navy, and tracings of positions of the topographic sheets were furnished when desired.

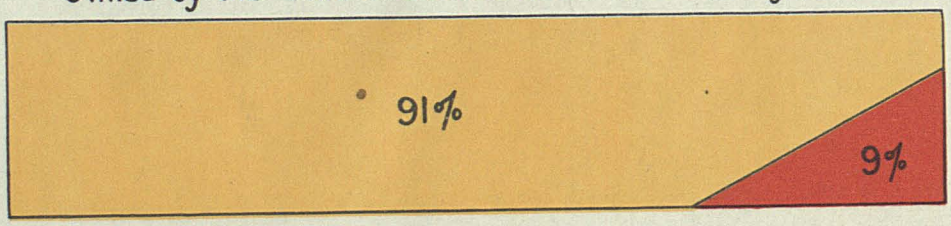
Up to July 1 the triangulation had been carried as far as the passage between St. Thomas and St. John. From there it was continued eastward until

Condition of water surveys, Pacific Coast and Alaska, 1919, as compared to the Philippine Islands

United States Coast and Geodetic Survey

Alaska

Owned by the United States since 1867 (52 years)

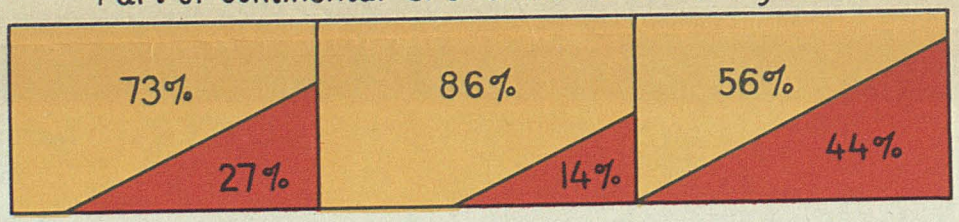


Yellow (91%) - represents unsurveyed water areas.
Red (9%) - represents water areas surveyed in past 33 years.

One vessel of the Surveyor type will require 118 years to complete a first survey of Alaska's exposed navigable waters, by which time all surveys in sheltered waters can also be completed by a continuation of the present rate of progress.

California Oregon Washington

Part of continental U. S. since 1848 (71 years)



Yellow (73%, 86% and 56%) - represents unsurveyed water areas.
Red (27%, 14%, and 44%) - represents water areas surveyed in past 69 years.

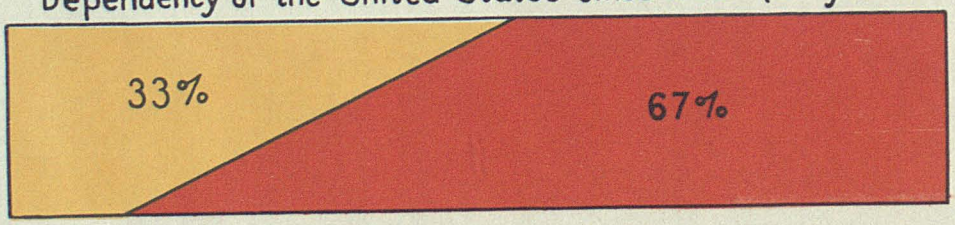
One vessel of the Surveyor type will require 20 years to complete a first survey of the navigable waters of this coast.

For 22 years no systematic survey of water areas has been made on account of lack of vessels.

Now compare work done in the

Philippine Islands

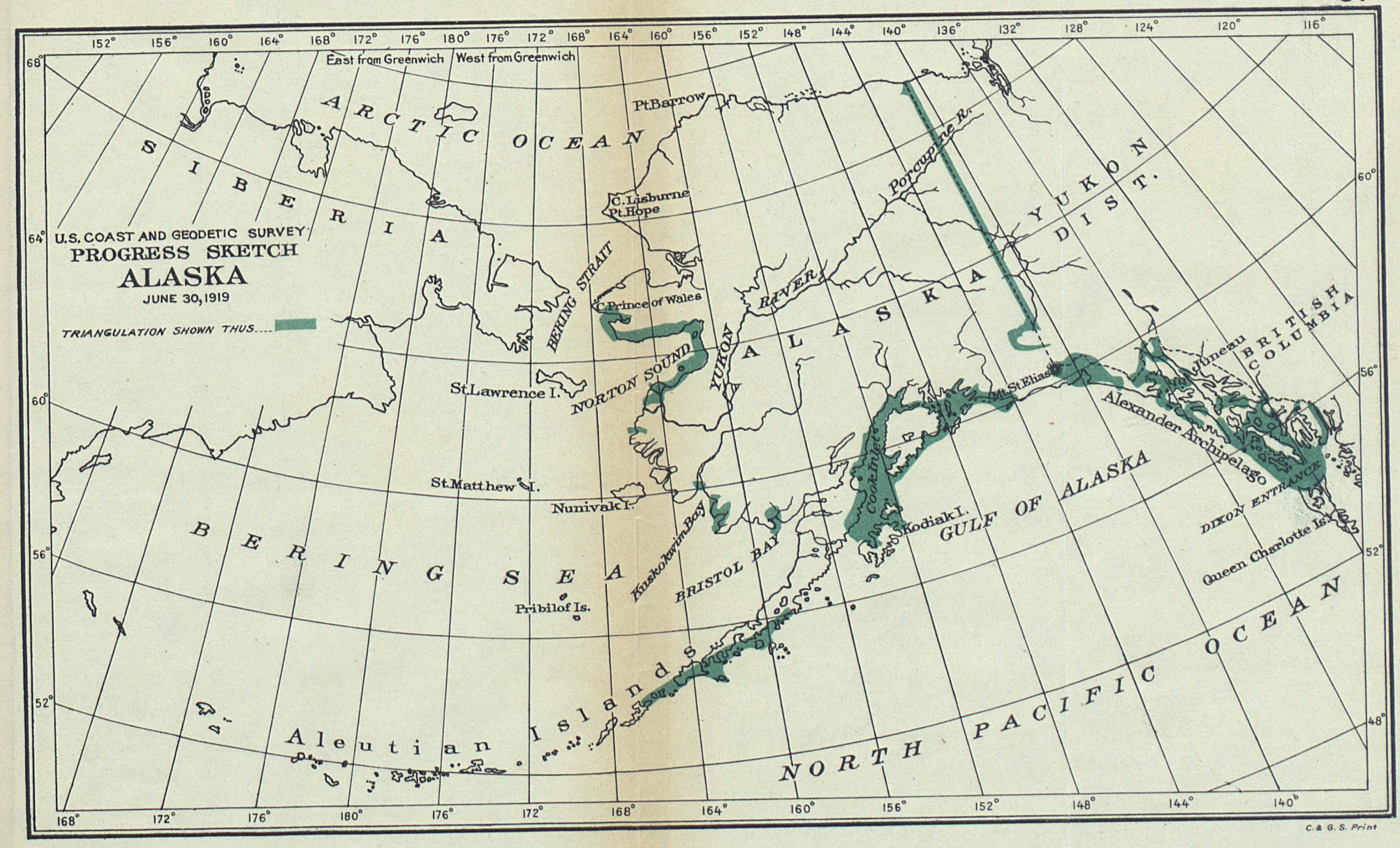
Dependency of the United States since 1898 (21 years)



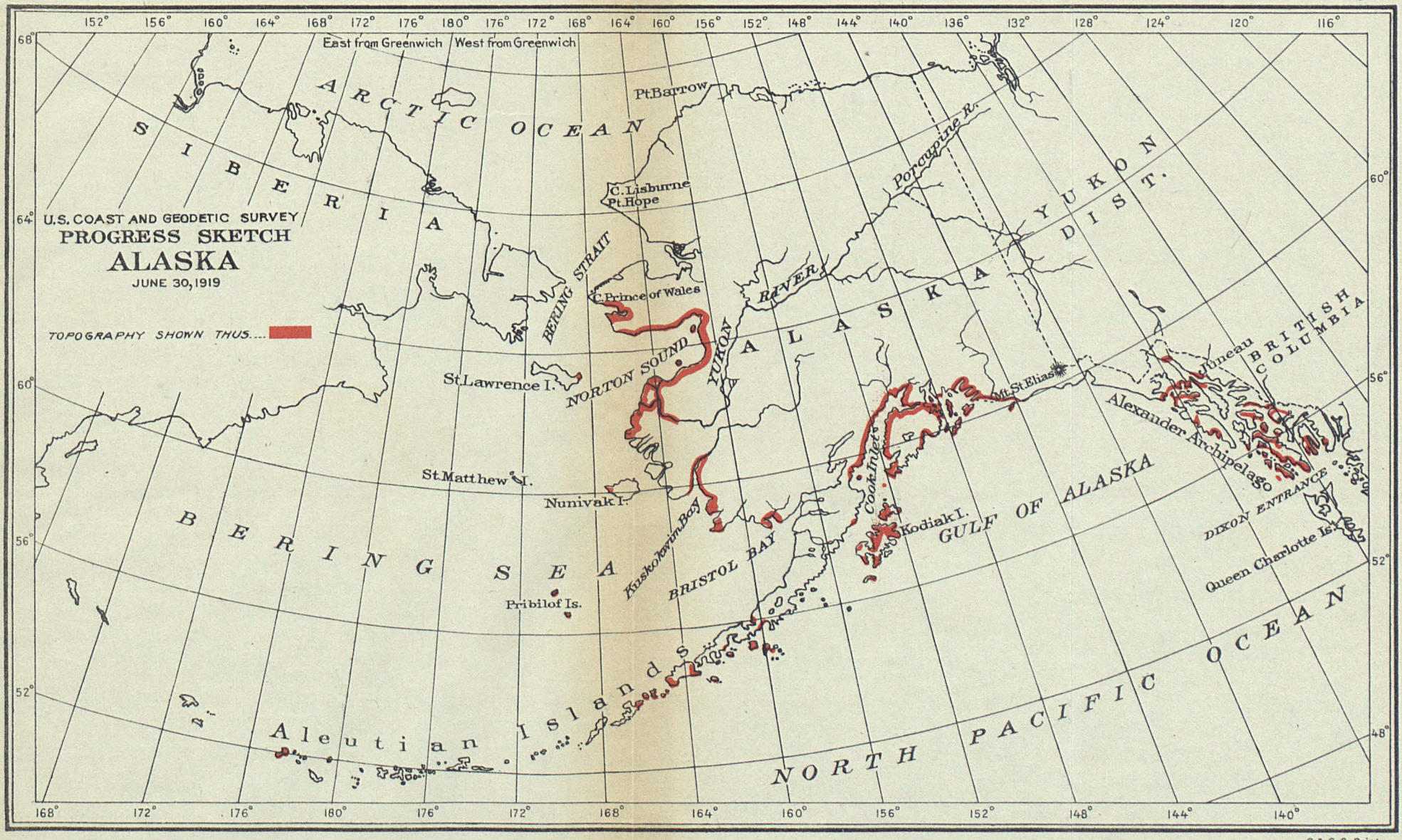
Yellow (33%) - represents unsurveyed water areas.
Red (67%) - represents water areas surveyed in past 19 years.

Philippine surveys have progressed more rapidly in 19 years than in the other regions shown on this sheet due to the funds and four (4) ships supplied by the Philippine Government.

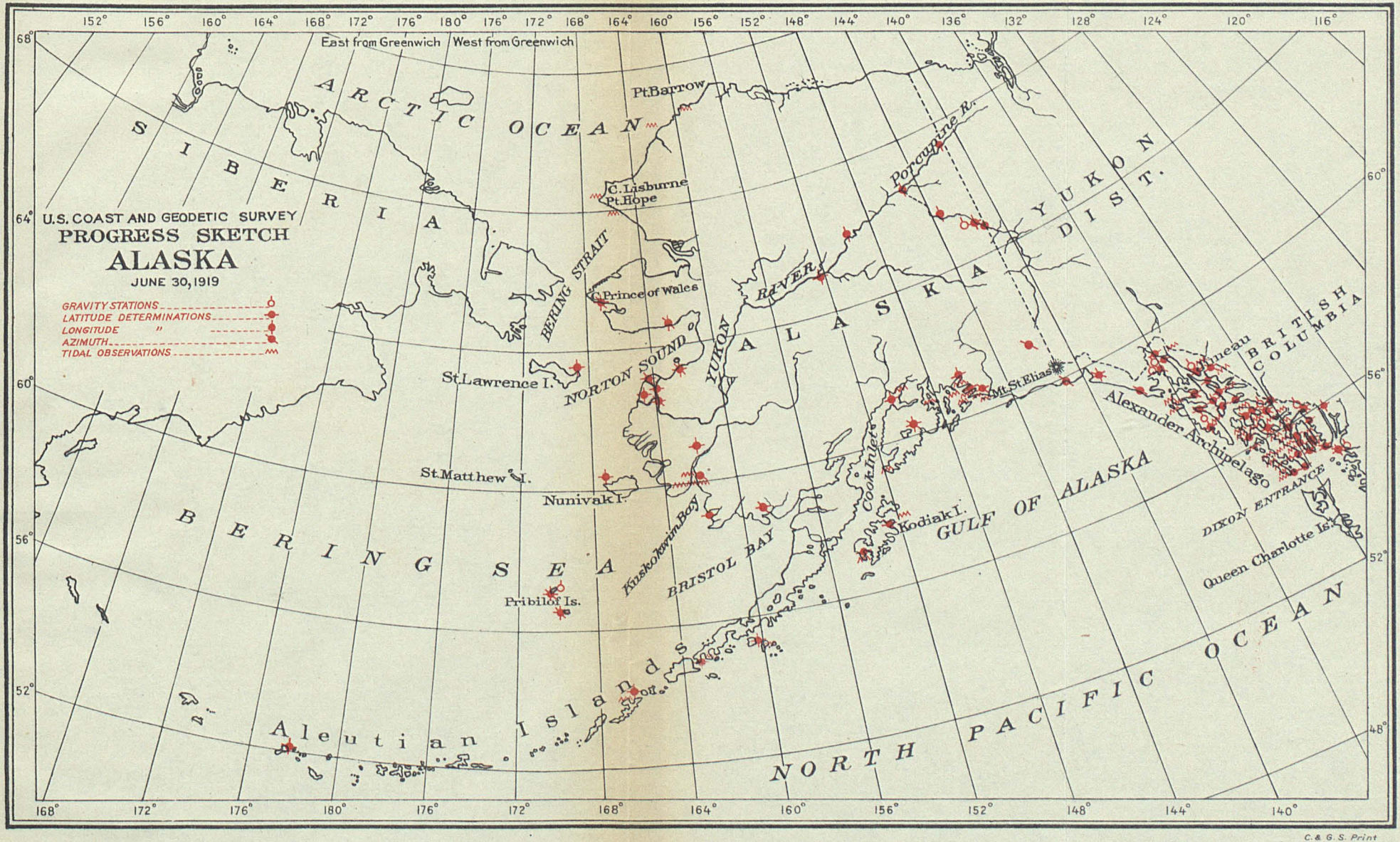
C.&G.S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1919
TRIANGULATION SHOWN THUS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

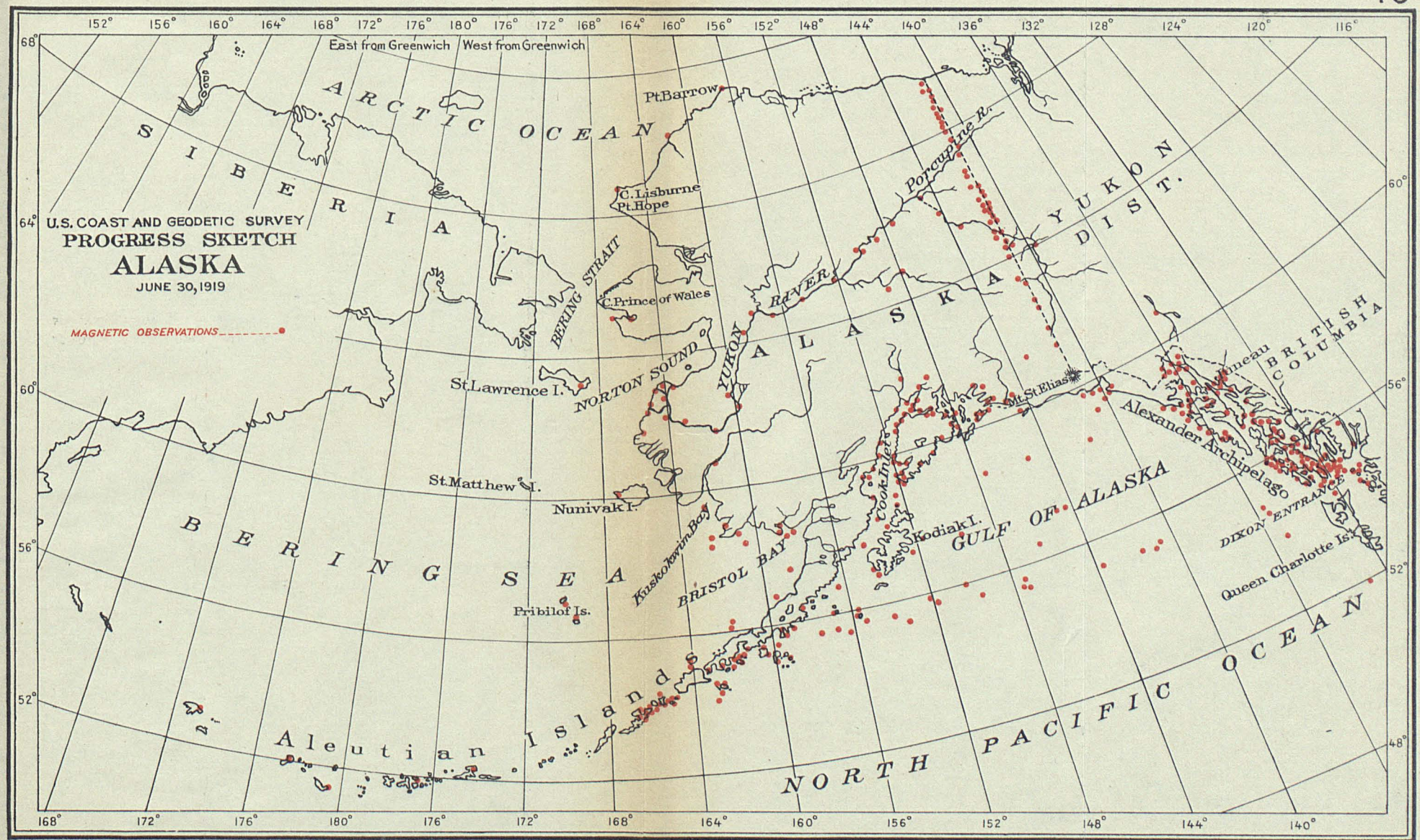
C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1919
TOPOGRAPHY SHOWN THUS....
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BERING SEA
BRISTOL BAY
Pribilof Is.
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1919
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
GULF OF ALASKA
Cook Inlet
Kodiak I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1919
MAGNETIC OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
St. Lawrence I.
NORTON SOUND
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
BRITISH COLUMBIA
Juneau
Mt. St. Elias
Alexander Archipelago
St. Matthew I.
Nunivak I.
BERING SEA
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN
C. & G. S. Print.

on December 31 the whole scheme in this direction was nearly completed. A few of the most eastern stations remained to be established and occupied.

Five stations were established on neighboring British territory, and sites for two more were selected, making seven in all.

Central-point figures were used rather than quadrilaterals. These gave the greatest number of stations on both sides of the islands of St. Thomas and St. John with which to cut in stations for topographic control with the least number of angles to observe.

Stations were established about 1 mile apart along the shore line, and cut in by triangulation. Flags were placed in trees on top of the prominent hills, and located by triangulation. These were for the topographic control. All stations, except the flags on the hilltops, were permanently marked and described.

At the beginning of the fiscal year about half of the field work on topographic sheets A, B, and C was finished. By December 31 all of these sheets, with the exception of a couple of days' work on outlying islands, which work was prevented by high seas, and sheet E were finished, and about half of sheet D. The office work on sheets B and C was practically completed.

The numerous trails, called roads, were so winding that they were run in most cases by plane-table compass traverses, the elevation being carried forward with the alidade, and checked wherever a triangulation flag was visible. The traverse was checked by three-point fixes wherever possible.

A considerable part of the islands was under cultivation during the slave days, but the islands are now covered by dense growths of vines, bush, and trees from 15 to 30 feet high. This made the interior topography difficult. On this account frequent topographic stations were established and marked along the various trails wherever a good three-point determination could be obtained, so that future surveyors could have plenty of points to which to tie in the land surveys.

Two topographic parties were in continuous operation. Each party was in charge of an officer. There were four men to a party.

In the course of the triangulation tangent cuts were taken to Little Tobago Island, Big Tobago Island, and Watson Rock. These cuts plotted on the existing chart put the islands several hundred meters farther west than shown on the chart. St. Thomas and St. John seem to be fairly correct.

When the arrangements were being made in Washington to begin this survey, it was thought that one year, at the most, would be needed to complete it. However, before the first two topographic sheets were finished, it was seen that the entire survey could not be finished within one year. It was found that the country was more heavily timbered than had been thought, and consequently it was more difficult to obtain the desired accuracy and detail.

By January 1, 1919, the triangulation had been carried as far eastward as Estate Carolina, on St. John, and most of the other stations in the St. John scheme had been established. The base lines of St. Thomas and St. John had been measured. Field work on topographic sheets B, C, and E was completed, and that on sheet A practically so. Sheet D was about half finished and sheet F was just started.

In other words the triangulation of St. Thomas and St. John was nine-tenths finished; five-sixths of the topography of St. Thomas and one-fifth that of St. John were completed.

The triangulation was continued in the same manner as previously. The remaining stations of the St. John scheme were occupied. These included stations on the neighboring British islands.

On February 1, the triangulation in that section being finished, the chief of party broke camp, and moved to St. Thomas, where arrangements were made to move headquarters to St. Croix.

While in St. Thomas the chief of party called upon the Governor of the Virgin Islands to inform him regarding the progress of the survey, and to request the assistance of a submarine chaser when the survey of Frenchman's Cap was made, and when the inter-island triangulation was carried out. The governor said that the matter would be given consideration.

Headquarters were moved to St. Croix on February 9. A month was spent on office work, consisting of getting up the semiannual report, and computing geographic positions.

The party started to build triangulation signals on St. Croix, March 12. A base site was selected, and the base net laid out. The base line was not meas-

ured, however, until May 2 as it was desired to have the services of the men from one of the topographic parties when the measuring was done. This was in order to save expenses as well as to have experienced men handling the tape.

In order to have the base line a multiple of 25 meters, and thus avoid a measurement of 10 or 15 meters with the steel pocket tape, one end of the base line was not established until the base-tape support stakes were set. Consequently no triangulation station from which this end of the base line was to be observed on could be occupied until the base was measured, without the necessity of reoccupying the station. Therefore a large part of the base-net scheme was established, and signal poles erected before any observing was done.

A quadrilateral composed of the stations East End (Vieques), Saba, Mount Eagle (St. Croix), and Caledonia (near Hams Bluff Light) was selected as the best means of carrying the geographic position and azimuth over to St. Croix. The observing on this quadrilateral was delayed until all field work on the topography of St. John was finished. Arrangements were made for the use of a submarine chaser to take the party to Vieques, and stand by until the survey was finished.

Everything was in readiness on May 12, so the various light keepers and observers took their stations. The party at each of the four stations had an electric signal lamp, an acetylene signal lamp, and a heliotrope.

Atmospheric conditions were bad the first week, but all of the observing at the four stations was completed the second week. Four sets of observations were taken. A set consisted of six measures of each angle with the telescope direct, and six of the explement with the telescope reversed.

The electric lamps were found to give the best satisfaction. They threw a smaller but stronger beam of light than the acetylene lamps, and, consequently, could be seen better by the observer. The heliotropes could not be seen over the long sides and diagonals except occasionally. The longest distance was 63,418 meters.

After the interisland triangulation was completed all parties were moved to St. Croix. There the topographers did office work on their St. Thomas and St. John sheets, the chief of party carried on the triangulation, and the new officer sent down to relieve one of the others did computing.

At the close of the fiscal year the triangulation of St. Croix had been extended from the western end of the island to Christiansted.

Two topographic parties were kept in the field as previously. They finished the topography of St. Thomas on February 10, and of St. John on May 3. The topographers then assisted in the interisland triangulation, after which they did office work on their sheets. It was desired to send the sheets to Washington as soon as possible, therefore no field work on St. Croix was allowed to interfere with the completion of these sheets for mailing. A field draftsman assisted in the inking of the sheets.

An automobile was used for the triangulation on St. Croix. This proved to be an efficient method of transportation.

A submarine chaser was placed at the disposal of the party for the survey of Frenchmans Cap and the interisland triangulation.

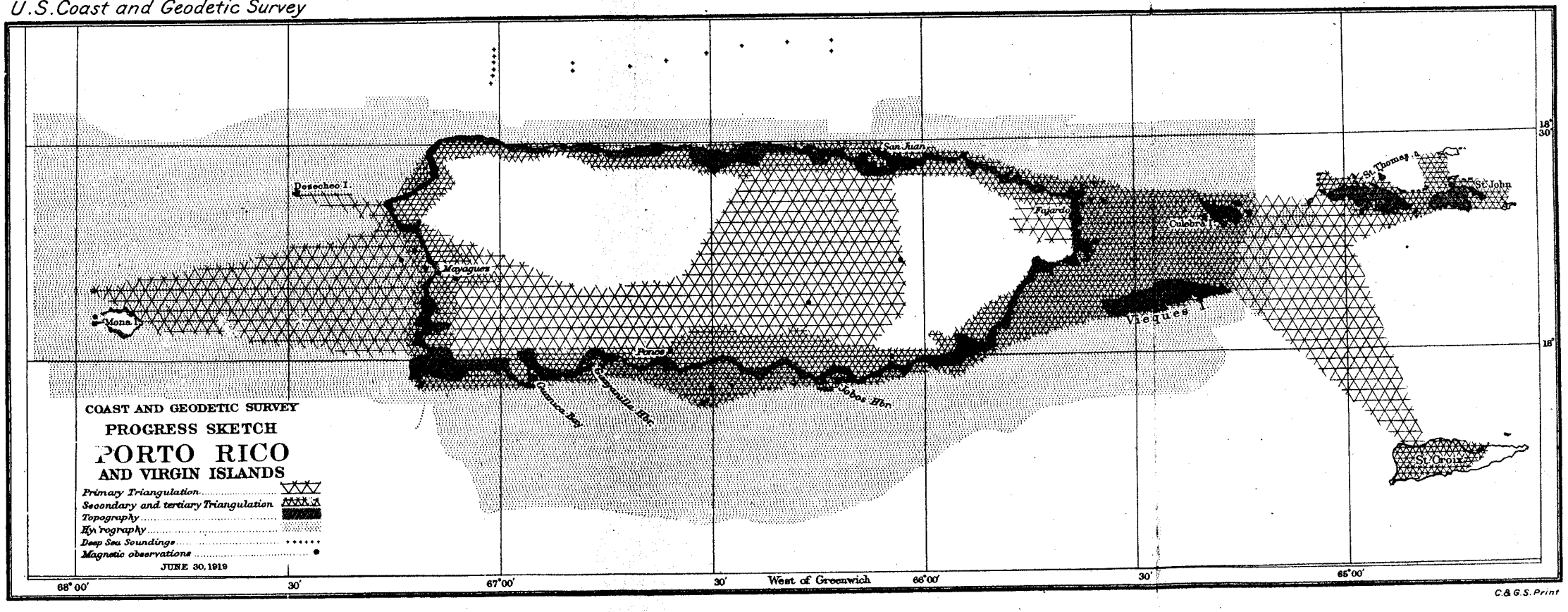
Endeavor was made to comply with the wishes of the Navy officials, and for that purpose frequent consultations were had with the various aids to the governor. They, in their turn, were very courteous, and rendered all possible assistance to the party.

HAWAIIAN ISLANDS.

HONOLULU MAGNETIC OBSERVATORY.

[FRANK NEUMANN.]

At the magnetic observatory at Ewa, Hawaii, the three magnetic variometers were kept in continuous operation, and double sets of absolute observations were made weekly, in order to determine base-line values. Scale-value observations were made monthly on the two intensity variometers as heretofore. Very little trouble was experienced with the working of these instruments, and the only abrupt changes of base line occurred when necessary adjustments were made in December. The scale value at the Z variometer shows a uniform increase.


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
PORTO RICO
AND VIRGIN ISLANDS
Primary Triangulation
Secondary and tertiary Triangulation
Topography
Hydrography
Deep Sea Soundings
Magnetic observations
JUNE 30, 1919
Desecheo I.
Mona I.
Mayaguez
San Juan
Fajardo
Culebra Is.
Vieques
St. Thomas
St. John
St. Croix
Ponce
Guanica Bay
Guayanilla Bbr.
Jobos Bbr.
18° 30'
18°
68° 00'
30'
67° 00'
30'
West of Greenwich
66° 00'
30'
65° 00'

C.& G.S. Print

The Milne seismograph was also kept in continuous operation, and all earthquakes were recorded. As the past winter was one of the driest in years, no trouble was experienced on account of humidity or tilting of the pendulum.

All computations and tabulations were submitted as heretofore. Base-line values were determined, and the hourly means of the three magnetic variometer traces were tabulated—also maximum and minimum ordinates. Reports were also submitted of all earthquakes. Time observations were made three or four times a month with a sextant.

Meteorological observations were made as follows: Antemeridian, inside and outside humidity; postmeridian, outside humidity, maximum and minimum temperatures, and rainfall. Outside thermograph traces were obtained and the general state of the weather noted. Monthly reports were submitted to the local Weather Bureau office in Honolulu.

PHILIPPINE ISLANDS.

[FREMONT MORSE, Director of Coast Surveys, July 1, 1918, to Feb. 10, 1919; HUGH C. DENSON, Director of Coast Surveys, Feb. 11, 1919, to June 30, 1919.]

During the year the field work of the survey was with a reduced force, the number of ships in commission being three—the *Pathfinder*, *Fathomer*, and *Romblon*, instead of the five that were continuously employed previous to the war.

In consequence of this reduction in force the output of field sheets was curtailed, and also the output of finished drawings from the Manila office. The latter was also affected by the outbreak of Spanish influenza in Manila, which at one time resulted in the absence of more than one-half of the office force.

The same disease ran its course among the complements of the surveying vessels. First, and in a mild form, it went through the *Fathomer;* later it laid up the crew and officers of the *Romblon;* and finally, in a more severe form, it struck the *Pathfinder* while she was engaged in her regular work on the Palawan coast, and took toll of eight lives from among the Filipino crew before it was finally overcome. It should be stated that the victims were among those who had joined the ship at Puerta Princesa or had been previously subject to the malarial fevers which are so prevalent on the Palawan coast.

There were no changes in personnel in the office during the period covered by this report and the routine continued as usual.

Tracings for two new charts and two complete new editions of charts and four tracings for correction pieces, were forwarded to the Washington office, besides miscellaneous corrections and new information for reprints of other charts. On June 30 there were 10 chart drawings, consisting of new charts, new editions, or correction pieces, in progress.

More than the usual amount of miscellaneous work was done in furnishing navigators with advance information, and the military, naval, and insular authorities with tracings of field sheets, or blue prints from those tracings.

The computing division continued as usual to care for the triangulation and tidal records, furnish data to the various United States Government and insular authorities as requested, and to keep up the office computations.

The chart division attended to the sale of charts and other publications, and distributed Sections VI and VII of the Philippine Islands Sailing Directions, which were received from the printer subsequent to July 1. The manuscript copy of Philippine Coast Pilot, Part I, was completed in August, and sent to Washington to be printed.

The geographical division of the office continued the work of preparing topographical maps of various sections of the islands. The tracings for map No. 6 were forwarded to Washington to be printed in December. This map covers the eastern part of central Luzon. Map No. 100, covering the entire Archipelago on a scale of 1:1,000,000, was in process of printing during the first half of the fiscal year. Four other topographic maps were in hand on June 30 in various stages of preparation.

Regular meetings of the Philippine Committee on Geographical Names were held monthly, and a great amount of work was accomplished toward correcting and unifying the spelling of names of the barrios of the island. The card index of these names was completed, and has been of great assistance. By its help much has been done to make the spelling of the same names alike in the various Provinces.

[A. M. SOBIERALSKI, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Triangulation: 122 square miles of area covered, 11 signal poles erected, 1 observing tripod and scaffold built (height 104 feet), 8 stations in main scheme occupied for horizontal measures, 18 stations in supplemental schemes occupied for horizontal measures, 5 stations occupied for vertical measures, 24 geographic positions determined, 12 elevations determined trogonometrically. Topography: 404 square miles of area surveyed, 98 miles of general coast line surveyed, 56 miles of shore line of rivers surveyed, 4 miles of shore line of creeks surveyed, 22 miles of roads surveyed, 7 topographic sheets finished, scales 1:20,000, 1:40,000, and 1:10,000. Hydrography: 352.9 square miles of area covered, 3,277.6 miles run while sounding, 59,841 soundings made, 14 tidal stations established, 4 current stations occupied, 7 hydrographic sheets finished, scales 1:20,000, 1:40,000, and 1:80,000.

On July 1, 1918, the steamer *Pathfinder* was at Puerto Princesa, Palawan. The party was engaged on the expansion net from the Iwahig base.

This base line is on level ground in a valley surrounded by high mountains, and to expand from the base to the main scheme triangulation, it was necessary to occupy four mountain peaks, Mount Beaufort, Thumb Peak, Stavely, and Central. Each of these peaks is above 3,000 feet, and 6 to 10 miles inland, making it an arduous task to reach and occupy them. Besides, the observations were hampered by smoky, hazy weather. On account of the poor visibility and, probably, on account of the great difference of elevation between stations, the observations were not as good as in the rest of the main scheme, but were within the requirements of accuracy.

While these observations were in progress, the ship and one launch party were engaged on hydrography and topography to the southward of Calver Point.

During the early part of August the ship was at Manila for minor repairs and supplies.

Upon the return of the ship to the working grounds, work on the hydrography and topography was resumed. Two stations in the main scheme, Calatugas and Albion Head, were reoccupied.

On September 15, the ship was called to Manila to certify to repair vouchers. As the ship took coal at the same time, this did not interfere materially with the work, although Mr. Auld was left at a distant triangulation station for 26 days, and had to live on the country most of the time.

During October the boilers were cleaned at Puerto Princesa, and at the same time the party was engaged on a special tidal investigation.

By October 27 the northeast monsoon was well established in full force. The work was hampered not only by the heavy wind and sea but even more by the haze which always accompanies a strong wind that brings rain.

On November 8 the whole ship's complement, officers and men, was taken ill with Spanish influenza. Nothing had been heard of the spread of this disease throughout the world, and it alarmed the party all the more for that reason. It proved very serious. Eight of the crew died, and many others did not recover completely for over a month. The director sent the *Romblon* with an additional medical officer, and the ship had to return to Manila in order to secure hospital accommodations; the crew was in no condition to do any work, but most of the men who were ill requested their discharges, and on December 8 the ship returned to the working grounds with practically a new crew.

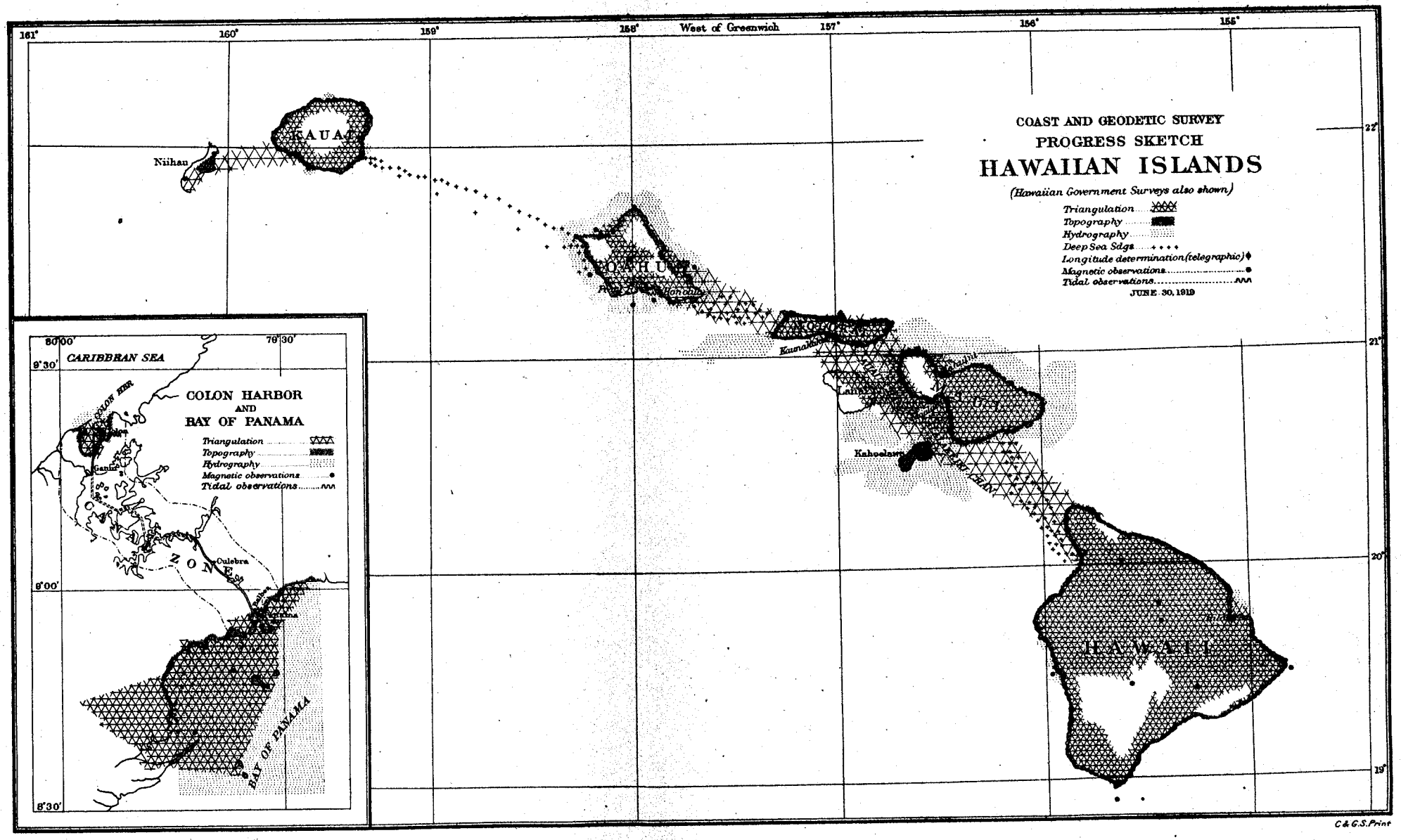
The results of the season's work were as follows:

Triangulation.—The Iwahig base was connected to the main scheme, on the line Thumb Peak–Central. The two values of this line as computed in the field check very closely.

Two stations in the main scheme, Calatugas and Albion Head, were reoccupied to observe some angles which had been omitted in the previous season's work.

The supplementary scheme of triangulation was extended to Bivouac Point, where it joins the main scheme. This system starts from the main-scheme line Arena–Sombrero and extends northward to the station Prom, which is connected with the main scheme; and it has now been connected with the main scheme at the southern end, so that the whole system can be adjusted to fit the main scheme.

Topography.—The topography of Puerto Princesa was completed. On this sheet were included all of the town of Puerto Princesa and all of the Iwahig Penal Colony. These settlements, together with the numerous streams entering the bay, made so much detail that it took a long time to complete the sheet, while the difficult country, mostly mangrove swamps, made it an arduous task.


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
HAWAIIAN ISLANDS
(Hawaiian Government Surveys also shown)
Triangulation
Topography
Hydrography
Deep Sea Sdgs
Longitude determination (telegraphic)
Magnetic observations
Tidal observations
JUNE 30, 1919
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Honolulu
Kaunakakai
Lanai
Kahoolawe
HAWAII
CARIBBEAN SEA
COLON HARBOR
AND
BAY OF PANAMA
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations
COLON HBR
Ganin
Culebra
BAY OF PANAMA
80°00'
79°30'
9°30'
9°00'
8°30'
C&G.S.Print

The topography was extended from Calver Point to Relief Point, where it joins the work of the steamer *Romblon* at triangulation station Shore, thus completing the topography of the east coast of Palawan.

Tagalinog Island was completed on a separate sheet on a scale of 1:10,000.

In order to show the contours from Inagauan to Bivouac Point it was necessary to lay out a 1:40,000 sheet, as the mountains are well back from the coast, beyond the limits of a 1:20,000.

Hydrography.—The hydrography of Puerto Princesa was completed, all the intricate area in the northern part of the bay being closely developed. This fine harbor will some day be of much more importance than at present.

A good typhoon anchorage was developed back of Malanao Island, but the reported passage was found so narrow and tortuous as to be impracticable.

The large number of shoals off the coast between Aborlan and Panacan required an unusual amount of close development.

A good clear channel, though narrow, as well as an excellent anchorage in northeast weather were developed between Rasa Island and the mainland.

The inshore work was carried to Bivouac Point.

It was planned to finish the ship work to a line north of Tagalinog Island, but the unusually hazy weather during the southwest monsoon, together with the fact that the northeast monsoon set in earlier than was expected, made it impossible to carry out this plan. An area of about 28 square miles east of Rasa Island remains to be completed; another area of about 8 square miles south of Rasa Island could not be finished; otherwise the hydrography is completed out to the 100-fathom curve to a line south of Bivouac Point.

Altnacraig Shoal was developed, and a 1-fathom spot found remarkably close to the position indicated on the chart; but there seems to be much shoal water to the southward which has not been examined.

An area of about 8 square miles near Tagalinog Island was examined, while a party was building a tall hydrographic signal on the island.

No sounding tubes were used in this season's work, all soundings being taken either with a hand lead (up to 40 fathoms) or up and down with wire.

An automatic tide gauge was kept in continuous operation at Puerto Princesa. Tide staffs were established at Aborlan and Panacan, and read when hydrography was in progress in the vicinity.

A special tidal investigation was made of the remarkable seiches in Puerto Princesa. Ten tide staffs were simultaneously observed, while currents were observed at the entrance. The results are as predicted, the seiches are almost simultaneous all over the bay, being very slight at the entrance and increasing in amplitude toward the head of the bay. Several fine series of oscillations were recorded.

Puerto Princesa was made the headquarters of the ship, although coal was obtained at Manila, a run of 360 miles.

The work was much appreciated by the people in Palawan. Everyone here is directly or indirectly interested in shipping, and they have had so much difficulty in getting vessels to come here, on account of the unreliability of former charts, that it is natural for them to be interested. But they show an intelligent appreciation of the enormous amount of work and expense necessary to carry out the work, and they have been most willing to cooperate in any way possible.

Information was furnished to the masters of the following vessels: *Mindanao*, *Midget*, *Poseidon*, *Pilar*, *Alphonso*, *Palawan*, and *Capt. Coppens*, besides the provincial authorities and various shippers.

On January 1, 1919, the steamer *Pathfinder* was engaged on the survey of the east coast of Palawan in the vicinity of Rasa Island. Although the northeast monsoon is usually very strong at this time, a typhoon which passed to the northward in the latter part of December caused a cessation of the strong northeast winds; taking advantage of this spell of good weather, it was possible to fill in all the gaps in the work, and leave it with no "splits."

The ship and one launch party were kept in operation up to January 17. On the following day the northeast monsoon set in strong again, and work could not be continued, so the ship returned to Manila for repairs, after taking some coal and dismantling the tide gauge at Puerto Princesa.

As a result of this month's work, all the hydrography was completed out to the 100-fathom curve east of longitude 117° 59′ and north of latitude 9° 00′. The inshore hydrography was extended a few miles to the westward of this line.

Current observations were taken while the ship was anchored on some of the offshore reefs. The series were too short to be of much value, but it ap-

pears that the current is much stronger near the 100-fathom curve, which here follows the edge of a shelf, than farther inshore.

The ship arrived at Manila on January 24. The boilers were cleaned, and then the vessel proceeded to Olongapo for repairs. Instructions from the office required competitive bids, so the vessel returned to Manila. The bids were opened on February 24, and the results wirelessed to Washington; owing to an unfortunate delay in the transmission of the messages, no answer was received until March 8. As soon as authority had been received, the vessel proceeded to Olongapo, arriving on March 10. Work on the repairs was immediately begun, and on March 11 the vessel was docked. On March 15 the command of the vessel was temporarily transferred to Robert J. Auld, jr.

[E. R. HAND, Commanding Steamer *Pathfinder*, Apr. 16 to June 30, 1919.]

SUMMARY OF RESULTS.—Magnetic work: Ship completely swung at 2 sea stations. Hydrography: 12,661 square miles of area covered, 3,724 miles run while sounding, 99 positions determined (double angles), 165 positions determined astronomically, 733 soundings made, 1 hydrographic sheet finished, scale of hydrographic sheets 1 : 200,000 and 1 : 400,000.

On March 29 when the command of the *Pathfinder* was transferred, the vessel was undergoing repairs at the Olongapo Naval Station. The vessel left the station with some items of repairs uncompleted, and arrived in Manila April 1.

After making the necessary preparations the vessel left Manila April 11 under instructions for deep-sea hydrographic work in the Sulu Sea.

The vessel arrived at Puerto Princesa, Palawan, on April 14, and on the morning of April 16 started east on the initial line of soundings.

The instructions called for deep-sea sounding exclusively, and in the Sulu Sea. The work was to be shown on two sheets. Sheet No. 1 covered a triangular area just outside Puerto Princesa. Sheet 2 (starting immediately below No. 1) provided for the development of an east and west strip over 200 miles in length between parallels 9° and 9° 32′ extending from the known soundings at the Palawan coast on the west to the limits of old work along the Negros shore on the east. The requirements of these orders were in substance as follows: Lines should be run east and west, with a spacing and sounding interval not to exceed 5 miles. A line once started to be carried without interruption to its conclusion, a requirement obviously necessitating day and night running. Careful and consistent watch for new dangers. Ends of lines to be tied to shore fixes, and offshore positions plotted by that astronomical method giving the utmost accuracy considering the time, conditions, and bodies available, or in lieu of better means, by dead reckoning strengthened by careful attention to correct compass deviations, well rated log, engine turns and time, wind and current velocities and directions; special attention, by means of split lines and shortened sounding intervals, to that ridge which appears to trend northeast and southwest through the center of the Sulu Sea. Careful record to be kept of all navigational work, and astronomical computations to be submitted with the sheets at the end of the season.

The orders outlined in the above paragraph were carried out.

Work was continued until June 20, when the vessel returned to Manila for the completion of repairs.

A careful search was made for Rubi Reef reported in 1902. An area of 600 square miles was covered with lines about 2½ miles apart, and soundings at the same interval. The bottom was found to be regular, sloping gently toward a 550-fathom spot over 20 miles to the northward. The soundings in the locality of the reported danger run 700 fathoms and over. It is recommended that Rubi Reef be removed from the chart.

[H. B. CAMPBELL, Commanding Steamer *Romblon*.]

SUMMARY OF RESULTS.—Triangulation: 115.2 square miles of area covered, 1 signal pole erected, 1 station in main scheme occupied for horizontal measures, 7 stations in supplemental schemes occupied for horizontal measures, 8 geographic positions determined. Leveling: 2 permanent bench marks established, 0.2 mile of levels run. Topography: 102.4 square miles of area surveyed, 66.5 miles of general coast line surveyed, 1.7 miles of shore line of rivers surveyed, 3 topographic sheets finished, scale 1 : 20,000. Hydrography: 608.7 square miles of area covered, 3,524.2 miles run while sounding, 9,071 positions determined (double angles), 56,965 soundings made, 2 tidal stations established, 3 hydrographic sheets finished, scales 1 : 20,000 and 1 : 40,000.

On July 1, 1918, the *Romblon* left the working grounds for Manila, arriving on July 4. Minor repairs were completed, stores were on board, and the ship was ready to sail on July 22, but was delayed until July 26 by distant typhoons.

From August 2 to October 9 work was continued off the southeast coast of Palawan, and three trips to Sandakan, British North Borneo, were made for coal. On each of these trips two camp parties were left on the working grounds.

Leaving for Manila on October 10, the vessel arrived October 12, and was ready to sail on October 25, on which date the epidemic of Spanish influenza laid up 15 men. Spreading rapidly to all hands, the epidemic held the party in Manila until November 12, when by transferring some of the crew of the *Fathomer* to the *Romblon*, it was possible to go to the assistance of the *Pathfinder* at Puerto Princesa, in accordance with orders.

Arriving in Puerto Princesa on November 14, on November 16 five men were transferred from the engineer force of the *Romblon* to the *Pathfinder*, to enable the latter vessel to get to Manila. From then until November 25, there were from three to five men sick on the *Romblon*, and it was not thought advisable to go to the working grounds where the vessel would be very short handed, as well as out of reach of medical assistance should it be needed.

On November 26 the ship arrived on the working grounds, and continued work until December 19, making one trip to Sandakan for coal. During this trip to Sandakan one camp party was left in the field. The *Romblon* sailed for Manila December 20, stopping at Puerto Princesa for coal, and arrived in Manila on December 23. On December 24 the boiler was blown down and general overhauling began.

Both the ship and the launch were engaged continuously on hydrography when the weather was favorable, the launch working from camp the greater part of the time.

In spite of every effort being made by the party on the ship to complete the southern portion of the work below Brooke Point, the plan failed on account of weather conditions. The work was then taken up closer inshore, between Brooke Point and Island Bay. In this locality a system of 1,200 meter lines was run offshore, outside the launch work, as far as signals could usually be seen. In the deeper water outside this area, lines parallel to the coast were run, whenever the weather permitted and there was occasion for the ship to run up or down the coast.

After the monsoon changed to northeast, the ship worked outside and near Island Bay, keeping near the anchorage and running as short a distance as possible to and from work.

On the runs to Sandakan, the ship sounded whenever the weather was at all favorable. This resulted in six lines from the working grounds to Cagayan Sulu, along the 100-fathom curve, and in three lines from Cagayan Sulu to the locality of Taganak Island.

The launch party, working from a camp about 15 miles south of Brooke Point, spent about two weeks developing shoals in that locality. When the monsoon changed, inshore work on the exposed coast was discontinued, and the launch worked in and off Island Bay.

On October 21 and 22 sounding was done inside the breakwater in Manila Harbor by a party from the *Romblon*, using a whaleboat and the launch.

Two topographic sheets were completed, and a juncture was effected with the work of the party on the *Pathfinder*, at triangulation station Shore.

The only triangulation done was the determination of the positions of eight new stations, to be used for the purpose of control in and to the south of Island Bay. Seven of these stations were built prior to July 1. All observing was done after that date.

From August 5 to October 5 a staff was read at Brooke Point from 6 a. m. to 6 p. m., and an automatic gauge was maintained in Island Bay. From November 26 to December 19, only the gauge in Island Bay was operated.

No currents were observed during this period.

Even early in August, when this season began, the haze was troublesome. It steadily grew worse, and late in September, there were times when the shore could not be distinguished at less than 10 miles. The clouds also gave more trouble than early in the year, the peaks usually being covered except for a very short time at sunrise or sunset.

When the party arrived on the working grounds in November, the northeast monsoon had set in, and the parties worked from Island Bay, where a good anchorage was to be had. Very little work was done by the ship at this time. Even when signals could be seen, and the sea was smooth enough to permit work, the facts still remained that, on account of the continual sea and clouded sky, shoals could not be seen, and bottom was barely visible at 5 to 6 fathoms,

and this in a locality where there are not only many shoals, but where they are very steep-to.

On October 12 while approaching Manila, the *Romblon* was signaled by the steamer *Palawan*, which was disabled by engine trouble near San Nicolas Shoal Light. At their request the *Romblon* towed the *Palawan* to the breakwater at Manila.

During the influenza epidemic, November 19 to 21, the *Romblon* made one trip from Puerto Princesa to Brooke Point, taking medicine and assistance to the natives. This trip was made at the urgent request of the provincial governor at a time when field work was impossible because of the weather. The coal burned on this trip was replaced by the provincial government.

From January 1 to May 13 the *Romblon* was tied up at Engineer Island, Manila, undergoing repairs. During this period the ship's crew was engaged in overhauling machinery, scaling, painting, etc.

In accordance with instructions dated February 25, 1919, two officers with a launch party from the *Romblon* were engaged in hydrography on Laguna de Bay from March 3 to April 19. The topography in this locality was found to be incorrect in places, and from March 18 to April 9 a third officer with a topographic party from the vessel was assigned to that work.

Upon the completion of repairs, on May 13, six months' stores were on board, coal was taken at Cavite, and the vessel sailed for the working grounds under instructions of the Director of Coast Surveys, dated April 29, 1919.

The party arrived at Guinayangan, Tayabas Province, on May 15, and work was at once begun. On June 13, it was necessary to leave for coal. Two topographic parties and one hydrographic party were left in the field and the ship sailed for Manila, arriving on June 16.

A few minor but essential repairs were made at Engineer Island, and on June 23 the vessel left for Cavite, where coaling was completed June 24. Sailing direct from Cavite on that date, the vessel was delayed by rough weather and a low barometer, and did not reach the working grounds until June 28.

The field work had progressed satisfactorily, and leaving two parties in camp, the vessel proceeded on June 29 to Port Pusgo, where she was anchored on June 30, waiting for the barometer to rise.

The triangulation in the locality of Laguna de Bay was not done by this party. However, it was used as control for the hydrography executed by the party from this vessel.

Referring to the triangulation at the head of Ragay Gulf near the mouth of the Guinayangan River, stations Guinayangan, Garcia, and Nasua were recovered without difficulty, and from the line Guinayangan to Garcia a scheme is being extended up the river. Before any observing was done, intersection stations were built, and these, with the built-up main-scheme stations, have furnished excellent control for hydrography and topography.

It was necessary in the river, because of the overhanging mangrove, to build tripods for observing. This greatly retarded the progress of the work, and, probably on account of the strong current, affected its accuracy somewhat.

The hydrography done by the party on Laguna de Bay was very thoroughly covered in the descriptive report accompanying the hydrographic sheets.

At Guinayangan, as the sounding barely extends outside the 5-fathom curve, it was all done by launch or whaleboat.

The launch was used from the southern limit of the work up to the bar at the river mouth. The depth varies from about 6 fathoms to 10 feet, at low water. The launch was run as slow as possible, and the soundings spaced as closely as could be done with one leadsman. The greater part of the area, that inside the 5-fathom curve, was covered with 50-meter lines. Outside the 5-fathom curve a few lines 100 meters apart were run, and the soundings were also spread slightly farther apart.

From a depth of about 10 feet, northward—that is, on the bar itself—the whaleboat only was used. Fifty-meter lines were run, and soundings taken much more closely than would be possible with the launch. Under about 9 feet, a sounding pole was used. From the whaleboat all soundings were read to the lesser half foot.

The control for the work consisted of triangulation stations and intersection stations, supplemented by topographic flags.

At Laguna de Bay the topography consisted only of revision and adjustment of such shore line as was found to be very much out by the hydrographic party. The usual topographic methods were used.

At Guinayangan two sheets are partially completed. A 1:10,000 scale, which covers the area outside the river mouth, is nearly finished, and a 1:5,000 scale, covering the lower portion of the river, is about half finished.

Good control is afforded on both of these sheets by the numerous triangulation stations. On the 1:5,000 sheet considerable delay is being caused by having to wait for low water.

On May 19 installation of the automatic gauge at Guinayangan was completed. There was trouble in getting a satisfactory curve, but this difficulty has probably been overcome by the change in the location of the gauge made on June 2 and 3.

On May 16 a tide staff was erected at Alunero. Since then readings were taken from 7 a. m. to 5 p. m. six days a week.

[S. D. WINSHIP, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Triangulation: 8 stations in supplemental schemes occupied for horizontal measures, 8 geographic positions determined. Magnetic work: Ship completely swung at one sea station. Topography: 0.2 square mile of area surveyed, 6 miles of general coast line surveyed, scale of topographic sheets 1:20,000. Hydrography: 1,131.3 square miles of area covered, 19,765 miles run while sounding, 21,169 soundings made, 3 hydrographic sheets finished, scales 1:20,000, 1:40,000, and 1:80,000.

Work in the Cuyo group, on which this party was engaged at the end of the previous fiscal year, was continued until July 12, when orders were received to return to Manila for repairs.

While the party was in Manila, some little work was done around the mouth of the Pasig River and inside the breakwater, under special instructions from the Director. At the request of the commandant of the navy yard at Cavite an officer was detailed to determine the angles of visibility of Sangly Point Light.

During the latter part of July the majority of the crew was taken with Trancazo, or Spanish influenza. On one occasion for several days only two men could be mustered on deck. Fortunately no fatalities occurred.

Before returning to the work in Cuyo West Pass, five days were spent in the vicinity of Ilog Anchorage, north coast of Mindoro, looking for two reported shoals, neither of which was found.

September 11 found the party again in Cuyo West Pass. On account of poor seeing conditions it was impossible to complete the triangulation connecting the Dalanganem Islands to the main scheme, though constant effort was directed toward it. The months of May and June are the best suited for triangulation in that locality. Sufficient points were determined, however, to carry on the hydrography indefinitely.

After coaling once in Iloilo, shortage of funds made it necessary to coal in Borneo. On two trips to Sandakan, British North Borneo, two sounding lines were run as far as North Tubbataha Reef.

On October 25, while returning from Sandakan, the *Fathomer* grounded on North Tubbataha Reef, under conditions described in a special report. It was an uncomfortable experience for all hands, though they were favored with the best of good fortune in getting off without aid and returning to Manila under their own steam. The *Fathomer* is the third of three vessels to pile up on Black Rock in the past three years and the only one to get off without help.

On arrival in Manila on November 1 it was found that all shipyards were so busy that no repairs could be undertaken on the *Fathomer* until January. As it did not seem advisable to work the ship during heavy weather of the northeast monsoon until the condition of the hull was known, the ship was tied up to await repairs. In the meantime the crew was retained and the entire ship, both inside and out, was given a thorough overhauling, which was badly needed.

While in the field the party had no headquarters. A tide staff was maintained at Araceli, Palawan, a party camped most of the time in the Dalanganem Islands, mail came to Cuyo, and the ship anchored on the nearest shoal or drifted if no anchorage was handy.

From January 1 to April 15 the *Fathomer* laid at Engineers Island, Manila, undergoing repairs. During this period she received a thorough overhauling, supervised almost continually by two officers. The other officers, while not engaged in some special assignment, applied themselves to the field records of the preceding period.

During February a reconnoissance was made of Laguna de Bay, and preparations made to start a survey early in March.

The Laguna de Bay party started March 1, in charge of an officer who was attached on that date for that purpose. He had with him another officer and a crew of seven men from this vessel, using the ship's launch and cutter. This

party executed hydrography on a 1:40,000 sheet, until April 10, when the party was recalled, as the ship was leaving for the south.

On April 15 the ship left for the working grounds.

The assignment consisted of hydrography, topography, and triangulation. The unfinished triangulation and topography of the Dalanganem Islands had to be done, as well as a complete survey made of the Cagayan Islands. The triangulation of the Dalanganems was completed, except one long line which has baffled all attempts. The topography was soon completed, however, and a party placed on the Cagayan Islands to reconnoiter, lay out a triangulation scheme, and do the observing. At the close of June this was about two-thirds finished.

The principal work is the hydrography. It consists of a 1:20,000 sheet of the Dalanganem Islands, a 1:80,000 sheet of Cuyo West Pass, on which the party has been working for a year, and a 1:200,000 of the northern part of the Sulu Sea, extending, roughly, from Piedra Blanca south to the Cagayan Islands, west to Rubi Reef, north to Dumaran Island, and east to Piedra Blanca, besides the two small sheets of the Cagayan Islands, which have not been touched.

The 1:80,000 sheet was worked on whenever possible, the distance run for coal cutting the available time to from 8 to 12 days per month. On those days, however, the ship almost invariably worked 12 hours a day, with two watches, thus taking advantage of all the daylight hours.

The 1:200,000 sheet is all deep water, from 600 to 900 fathoms, with about 25 soundings of greater depth in the southeastern portion. When going for coal, a line was run both going and coming, fixing each end to shore objects and controlling the rest by astronomical observations.

In addition there are two sheets covering the Cagayan waters themselves. One, 1:20,000, takes in the intimate waters of the group, the other, 1:40,000, takes the reefs and shoals to the northeastward. No work has been done on these sheets.

During the entire period a tide gauge was maintained at Araceli, Dumaran Island, Palawan. Mail was received at Cuyo, and coal at Sandakan, British North Borneo.

After June 3 a camp party, consisting of one officer and five men, was maintained on the Cagayan Islands, occupied in reconnoissance and triangulation.

On June 29 the ship returned to Manila, under orders from the Director, leaving a party in the field. On the following day accounts were closed, inventories were signed, and the command turned over to another officer under orders from the superintendent.

SPECIAL DUTY.

INSPECTION OF AERONAUTICAL EXHIBITS AT MADISON SQUARE GARDEN, NEW YORK, N. Y.

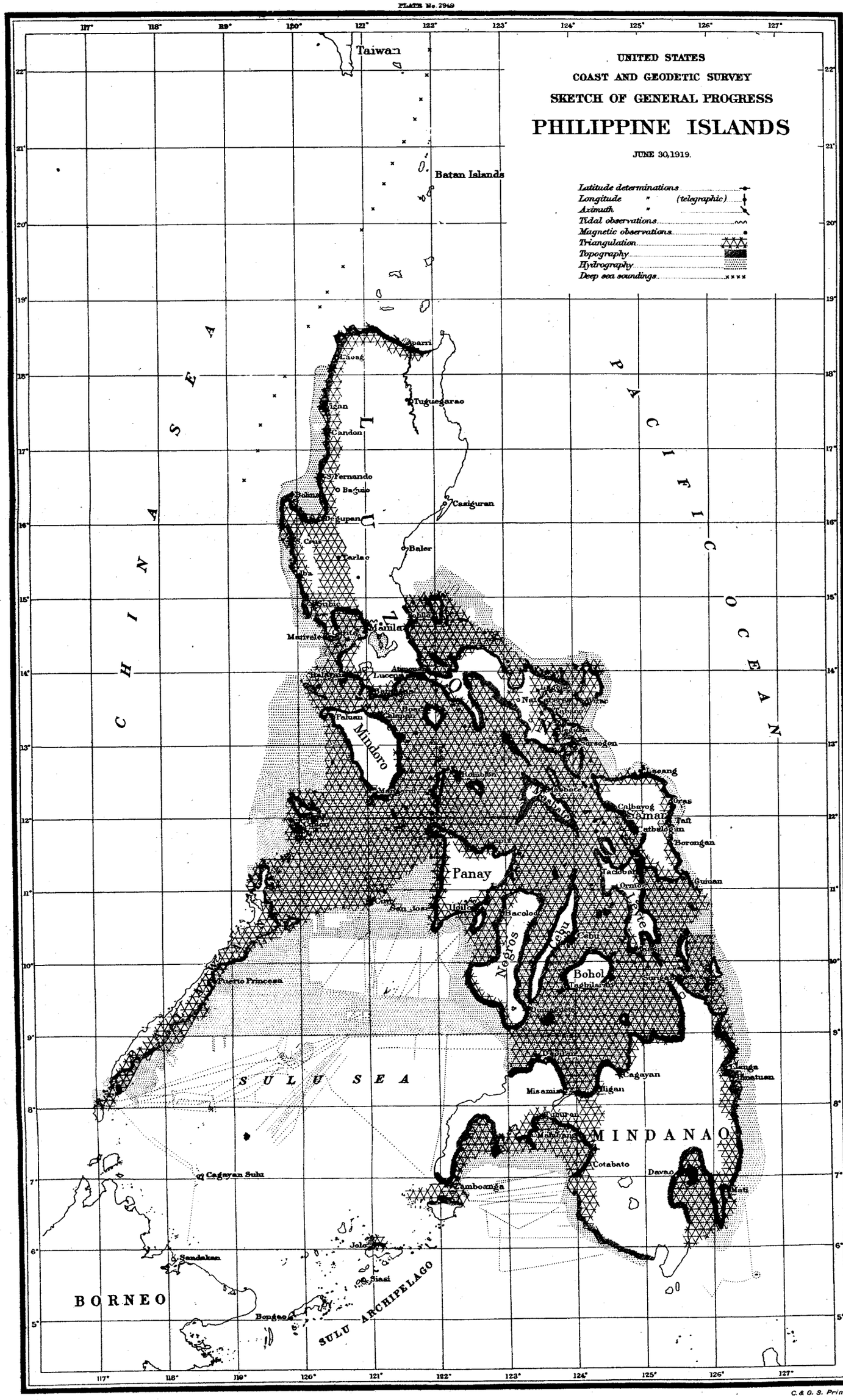
[E. G. FISCHER.]

On March 13 an inspection was made of the aeronautical exhibits at Madison Square Garden and the Sixty-ninth Regiment Armory, New York, with a view to gaining such knowledge of recent developments in such scientific instruments and apparatus as might be advantageously used in the work of the Coast and Geodetic Survey. The exhibit illustrating the latest advances in aerial surveying was also examined.

The part of the exhibit most directly relating to the work in which the Coast and Geodetic Survey is engaged, that of photographic surveying from the air, was highly interesting, and particularly so on account of the very short space of time in which a plan of an extended area can be photographed, enlarged, and assembled into a complete whole.

It is claimed that trained men can obtain the photographs for mapping an area of 30 square miles in one hour's flight. A map of the route from Fort Sill to Wichita Falls was made from 4,200 exposures obtained in 60 flying hours, by students in training. But, as the topographer on the ground, having before him the altitudes of the points he establishes almost in their linear extent, but being obliged to shift his station frequently to observe and establish horizontal distances, the aerial topographer, inversely, at once obtains all the latter, but only limited information as to the heights of the points established.

Information was obtained in regard to available maps produced by this method, and also in regard to a new aluminum alloy known as "acieral," of which samples were obtained for testing with a view to possible use in the construction of instruments.



U.S. Coast and Geodetic Survey

C. & G. S. Print

DISTRICT OF COLUMBIA.

[H. G. AVERS.]

SUMMARY OF RESULTS.—Topography: 2 acres of area surveyed, 1 topographic sheet finished, scale 1 inch to 20 feet.

In October, at the request of the Supervising Architect of the Treasury Department, elevations were determined at 20-foot intervals of the grounds in the rear of the Hygienic Laboratory, Washington, D. C.

This plot had been surveyed originally by George D. Cowie in 1912, but several changes that had been made in the grades necessitated a resurvey before plans for a contemplated new building could be drawn.

The results of the survey were plotted on a sheet on scale of 1 inch to 20 feet and furnished to the office of the Supervising Architect.

Two assistants to act as recorder and rodman were furnished by the Supervising Architect's office and the work was done without expense to the Survey.

[F. B. T. SIMMS.]

In conformity with a request from the Navy Department, a trial course 1 nautical mile in length was established for the use of the naval air station at Anacostia, D. C.

The Navy Department furnished the boats, men, and material necessary for this work and field work was in progress on April 3, 4, 7, 9, and 10, 1919.

The method of establishing the course consisted of selecting a point A, on the United States naval magazine wharf, Bellevue, readily located by triangulation, and to serve as a point on the southern range of the trial course. A suitable course for hydroplanes was laid off on hydrographic sheet, scale 1:10,000, along the east edge of main channel 1 mile north of A; allowing also for a safe depth of water for the approaching and leaving course. This course was found to be 14° N. 19′ E.

A point distant 1 nautical mile northwest from A, along the azimuth line 14° N. 14′ E., was platted on topographic sheet, scale 1:4,800, and the point C, on the ground corresponding to the platted position, was selected by identifying certain topographic features in the locality. A and C, however, were found not to be intervisible; it was impossible to find two such points 1 mile apart located on this shore.

The two points, A and C, were located by triangulation—the azimuth from A to C was found to be 14° N. 20′ 50″ S., and the distance between them 1,928.27 meters, exceeding 1 nautical mile (1,853.25 meters) by 75.02 meters. It is seen that azimuth A to C is practically the same as that of the course itself, and for the sake of simplifying the computations the azimuth N. 14° 20′ 50″ was adopted. The azimuths of the ranges, therefore, would be 104° N. 20′ 50″ E.

It remained now to locate a point B on the northern range distant 1 mile from A, or 75.02 meters from C, if measured in a direction toward A. It was necessary, however, to measure a distance along edge of bluff on a line 18° 30′ to the left of the direction C to A, or 79.11 meters, establishing the point B on the north range. (The measurement 79.11 meters was made along series of level stakes about 15 to 19 meters apart.)

Suitable signals were then built to mark the north range, one of them being built adjacent to the stub marking B, the other about 40 meters inshore and on the azimuth line 104° N. 20′ 50″ E. through B, obtained by observing angle at B between distant triangulation and inshore range signal. (The azimuth to the triangulation station having been computed.)

Two signals marking the south range were built on the azimuth line 104° 20′ 50″ through A, the front range being placed on the face of the wharf, about 1 foot away from A and the other range was built on shore near the wharf and about 80 meters from A. It was found impracticable to locate the rear ranges by triangulation, as they were not visible from more than one triangulation station.

The ends of the course were marked by buoys. In order to place a buoy on the course, the angle between range and a certain identified object was taken from the topographic sheet; the desired spot was then obtained by getting on range while sighting the given angle between range and object with a sextant.

It was understood that the buoys and moorings are to be replaced later by larger gear by the naval air station, and in order to relocate them, cross ranges were noted for the north-end buoy and the south-end buoy.

MARYLAND.

[E. D. BROMLEY.]

Work was undertaken at the request of the War Department for the purpose of determining by triangulation the geographic positions of certain range towers for the Aberdeen Proving Ground from Mulberry Point to Love Point, Kent Island, upper Chesapeake Bay.

In March and April, 1918, several towers had been located by John A. Daniels as far south as Worton Point. These were found inadequate in number and range for the large guns to be tested at the grounds, and the scheme was therefore extended south to Love Point, Kent Island.

First a scheme of towers was selected using both sides of the bay. This scheme was laid out, the necessary clearing done, and signals built. After the observations had been completed, it was decided by the proving-ground officials that the towers on the western shore were dangerous, being in line of fire at certain ranges. It was then decided to place extra towers on the eastern shore and eliminate all proposed locations on the western shore.

With this new scheme in view, all the stations had to be reoccupied and a new list of directions made for each station, including the new ones.

The towers were located back from the shore, usually about 100 meters, and in some cases 400 meters, which necessitated a great amount of clearing for observations of range firing and for measuring the angles of the triangulation.

The towers themselves could not be used in observing the angles for the triangulation, as they were only single towers with four legs, having a house at the top 10 feet square. Most of the towers were not built when the observing was done. In some cases the instrument was set on a special tripod built under the range towers and sometimes on its own tripod set up on the ground over the station mark. The towers are eccentric to the triangulation stations.

There were three regular triangulation stations established.

There were only four old triangulation stations recovered from Love Point, Kent Island, to Turkey Point Lighthouse, Turkey Point, and it was necessary to make a complete scheme of triangulation for the whole of the upper Chesapeake Bay.

The Aberdeen Proving Ground furnished recorders and laborers. One recorder and one helper were used in the triangulation party. Fifteen men and a foreman were engaged in building signals and clearing trees on the western shore and on Pooles Island. On the eastern shore a detail of 12 soldiers and 1 sergeant were employed cutting trees, marking stations, and building signals. The detail camped along in the different places, and rations were furnished them from the proving grounds. Transportation was furnished by the proving-ground authorities in either boat or automobile.

In all there were 42 stations in the scheme, including 7 lighthouses and the 2 range lights on Pooles Island.

The officials of the Aberdeen Proving Ground cooperated in the work in every way possible.

FLORIDA.

[H. LEYPOLDT.]

In February a conference was had with the commanding officer of the naval air station at Miami, Fla., for the purpose of ascertaining to what extent the method of topographic surveying by airplane would be useful in the work of the U. S. Coast and Geodetic Survey.

The commanding officer of the naval air station was instructed by the Navy Department to cooperate with the party of the Coast and Geodetic Survey at work at Miami, and to render every assistance which would not actually interfere with the military operations of that station.

The methods used in aerial photography were examined and a report made on the subject.

MARYLAND.

[PAUL M. TRUEBLOOD.]

SUMMARY OF RESULTS.—Triangulation: 132.5 square miles of area covered, 30 signal poles erected, 19 stations in main scheme occupied for horizontal measures, 3 stations in supplemental schemes occupied for horizontal measures, 37 geographic positions determined.

The location of ranges, torpedo firing course, Potomac River, and revision of triangulation, Potomac River, Piney Point to Blackistone Island, are two proj-

ects which were executed as one continuous piece of work and both are therefore covered in a single abstract.

The work originally requested by the Navy Department was the establishment of permanent shore ranges for a torpedo firing course in the Potomac River. The firing point was to be defined by ranges intersecting at a point 2,500 yards south of Piney Point Lighthouse. The true bearing of the firing range was 122° from this point (geodetic azimuth 302°). Cross ranges were to be located which would intersect the firing range at 4,000-yard intervals from the firing point up to 20,000 yards. The cross ranges were to intersect the firing range at an angle of approximately 90°, the shore points were to be permanently marked, and they were to be far enough apart to make a "sensitive" range; that is, so that the range marks would open considerably for a slight variation from the exact intersection.

To this was added the revision of triangulation from Piney Point Lighthouse to Blackistone Island, so as to furnish geographic positions, lengths, and azimuths for the firing range from the lower proving grounds.

A number of supplementary points were added to the main scheme, in order to have a sufficient number of observing stations convenient to any part of the river.

Instructions for the field work were issued under date of March 28, and on that day a reconnoissance trip was made to Millers Wharf, Md. At a conference with Capt. Miller it was arranged that a submarine chaser was to be detailed by the Navy and a working party and equipment were to be supplied. while the Survey was to furnish the instruments and any additional labor and materials that might be necessary. The chaser was to be available April 21.

On April 19 the chief of party left for the field. A room for the storage of instruments and for computing was obtained on April 21, and on the 22d the submarine chaser arrived with the working party and equipment.

It was found that most of the old-scheme stations of the triangulation had been lost. It was therefore necessary to lay out a new scheme of simple quadrangles with sufficient points to determine the range stations by intersection. The reconnoissance and signal building were done at the same time, as it was found that the original figures could be followed in a general way.

Most of the observing was done by the chief of party, using the 7-inch Berger theodolite No. 194. Six stations were occupied by Lieut. Simpson Earle. The accuracy of the work as indicated by the triangle closures is very satisfactory.

Valuable assistance was rendered by Lieut. Earle and by the Navy in furnishing a submarine chaser, working party, equipment, and signal-building material. Lieut. Earle assisted in building the signals and marking stations in the lower reach of the river, and did all of this work in the upper reach from Piney Point to Blackistone Island. He also did a considerable amount of observing and assisted in every way possible to keep the work going smoothly.

Respectfully,

E. LESTER JONES,
Superintendent.

To Hon. WILLIAM C. REDFIELD,
Secretary of Commerce.

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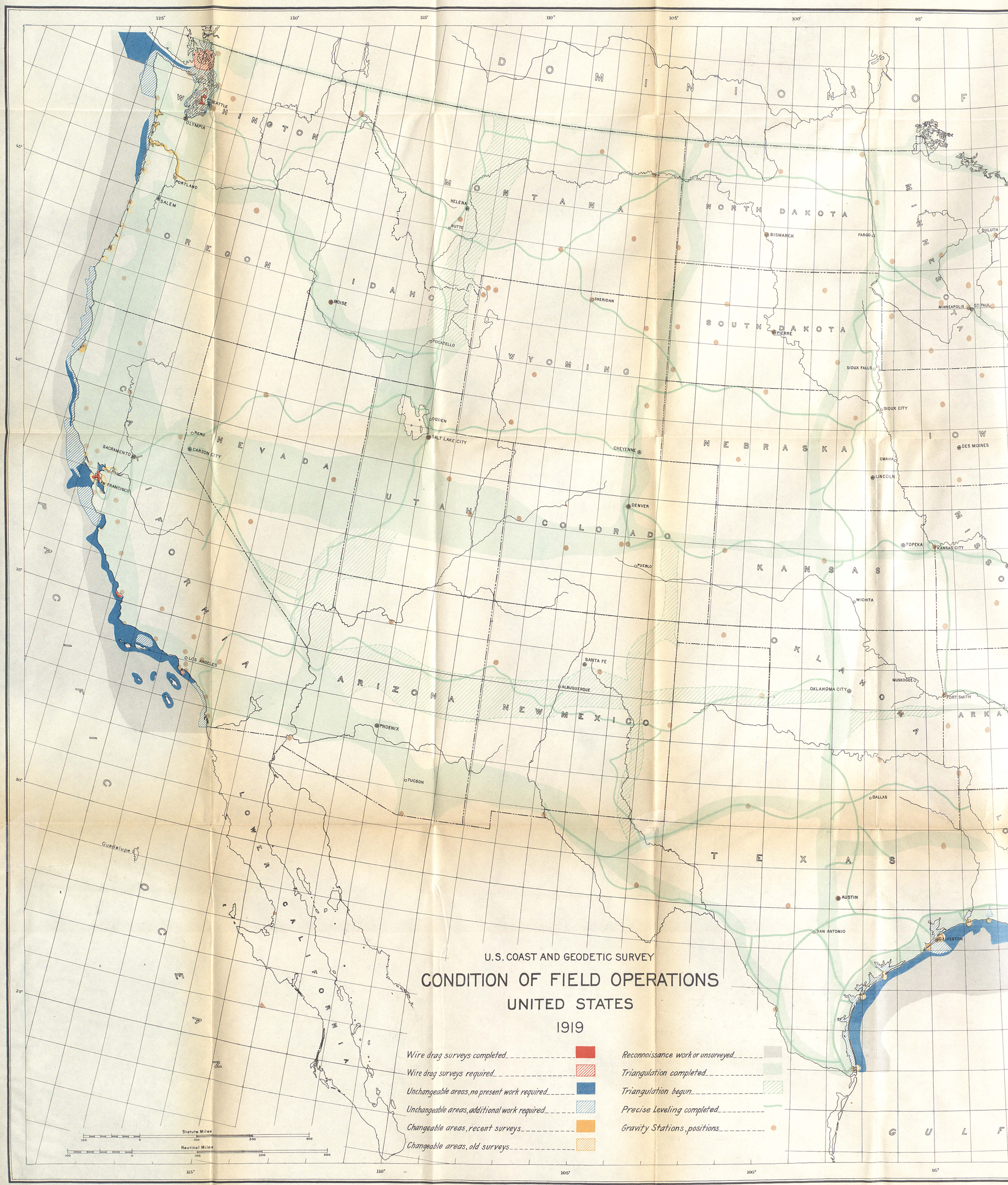
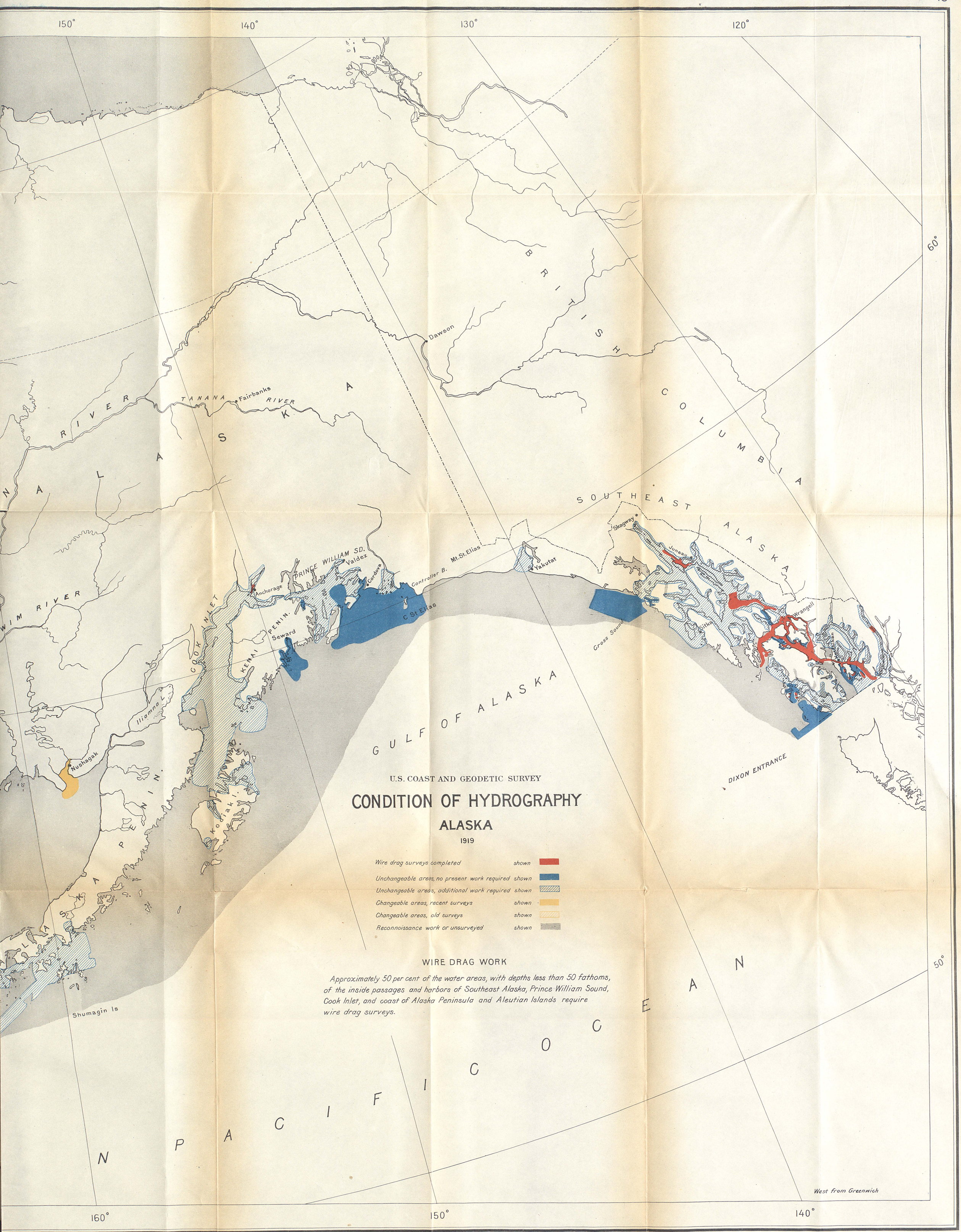

U.S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD OPERATIONS
UNITED STATES
1919
Wire drag surveys completed
Wire drag surveys required
Unchangeable areas, no present work required
Unchangeable areas, additional work required
Changeable areas, recent surveys
Changeable areas, old surveys
Reconnoissance work or unsurveyed
Triangulation completed
Triangulation begun
Precise Leveling completed
Gravity Stations, positions
Statute Miles
Nautical Miles
DOMINION OF
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
PACIFIC OCEAN
GULF
SEATTLE
OLYMPIA
PORTLAND
SALEM
HELENA
BUTTE
BOISE
POCATELLO
SHERIDAN
BISMARCK
FARGO
DULUTH
MINNEAPOLIS
ST. PAUL
PIERRE
SIOUX FALLS
SIOUX CITY
OGDEN
SALT LAKE CITY
RENO
CARSON CITY
SACRAMENTO
SAN FRANCISCO
CHEYENNE
OMAHA
LINCOLN
DES MOINES
DENVER
TOPEKA
KANSAS CITY
PUEBLO
WICHITA
LOS ANGELES
SANTA FE
ALBUQUERQUE
OKLAHOMA CITY
MUSKOGEE
FORT SMITH
PHOENIX
TUCSON
DALLAS
AUSTIN
SAN ANTONIO
GALVESTON
Guadalupe I.
125°
120°
115°
110°
105°
100°
95°
45°
40°
35°
30°
25°

C. & G. S. Print

100°
95°
90°
85°
80°
75°
70°
65°
45°
40°
35°
30°
25°
CANADA
DAKOTA
FARGO
DULUTH
MINNESOTA
MINNEAPOLIS
ST. PAUL
WISCONSIN
MADISON
MILWAUKEE
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
SIOUX FALLS
SIOUX CITY
IOWA
DES MOINES
OMAHA
LINCOLN
NEBRASKA
CHICAGO
ILLINOIS
SPRINGFIELD
LANSING
DETROIT
INDIANA
INDIANAPOLIS
OHIO
COLUMBUS
CLEVELAND
CINCINNATI
WHEELING
PITTSBURGH
PENNSYLVANIA
HARRISBURG
NEW YORK
ALBANY
BUFFALO
VERMONT
BURLINGTON
MONTPELIER
NEW HAMP.
CONCORD
PORTSMOUTH
MAINE
AUGUSTA
PORTLAND
MASS.
BOSTON
WORCESTER
PROVIDENCE
R.I.
CONN.
HARTFORD
NEW HAVEN
NEW YORK
NEW JERSEY
NEWARK
TRENTON
PHILADELPHIA
WILMINGTON
DOVER
DEL.
MARYLAND
BALTIMORE
ANNAPOLIS
WASHINGTON D.C.
VIRGINIA
RICHMOND
NORFOLK
W. VIRGINIA
CHARLESTON
KENTUCKY
FRANKFORT
LOUISVILLE
EVANSVILLE
TENNESSEE
NASHVILLE
MEMPHIS
NORTH CAROLINA
RALEIGH
WILMINGTON
S. CAROLINA
COLUMBIA
CHARLESTON
GEORGIA
ATLANTA
SAVANNAH
ALABAMA
BIRMINGHAM
MONTGOMERY
MISSISSIPPI
JACKSON
MERIDIAN
FLORIDA
TALLAHASSEE
JACKSONVILLE
TAMPA
KEY WEST
LOUISIANA
NEW ORLEANS
BATON ROUGE
MOBILE
ARKANSAS
LITTLE ROCK
FORT SMITH
MISSOURI
JEFFERSON CITY
ST. LOUIS
KANSAS CITY
KANSAS
TOPEKA
WICHITA
OKLAHOMA
OKLAHOMA CITY
MUSKOGEE
TEXAS
DALLAS
AUSTIN
SAN ANTONIO
GALVESTON
ATLANTIC OCEAN
GULF OF MEXICO
CUBA
HABANA

160°
170°
180°
170°
160°
150°
ARCTIC OCEAN
SIBERIA
Pt. Barrow
Icy Cape
Pt. Hope
BERING STR
Nome
St. Lawrence I.
St. Michael
YUKON RIVER
KUSKOKWIM RIVER
60°
St Matthew I
Nunivak I.
Nushagak
BRISTOL BAY
Pribilof Is
BERING SEA
ALASKA PENINSULA
Unimak I.
Shumagin Is
Attu I
ALEUTIAN IS
Unalaska I
Kiska I
Atka I
Tanaga I
East from Greenwich
180°
170°
160°

C. & G. S. Print


150°
140°
130°
120°
60°
50°
160°
150°
140°
BRITISH COLUMBIA
SOUTHEAST ALASKA
Dawson
TANANA RIVER
Fairbanks
YUKON RIVER
ALASKA
Skagway
Juneau
Yakutat
Mt. St. Elias
Controller B.
C. St Elias
Cordova
Valdez
PRINCE WILLIAM SD.
Anchorage
COOK INLET
KENAI PENIN.
Seward
Cross Sound
Sitka
Wrangell
GULF OF ALASKA
DIXON ENTRANCE
Iliamna L.
Nushagak
ALASKA PENIN.
Kodiak I.
Shumagin Is
NORTH PACIFIC OCEAN
West from Greenwich
U.S. COAST AND GEODETIC SURVEY
CONDITION OF HYDROGRAPHY
ALASKA
1919
Wire drag surveys completed shown
Unchangeable areas, no present work required shown
Unchangeable areas, additional work required shown
Changeable areas, recent surveys shown
Changeable areas, old surveys shown
Reconnoissance work or unsurveyed shown
WIRE DRAG WORK
Approximately 50 per cent of the water areas, with depths less than 50 fathoms, of the inside passages and harbors of Southeast Alaska, Prince William Sound, Cook Inlet, and coast of Alaska Peninsula and Aleutian Islands require wire drag surveys.