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ANNUAL REPORT

OF THE

DIRECTOR, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1922

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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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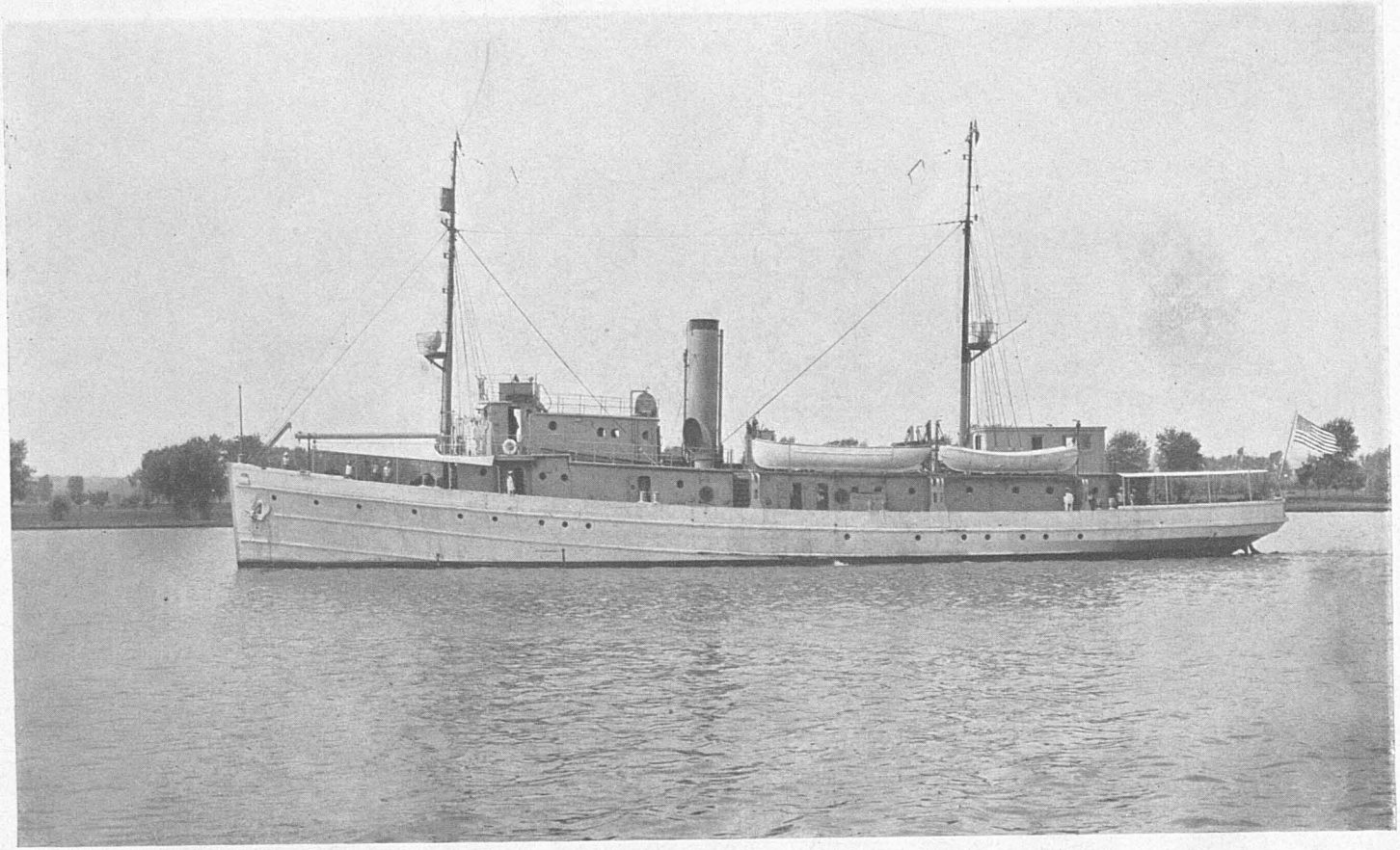

U. S. COAST AND GEODETIC SURVEY STEAMER "PIONEER."

REPORT

OF THE

DIRECTOR, U. S. COAST AND GEODETIC SURVEY.

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, October 5, 1922.

SIR: There is submitted herewith my eighth annual report. This report is for the fiscal year ended June 30, 1922, and is the ninety-first annual report of this bureau.

INTRODUCTION.

PART I. SUMMARY OF CONDITIONS AFFECTING THE BUREAU.

Chapter I. Immediate increase in salaries the vital need, pages 6 and 7.
Chapter II. The bureau's most important problems, pages 8 to 22.
Chapter III. Purchase of Dutch Harbor, Aleutian Islands, Alaska, as a Federal Government fuel and supply base, pages 23 and 24.
Chapter IV. Central Bureau of Information in Washington needed.

PART II. THE WASHINGTON OFFICE.

Chapter I. The accomplishments in the Washington office during the past fiscal year, pages 26 to 42.
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PART III. IN THE FIELD.

Chapter I. Accomplishments in the field during the past fiscal year, pages 47 to 61.
Chapter II. Present condition of hydrographic, geodetic, magnetic, and tidal and current surveys, pages 62 to 94.
Chapter III. Program for current fiscal year in the field, pages 95 to 100.

PART IV. DETAILED STATEMENT OF FIELD WORK, PAGES 101 TO 146.

INTRODUCTION.

In the past year this bureau has made notable progress in advancing its work. This has been accomplished through efforts of the personnel of the bureau operating in Washington and in the field, supplemented by the help of the Secretary of Commerce and the Director of the Bureau of the Budget.

My report for last year emphasized the urgent need of new vessels to take the place of craft that, on account of age and unsuitability for our work, had been condemned and sold. This need has been met by the transfer of two mine sweepers from the Navy Department to this bureau. This transfer was made possible by the efforts of the Bureau of the Budget.

These vessels were renamed the *Pioneer* and the *Discoverer*. They are of the seagoing tug type, of robust construction, built in 1918 for sweeping for mines. They are constructed of steel, with single screw, length of 180 feet, beam of 35 feet 6 inches, maximum draft of 10 feet, displacement of 1,000 tons, triple-expansion reciprocating engine, 1,400 indicated horsepower, maximum speed 14 knots, cruising speed 11 knots, two separate boiler compartments, water-tube boilers, oil fired, fuel capacity 82,660 gallons, fresh-water capacity 25,000 gallons, and with quarters for a complement of 11 officers and 54 men.

Plans and specifications were prepared to alter these vessels so as to fit them for surveying duty. The vessels as built were, in general, well adapted to that purpose, but they did not have sufficient accommodations for a large surveying party, and Congress in a deficiency item provided the necessary funds for altering them. These alterations are now practically completed, and both vessels will soon leave for the Pacific coast.

Recently arrangements were made through the Bureau of the Budget for the transfer of a third mine sweeper. This vessel is the *Flamingo*, now laid up at the Portsmouth Navy Yard, which will be renamed the *Guide*. Congress has again helped by providing the funds for similar alterations for this vessel, but no work has yet been undertaken, as the entire survey personnel necessary to man her is engaged in prosecuting field work during the good weather of the summer season. As soon as the weather conditions prevent continued efficient field work, readjustment of field parties will furnish sufficient personnel to proceed with alterations of this vessel.

There has been great need for an addition to the bureau's fleet of surveying vessels, and it is an assured fact that these three ships will materially increase the output of hydrographic work, thereby expediting the charting of our waters. In addition to this, the unit cost will be decreased as a result of having more up-to-date equipment.

Another step forward has been taken in connection with the administration and maintenance of our headquarters in Washington. Due to readjustments in existing methods of handling the personnel and carrying on our other work, the number of employees has been reduced. This has resulted in an actual saving to the Government and a marked increase in the efficiency of the office.

Another matter worthy of including in the opening pages of this report is the carefully worked out organization in the manner of handling the sale of charts, coast pilots, and tide tables of the bureau, as a result of which they were put more easily within the reach of the public and at the same time kept up to their highest degree of efficiency.

The Coast and Geodetic Survey is essentially a manufacturing plant, and its usefulness is therefore determined to a considerable extent by the availability of its product. Realizing this, the greatest

pains have been taken to perfect a selling organization which, on the one hand, will enable the navigator promptly and readily to obtain the latest correct publications dealing with any part of our navigable waters, while, on the other hand, it protects the public pocketbook against undue loss resulting from the fact, which will be explained in a moment, that the chart is a perishable product, requiring frequent renewals of stock.

Anyone can obtain these publications by writing to the Washington office of the bureau, but their principal distribution is effected through the bureau's field stations and agencies located at vantage points along the coast. Every seaport of any importance in the country has convenient access to at least one such agency, while the maximum number at any one place is found at New York, which has 8. In the United States on June 30, 1922, there were 112 such agencies; in Alaska, 12; in Canada, 5; in the Philippine Islands, 4; and in Hawaii, Porto Rico, the Canal Zone, Germany, and Italy, 1 each.

The agencies are given to ship chandlers, dealers in marine hardware, makers and repairers of nautical instruments, compass adjusters; in other words, to those merchants with whom the navigator naturally comes in contact during his stay in port. Charts are sold to these agents at 66⅔ per cent of the retail price, and each agent is under contract to sell at neither more nor less than the price printed on the publication.

I have said that the chart is a perishable product, and that statement doubtless requires explanation. In the zone between land and sea which it portrays constant changes are in progress, due alike to natural forces and to the works of man. Ocean waves and currents are constantly taking material from one place and depositing it in another. River currents are carrying their burdens of sediment, which they deposit on reaching the open waters of the ocean. Bars and channels are constantly shifting. Men are dredging channels, filling up tide flats and building their manufacturing plants or terminal facilities upon them, and establishing or shifting lighthouses, beacons, and buoys to conform to the changing demands of commerce.

The charts must be kept corrected to show all these changes. This means that each edition of the chart of any of our important seaports soon becomes obsolete and must be superseded by a new edition showing the changes that have occurred since the preceding one was printed. If these changes affect important details, it may become unsafe for a mariner to use the preceding edition, and some means must be found to prevent his purchasing an obsolete copy.

For this reason the survey maintains a strict control over the stock of charts in the hands of its agents. They can not sell to other firms who are not agents. Whenever new and important information is received, a new edition of a chart is printed. Agents are notified in advance of this new print and are required to withdraw from stock all copies of the chart to be superseded. These charts are later destroyed by some Federal officer and the agent is given credit for their value. Agents are required to order publications frequently and in quantities only sufficient to meet their needs for a brief period.

The survey maintains a constant watchfulness to see that the agents conform to these requirements. The larger and more im-

portant agencies are inspected annually and the less important biennially. The field stations in charge of an officer of the survey are located in a number of the principal seaports, part of their function being to exercise supervision over the agencies in their respective districts, as well as to serve as a point of contact between the survey and the public.

The Notice to Mariners, a weekly publication issued jointly by the Coast and Geodetic Survey and the Bureau of Lighthouses, keeps the mariner informed of all important items affecting navigation in American waters, including a notice of all new charts or any new editions published by the survey. About 4,000 copies of the publication are distributed free each week.

One additional item is required to perfect this part of the service which the bureau renders the public. The charts are constantly being corrected in a multitude of minor details, each of which is important but not sufficiently so to justify new editions with the resulting cancellation of existing copies. These corrections reach the public from time to time in the form of new prints of the current edition, which are made as the existing stock becomes depleted. As a rule, the information regarding these changes has been furnished the navigator in the Notice to Mariners, so that it is to some extent possible for him to make the necessary corrections on his own charts. It would be a great convenience to him, however, if a draftsman could be assigned to each of our field stations. The mariner could then bring his charts to the station and have them corrected during his stay in port. In fact, the service would be more than a convenience, for this draftsman could make corrections which the navigator can not make because of his lack of skill to depict them, and the latter could then use the charts with assurance of their adequacy, which he must lack as long as he makes the corrections himself. The British have long maintained such a service, but the Coast and Geodetic Survey has thus far been unable to inaugurate it because of lack of provision of the necessary personnel.

Another important item in which marked progress has been made during the year is in making our records accessible and at the same time protecting them, in a measure at least, from the hazard of fire and from unnecessary exposure and handling. A fireproof vault was provided in 1918 for the field sheets of the survey, but the other records remained on wooden bookshelves, which not only endangered them through hazard of fire but also made them subject, on account of their age, to rapid deterioration through exposure to dust, etc. Another item of good administration is the installation of modern metal bookshelves. To-day these valuable records, although not afforded the protection which would result from their housing in a fireproof building, are yet for the first time given the maximum protection from destruction and deterioration which is possible so long as the bureau occupies its present quarters.

The extent to which these records are involved in the bureau's need for new and modern housing will be evident when we recall that they are the results of a century of continuous activity. If destroyed, no amount of money could reproduce them, for they picture facts and conditions which no longer exist. They constitute the only record of their kind in the field of activity delegated to the survey—a record which is constantly consulted by persons interested in spe-

cific problems which in many cases can be solved only by the assistance thus afforded. The physiographer studying the evolution of our changing coasts; the engineer seeking to protect valuable land from erosion or for the horizontal and vertical control of his engineering projects in the interior; the surveyor endeavoring to retrace some line surveyed with the compass many years ago; the litigant who, to establish his claim, must procure an authentic map showing an area as it existed at some former period; all these are constantly turning to the Coast and Geodetic Survey for assistance which can be rendered only by reference to these records.

Another step forward has been taken in the handling of our charts and other nautical publications which has resulted in a greater income to the Government. This is an increase of 50 per cent in the prices at which these publications are sold to the public. This increase was made to meet the greatly increased cost of all materials used in chart production in order to conform to the law which requires that these publications shall be sold as nearly as practicable at the cost of paper and printing. Inasmuch as the entire amount received is returned to the Treasury of the United States, this means that nearly double the former return from the sale of charts, coast pilots, and tide tables goes to the credit of the Government.

Part I.—SUMMARY OF CONDITIONS AFFECTING THE BUREAU.

CHAPTER I.

IMMEDIATE INCREASE IN SALARIES THE VITAL NEED.

In my preceding reports, and especially in my report for 1921, I discussed at some length the fundamental trouble in this bureau and, referring to the bureau as an efficiently functioning organization, I laid stress above everything else upon the deplorable situation of the underpaid employees of the Coast and Geodetic Survey. Unfortunately, this condition has not been changed, and while many other things have been done to benefit the bureau it is my opinion that the bureau as a business organization can not function properly until this fundamental trouble is corrected.

The average person does not realize that the very heart of the Government, speaking of it as a whole, is being eaten away, leaving what appears from the outside viewpoint to be a working organization, but one which is steadily and certainly deteriorating from within. Instead of encouraging, or at least making certain that the able men of the Government are retained and made reasonably satisfied, there is a deplorable lack of action for this desired result which is working toward a sure and certain depletion of the very backbone of the working forces of the Government.

In 1886 steps were taken through the proper channels to make a readjustment, or reclassification as it is better known, of the Government salaries, but after 36 years, with much money spent on investigations of this subject, conditions are unchanged, and from the standpoint of economy and wise administration it appeals to me that it would be infinitely better to curtail some of the existing projects if necessary and use the money to remedy this pressing evil.

The institutions for higher education in the United States have plants and endowments representing hundreds of millions of dollars. Tens of thousands of the most ambitious young men and women at great expense spend about four years each at these institutions in taking advantage of the opportunity to acquire a higher education. Many of these young people have a vision of being able as a consequence to serve the Nation better in some intellectual pursuit. Little do they know what is before them. After graduation, often with debts incurred in order that their college work may be completed, they are offered such meager compensation in the intellectual field that many of them are forced out of it into positions in the industrial and commercial fields, where they are not only no better off for their higher education but are often actually handicapped because of it.

There is no better way to illustrate the deplorable situation regarding the underpaid employees of the Government than to use as a

parallel what has recently transpired at one of our large universities. The trustees of this university have announced that hereafter no instructors who are married will be engaged. In other words, instructors are paid such low salaries that they can not support and rear a family while connected with the institution. Their condition is very similar to that of many of the highest-trained men in the Government to-day and is practically what many of the ablest men of the Government are facing. They are not able on the salaries paid them by the Federal Government to maintain a family in reasonable comfort and security, and this appeals to me as an inexcusable situation.

Under present conditions the Government must either be deprived of securing and keeping the best men in the service, or these men if secured must be deprived of the privilege of marrying, or, if married, from raising a family. These are hard facts, but nevertheless they are true and should be faced frankly, as the existing conditions are just the opposite of economy and good business.

Is it not time for the thinking people of this land to stop and consider the danger of starving its intellectual workers? Should not the improvement start in the Federal Government? With few exceptions the salaries offered to men and women by the Government are below those paid for skilled labor in mechanical trades outside of the Government. There is much talk throughout the country of people flocking to the Government service. This has not been noticed for many years by those officials seeking persons who can really do the work as it should be done. After trying for months and years to get personnel of the proper caliber, the responsible officials are often compelled by circumstances to take the best material which offers. The result is that there has been a gradual deterioration in the personnel of the Government service, and if this is not checked the consequences will be more disastrous than many realize.

The Government is to-day in dire need of the services of well educated and trained men and women, but the only way in which it can attract them is to give salaries at least as large as those paid to trained workers in commerce and industry. The Government is, or should be, in the market to buy the services of the highest types of men and women. It will either go empty handed or will have to be satisfied with inferior material if it will not pay the price, and must therefore suffer the inevitable consequences.

The existence of underpaid intellectual workers in the Government and in the faculties of our universities and colleges is a blot on our body politic. Those in whom the remedy lies should at once take serious thought of this most serious condition.

CHAPTER II.

THE BUREAU'S MOST IMPORTANT PROBLEMS.

NEW BUILDING NEEDED FOR ECONOMY'S SAKE.

During the past seven years the necessity of a proper building for the housing of this bureau has been reiterated in my annual reports. During this time and until the situation is remedied the output of the bureau has been and will necessarily be produced at an abnormally excessive unit cost. This is due to the fact that the buildings occupied by the bureau are wholly unsuited to the purposes for which they are used.

The bureau is housed in seven different buildings, only one of which was designed to serve its needs, and even this one is a wartime product, constructed in haste to provide for expansion that was absolutely necessary to supply the Navy with charts and navigating instruments during the war. The other six were constructed long ago and for other purposes—two for dwellings, one of which was later equipped with iron window blinds to provide fire protection when rented for the occupancy of this bureau, another for a stable for the two buildings to be occupied as dwellings, and two others to be used as hotels. Yet these buildings of different sizes, different floor elevations, separated in groups and connected by open and inclosed bridges, constitute the home of an organization that prepares and prints and charts of all of the navigable waters adjacent to the United States and its possessions.

There is a direct loss, indefinite in calculation but nevertheless very apparent, with the bureau housed in the present unsuitable quarters. While the bureau is an industrial organization, its operation is based on Government appropriations and not on competition with other industrial organizations. Were the existence of the bureau dependent on competition with like industrial organizations the high unit cost of production resulting from improper housing facilities would manifest itself at once and force remedial steps. Industrial organizations that have successfully met competition have early discovered the necessity of adopting labor-saving devices and routing work, so that the maximum is accomplished with the minimum of effort.

Such ideals can not be attained in this bureau. The reasons are readily brought to light if we trace any given output of the bureau through the line of production. Take, for example, the production of a nautical chart. The raw materials from which a nautical chart is compiled are obtained from various sources. Largely they constitute the records of field surveys of this bureau, surveys by the Corps of Engineers of the Army, and of other governmental organizations. The original records from these sources are valuable and must be protected from fire. They are therefore necessarily filed in the most nearly fireproof building of the bureau. This is

a considerable distance from the drafting hall (350 feet), and much valuable time is consumed by the draftsmen and compilers in going to and from the fireproof building to search out records that are needed. The archives in which these records are kept should, therefore, be adjacent to the drafting hall, but this is impossible as the bureau is housed at present.

The next step in the production of a nautical chart is to either prepare from the complete drawing an engraved plate from which to print the chart or to reproduce the drawing by lithography. The lithographers and the engravers should, therefore, be adjacent to the compilers of the chart and under the direct supervision of the chief of the division. To obtain proper lighting facilities for this work, the engravers are necessarily distributed throughout three different buildings, and to reach the lithographers the chief of the division having the work in charge must pass through five different buildings. Under these conditions a high degree of efficiency is impossible. When the chart is prepared for the press either on an engraved or lithographed plate, further delays necessarily result from the fact that the printing presses are housed in one building while the paper stock is housed in a separate detached building, necessitating its removal and transportation by hand from the detached building to the building in which the printing presses are housed.

Again, when the charts are printed they are necessarily stored on the shelves in a building detached from the one in which they were printed, which necessitates their transportation by hand to a different building and assembly on shelves provided for their storage. This cumbersome method of production of a nautical chart is duplicated in every other output of the bureau, and year by year the products of the bureau are brought forth at an excessive unit cost. The remedy is a new building designed to permit production at the lowest possible unit cost.

WIRE-DRAG WORK IN NEW ENGLAND WATERS SHOULD BE RESUMED AND COMPLETED WITHOUT DELAY.

Last year in my report, and also before the appropriations committee, I laid emphasis on the fact that the wire-drag work in New England waters, stopped during the war, should be resumed and completed without delay. The amount necessary to carry on the work was refused, and I renew the recommendation that every effort be made to secure the funds to carry on the work during the fiscal year 1924.

Too much stress as to the importance of this work can not be advanced, as greater amount of shipping and increased draft of vessels are only forewarnings that sooner or later unless these close surveys are made mishaps will result, with loss of life and property. It is erroneously believed by many that on account of these waters being so old in connection with shipping no disaster can happen, yet it is only a few years ago that a vessel struck a rock at the entrance to Buzzards Bay, and only good fortune prevented the vessel from foundering. As it was, it was badly damaged, and whereas the water surrounding the rock indicated a depth of 5 fathoms, or 30 feet, over the bowlder itself there was only 17 feet of water. This only

emphasizes the old question that is asked, Why don't vessels hit these submerged rocks? And the answer is, Give them time enough and they will.

Wire dragging is an important part of the hydrographic work on the Atlantic coast, and for the last 15 years there have been such operations to find and locate detached rocks and bowlders which are so small that they can not be found by ordinary methods of hydrography. Hundreds of such rocks, many of which were real menaces to navigation, have been found by this method. Many of these rocks are located in areas which had been surveyed carefully by means of lead and line, of which there was no previous indication prior to their detection by wire drag. Some had been located by vessels striking them, resulting in considerable damage to the vessels.

For several years prior to and including the summer of 1919 two drag parties operated each summer on the New England coast from northern Maine to Connecticut. This work was stopped in the fall of 1919 and has not been resumed since then because of lack of sufficient appropriation to carry on the work. All of the drag equipment, which includes six launches, remained idle from the close of the 1919 season until last summer, when half of the equipment was sent to Porto Rico, and the other half is still idle.

Approximately 3,000 square miles of water area of the New England coast is yet to be dragged, of which a little over 1,200 square miles are in areas where there is much shipping. This area comprises five sections of the coast, as follows: Five hundred and forty square miles between the entrance to Penobscot Bay and the mouth of the Kennebec River, 120 square miles in the entrance to Portland Harbor, 156 square miles just south of Cape Elizabeth, 51 square miles close to the shore between Cape Porpoise and Piscataqua River, and 380 square miles between Piscataqua River and Cape Ann.

It is through these undragged areas that all vessels bound for Bath and Portland, Me., and Newburyport, Mass., must pass. Besides these cities, there are numerous small ports and summer resorts which can be reached by water only through these undragged areas, and in addition most of the coastwise navigation along the southern Maine, New Hampshire, and northern Massachusetts coasts is through some part of these undragged areas. On the completion of these 1,200 square miles, which should be immediately dragged, the whole northern New England coast from Penobscot Bay to Cape Cod Bay will have been thoroughly explored, with the assurance that these waters contain no uncharted dangers to navigation. This project, which is believed to be one of those most urgently in need of immediate attention, should not be deferred until the further loss of vessels and the lives of their passengers and crews attracts attention to this lack of adequate surveys.

LAND SURVEYS AND MAPS OF IMPORTANCE TO COMMERCE AND INDUSTRY.

Congress has intrusted to the Coast and Geodetic Survey the extension of horizontal and vertical control surveys over the United States and Alaska. These control surveys, consist of triangulation and leveling which provide the latitudes, longitudes, and elevations of stations suitably located for the use of the engineer in his cadastral,

topographic, State, boundary, and city surveying and mapping. Besides, these stations are used in much construction work, notably in drainage and irrigation projects, railroad and highway extension, and flood control.

It is most unfortunate that the very small appropriations for the geodetic work have prevented the Coast and Geodetic Survey meeting the urgent demands made upon it. It is true that Congress has increased the annual appropriation for the control surveys over what it was a few years ago. This is most commendable, but the engineers of the country can not understand why control surveys are not now completed. After this work was added to the bureau's activities, it was felt that funds would be provided to push the work far more rapidly than has been the case. The question has been asked, What is the practical value of the control survey? This inquiry is as pertinent as asking the practical value of the steel framework of a large office building.

The surveying and mapping of a large area such as the United States or Alaska simply can not be done properly without starting and checking points. If a man's activities are confined to his own city or village, he needs only a local map; but suppose he must travel into surrounding areas, then he needs additional maps. Suppose he is connecting the drainage and sewerage systems of the city and the surrounding districts, then his maps must show very accurately the distances and difference in elevation between points within the combined area in question. The several maps must be coordinated. Without accurate map data extensive engineering work can not be done without great waste of money. The connection of the street system of a city with the State highway system necessitates an accurate knowledge of the positions on the earth's surface and their elevations of many points in the area involved. If an extensive drainage project is undertaken, the engineer must first know the lay of the land or its configuration before he will begin constructing canals to drain the area. Many similar cases could be noted to show the dependence of engineering projects on accurate survey and map data.

Maps showing the location of an area and its configuration can not be made to conform to maps of the adjacent areas without having a single connected system of triangulation and also of leveling over the entire area. To-day there are many large areas in the United States where detailed surveying and mapping are retarded owing to the lack of control data. This involves the retardation also of the industrial and commercial development within those areas. There are many cities to-day waiting for control surveys to be carried close to them in order that they may adopt modern methods in city planning and development. The extension of the triangulation system over the country will furnish the only reliable and unchangeable reference stations for the boundaries of the property of a State, city, county, corporation, or individual. With proper State, city, and private cadastral surveys based upon the control surveys made by the U. S. Coast and Geodetic Survey, much of the expensive litigation over property boundaries would be eliminated.

Even a casual consideration will convince anyone that almost every important human activity is dependent upon a knowledge of

place and elevation. These can only be supplied by surveys and maps, and these in turn must depend upon the fundamental control surveys made in our country and in Alaska by the Coast and Geodetic Survey.

The release of our country from debt depends upon our industry and commerce. In many directions these are held back by a total lack of knowledge of local conditions which alone can be supplied by the proper surveys and maps. I must again urge that the framework for the detailed surveys and maps and other engineering work of the United States and Alaska be given such support as its importance justifies.

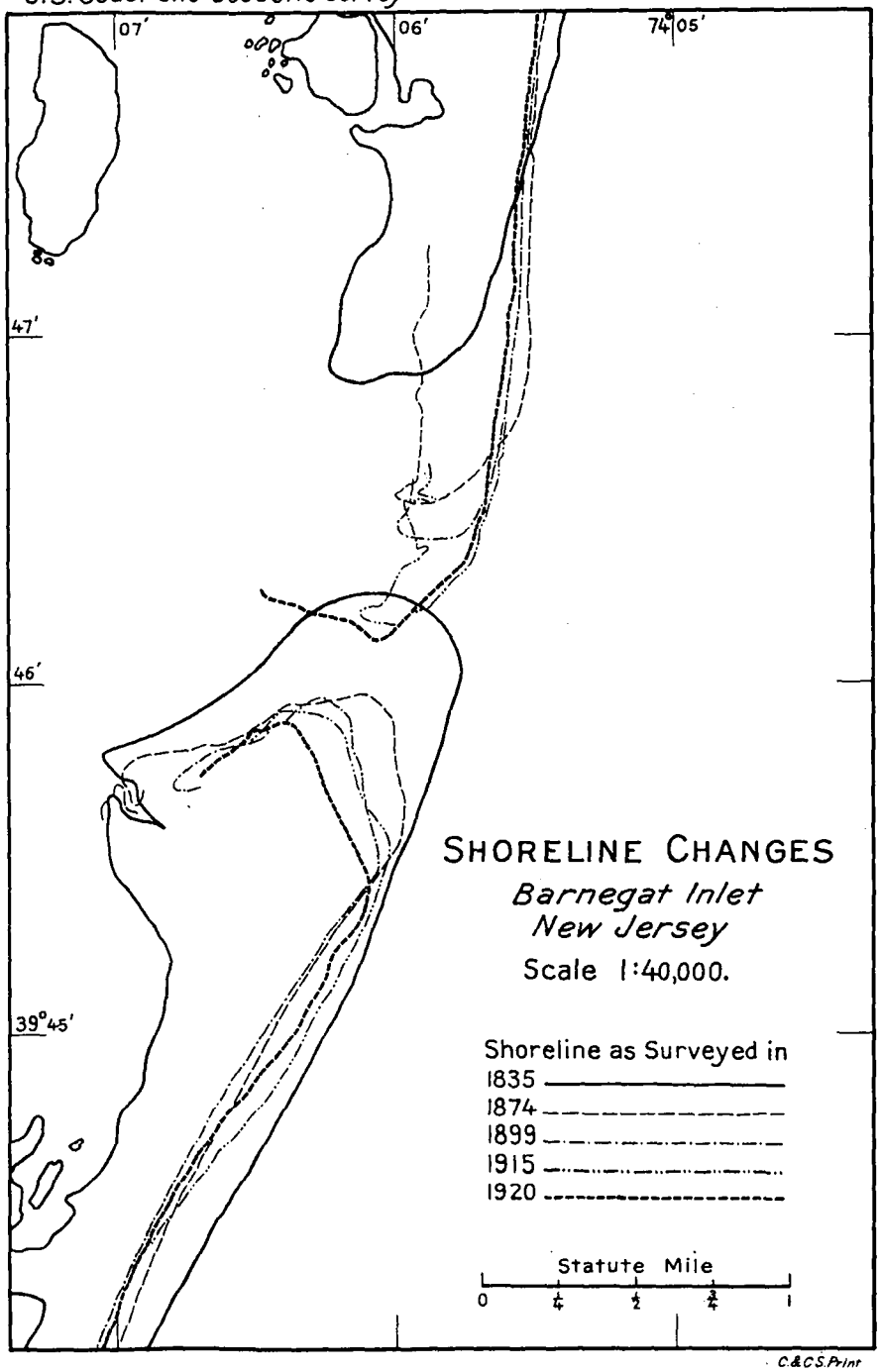
OUR COASTS AND SHORE LINES MUST BE PROTECTED.

The layman unfamiliar with the seacoast usually thinks of the land and sea as unchanging in their relation to each other, or, if he realizes that changes may be occurring, he thinks of them as measurable only in terms of geologic periods. This, however, is very far from being the truth. This zone where land and water meet is the scene of unceasing conflict, the results of which, in the form of changes in the shore line, are in some cases actually perceptible from day to day.

The erosions of Nantucket Island, of the south shore of Long Island, or along the New Jersey coast, are striking examples of the power of the sea to degrade the shores, while Cape Cod and Sandy Hook are equally conspicuous instances of the opposite result of the conflict when the land has been able to take from the sea material with which to build up and expand itself.

From New York Harbor southward to and including the Gulf coast the terrain adjacent to the shores consists principally of a low flat or gently sloping plain. The beaches are of sand, easily eroded, and subject to constant changes due to the action of the winds, waves, and currents. The ocean is engaged in a constant attack upon the land adjacent, cutting it back and carrying away the resulting débris. The resistance of the shores depends upon the degree of their exposure to the attacking forces and upon the character of the materials composing them. A coast such as I have described is particularly susceptible to attacks, and the changes produced are constant and comparatively rapid.

For almost a century the Coast and Geodetic Survey has been engaged in making surveys and resurveys of this changeable coast in order that the charts published by the bureau may be kept corrected to show existing conditions. The data thus accumulated constitute a record of the nature and extent of these changes which can nowhere be duplicated and which is of great potential value to geologists, physiographers, and engineers. That value is largely potential as yet, because it is only in recent years and in a comparatively small number of restricted localities that this encroachment of the sea has reached a stage to arouse public interest. There is no doubt, however, that with the lapse of time the beaches along our Atlantic coast will become of constantly increasing importance, and that such increase will be accompanied by an augmented interest in and demand for their protection.


U.S. Coast and Geodetic Survey
07'
06'
74°05'
47'
46'
39°45'
SHORELINE CHANGES
Barnegat Inlet
New Jersey
Scale 1:40,000.
Shoreline as Surveyed in
1835
1874
1899
1915
1920
Statute Mile
0
1/4
1/2
3/4
1
C.&C.S.Print

In some localities, indeed, the time for action has arrived. In March, 1922, the Board of Commerce and Navigation of the State of New Jersey requested the assistance of this bureau in a study to be made of the erosive action of the sea upon the beaches of the New Jersey coast—and of engineering measures to be taken to prevent further damages. The situation of this stretch of the coast was generally serious and in some localities critical. These beaches constitute one of the most important assets of the State. They are the site of some of the best-known and most popular summer resorts in the United States. The assessed value of the property along this narrow strip of sand, in some places only a few hundred yards wide, exceeds $300,000,000. Practically all the most valuable improvements are immediately adjacent to the ocean front. Every year the gales do immense damage, and in some localities the situation has reached a stage to jeopardize the continued existence of the local community.

This office assured the board of commerce and navigation that it would be glad to cooperate in every possible way both by giving the board access to all survey records and by placing at its disposal the knowledge and experience of survey engineers and cartographers expert in the interpretation of the phenomena to be studied. After some preliminary discussion and a conference in New York the board requested the director to designate a representative to serve on an engineering advisory board which was to take charge of this investigation, whereupon the director designated the chief, division of charts, for that duty.

The various steps in an investigation of this character may be grouped under three headings: (1) Determine as accurately as possible the nature of the changes which are taking place along the shores. (2) Determine the nature of the forces and the manner in which they act to produce the changes ascertained under the preceding heading. (3) From a consideration of the two preceding items determine upon the types of engineering structure best adapted to oppose the action of the destructive forces.

This office has undertaken the production of a composite map showing the shore line as determined by each of the topographic surveys made by the survey since the first one was undertaken in 1839. The map shows the results of four complete surveys of the coast line of the State with double that number at many of the localities where changes are most rapid. The picture which it thus affords of the evolution of the coast during the past century, supplemented by additional data resulting from other local surveys by Federal, State, and municipal agencies, will enable the board to determine with considerable accuracy the nature of the changes which have taken place during that period.

At the request of the board the survey representative has undertaken to make a preliminary investigation which will be the first step in finding the answer to the second question. He will spend some time on the coast interviewing local engineers, keepers of lighthouses and Coast Guard stations, and other persons having detailed local knowledge. These men have observed the destructive forces in action; they know the winds, the waves, and the currents, and

their effect upon the beach. The information which they furnish will be of material assistance in answering the second question and will assist the board in determining what further investigations are necessary to find the answer.

The State of New Jersey is the pioneer in this study. In so far as this office is aware this is the first time that a large-scale, exhaustive investigation of the subject has been undertaken in this country. The plans formulated by the State board give promise of a thorough study of the subject which will be of immense value to all agencies which must hereafter undertake beach protection. In cooperating, therefore, this office is serving not only the State of New Jersey, but, potentially, every seaside community from the eastern end of Long Island to the Rio Grande River.

CURRENT AND TIDAL DATA OF VITAL IMPORTANCE TO NAVIGATORS.

Of increasing importance, the subject of currents is engaging the attention of this survey, and it is devoting to the securing of observations and data such funds as are appropriated and such time to the working up of this material and discussion of the results as an understaffed and underpaid personnel can spend.

In coastwise navigation it is evident that currents play a very important rôle. Not only may millions be saved by making use of favorable currents, but, more important still, when thick weather makes it impossible for the navigator to secure his position either by terrestrial landmarks or astronomical observations, it is a matter of the utmost importance that he know the currents to which his vessel may be subject and which may, unknown to him, be carrying his valuable cargo of life and property to destruction by stranding on exposed coast lines.

Pacific Coast Currents.—This is especially true in the case of the Pacific coast, where in the more than 1,000 miles of coast line from the Mexican border on the south to the Strait of Juan de Fuca on the north harbors are many miles apart, sailing courses long, and periods of thick weather of comparatively frequent occurrence. In the past 20 years more than 100 vessels have been stranded or wrecked on the Pacific coast of the United States, taking a toll of hundreds of human lives and millions in property, in spite of the fact that the navigators of the Pacific coast rank with the best in the world. It is unquestionable that an adequate knowledge of the currents would have prevented a considerable part of this enormous loss.

An accurate knowledge of the coastal currents can be secured only by systematic observations, and while these involve the expenditure of money it is to be remembered that a very small fraction of the money lost because of lack of this knowledge, not taking into consideration human life, would suffice for all observations.

The survey has already made use of all avenues for securing information at moderate cost. Advantage has been taken of the five light vessels stationed along the coast, and with a small expenditure of funds valuable information has been secured. Thus, it has been discovered that, contrary to the general belief—that of the mariner included—a wind creates a current, not in its own direction, but in a direction which on the Pacific coast is from 15° to 20° to the right of the wind direction. In other words, a wind blowing from the

south parallel to the coast will not create a current parallel to the coast, but one setting about 15° toward the coast—a fact, until brought out by these current observations, unknown to the mariner.

There is now needed a systematic study of the currents between the light vessels, for these are so far apart on that coast as to give no clue to the currents that may be running in the long stretches between them. A modest appropriation that will permit the carrying into effect of plans outlined for a systematic survey of these currents will be a long step toward the safeguarding of life and property on vessels engaged in commerce along the Pacific coast.

New York Harbor Currents.—The waterways which lead to the principal port of the United States exhibit the most complicated current and tidal phenomena of any of the important ports of the world. Many ports are situated in tidal rivers, others on bays or sounds connected with the sea; but in New York Harbor we have an intercommunicating system of tidal waterways made up of three bays, four straits, a tidal river, and a sound. The resulting current and tidal phenomena are exceedingly complex, and in the case of Hell Gate the currents are of such velocity that advance knowledge of the times of slack current is a matter of utmost practical importance. Congress during the past year realized the fact that this port, which is one of the greatest in the world, had not yet had a systematic current survey, and this in spite of the fact that many millions have been expended by the Federal Government in improving those waterways. The docking of large vessels costing millions and carrying valuable cargo should without question have the advantage of the best obtainable knowledge, for here a matter of minutes is of importance.

Fortunately, Congress has made this modest appropriation and with the cooperation of the U. S. Engineers Office, first district, New York, a carefully planned and efficient survey is to be made of this harbor during the fiscal year 1923, which will make it possible to predict in advance the exact time of the turning of the currents in the various portions of the harbor. This will be of the greatest importance in the handling and docking of large vessels. In addition this current survey will at the same time bring out facts of importance in the economical solution of the pressing sewage problems involved in the location of a city of many millions of inhabitants. Such information will be secured at no additional cost.

What is being done in New York will be necessary to do in our other important harbors. On the west coast there is need of a similar survey in San Francisco Harbor. It is important to note that it will be by far the most economical procedure to do this work in a systematic manner, taking up each year that port in greatest need of such a survey, and which can at the same time be most economically carried out with reference to floating equipment and personnel. Such a systematic procedure permits the best use of an expert organization for the carrying out of the highly technical work involved. The importance of this work to our growing merchant marine, as well as to our Navy, demands that it be carried out for the more important ports of our country.

Tides.—With the growth of population and the increase of industries along our coasts, the importance of a thorough knowledge of

the tides—their characteristics, times of occurrence, effects of winds and unusual weather conditions, the effects of deepening of channels and general harbor improvement—is becoming a matter of the greatest practical necessity.

Originally the tidal work of this survey was that necessary in connection with the charting of the coastal waters; but with the increased drafts of vessels engaged in commerce the necessity for an advance knowledge of the times and heights of high and low waters at the more important ports is apparent. The survey on very meager appropriations has met the needs of the mariner, developing new methods of studying the complicated problem of the tides, and devising a machine for predicting the tides years in advance, so that this important work—important both for the Navy and merchant marine—is done in a most economical manner.

The subject of tides is now becoming of importance in coast protection and in harbor improvement. As our coastal lands are becoming more valuable, we can no longer allow the encroachment of the sea through the action of tides and waves. In this connection the effect of winds and unusual weather on the height of the tide is an important factor—a problem the survey is studying, but which the enormous increase of work in connection with its regular duties and the shortage of trained personnel prevents it from attacking in the most efficient manner.

With the importance of an American merchant marine fully recognized, harbor improvements involving an outlay of many millions annually are being prosecuted. In a number of cases a knowledge of the action of the tides subsequent to such improvement is wanting, and when the engineer turns to this survey for information in specific cases—for this bureau is the only agency in the United States that deals with tidal matters—we can generally furnish him valuable information, but in some cases are unable to furnish the exact data because appropriations are so small as not to permit a study of the matter to be made; and there can be no question that because of this some part of the appropriations spent on harbor improvements does not bring the maximum benefits, while a fraction of this would permit the survey to secure information of value for all time.

In one other direction the tides are of great practical importance. The question as to the rising and sinking of the coast—a matter not only of local but also of national importance—can be determined only by means of tidal observations. Fortunately, the survey has been able to so conduct the tidal work that this information is being secured without additional cost.

MAGNETIC WORK IMPORTANT TO COMMERCE AND SURVEYORS.

1. Standardizing of the Observatories.—The chief need is to make conditions practically the same at all observatories in order that assignments may be similar. This requires that quarters for the observers be built at Cheltenham, Md., the only observatory not so provided, and that the observatory on the island of Oahu be given ready access to Honolulu by building an inexpensive road to the nearest railroad and town.

2. FIELD WORK.—An additional observer is required to examine previously established stations and replace those that have disappeared in order to meet the urgent needs of local surveyors.

3. PHILIPPINE ISLANDS.—A magnetic resurvey of the Philippine Island is required in order to be sure that correct information is being furnished for use on the charts.

SEISMOLOGICAL (EARTHQUAKE) INVESTIGATIONS MEAN SAFETY OF MANY PEOPLE.

During the last century six major earthquakes have occurred in the United States, Alaska, and the insular posessions, some causing great loss of life and property. Two of these, that at Charleston in 1886 and that in the upper Mississippi Valley in 1811, then scarcely inhabited but now densely populated, were in regions not generally considered to be subject to earthquakes. Minor earthquakes have occurred recently in Utah, Nevada, Washington, and New Brunswick, Canada, indicating that this is a live subject and one of widespread interest. Earthquakes are of special importance in California, and this bureau is now cooperating by means of precise surveys to determine movements of the surface, with the Carnegie Institution and other organizations in an investigation which may make possible earthquake predictions and at least designate areas where special precautions in construction should be used and regions where important construction should be avoided.

In order to study earthquakes, instruments known as seismographs must be operated at fixed observatories. They should be of the highest type, continuously operated by the most skilled observers in order that the earthquake records may be correctly interpreted. This bureau has operated seismographs at five widely separated stations for 18 years, but as the work has been supplemental to magnetic work the stations have not been of high class. Seismological investigation has been assigned to the Weather Bureau. With the development of instruments of the highest accuracy it has been found that the observers of that bureau do not have the type of skill required to get the best results. Such skill comes from the operation of magnetic instruments, and therefore the operation of such instruments by the Coast and Geodetic Survey presents no difficult problem.

It is proposed to equip the magnetic observatories at Tucson, Ariz., and Sitka, Alaska, as first-class stations with new instruments of high grade, thus making them first-class seismological stations. These are selected as being in relatively quiet regions near to regions of great activity in the present or recent past.

Valuable results to be obtained include: Important assistance will be given to the California program, as it will make it possible to separate accurately local from widespread earthquakes. Valuable information will be obtained as to conditions in the vicinity of the great irrigation projects of the West. These involve the life and security of great numbers of people and the safety of vast property. If through ignorance of conditions a great dam were placed across an active fault, it would be completely destroyed by a major earthquake. Knowledge of earthquake regions would be useful in connection with precise triangulation and levels. In Cali-

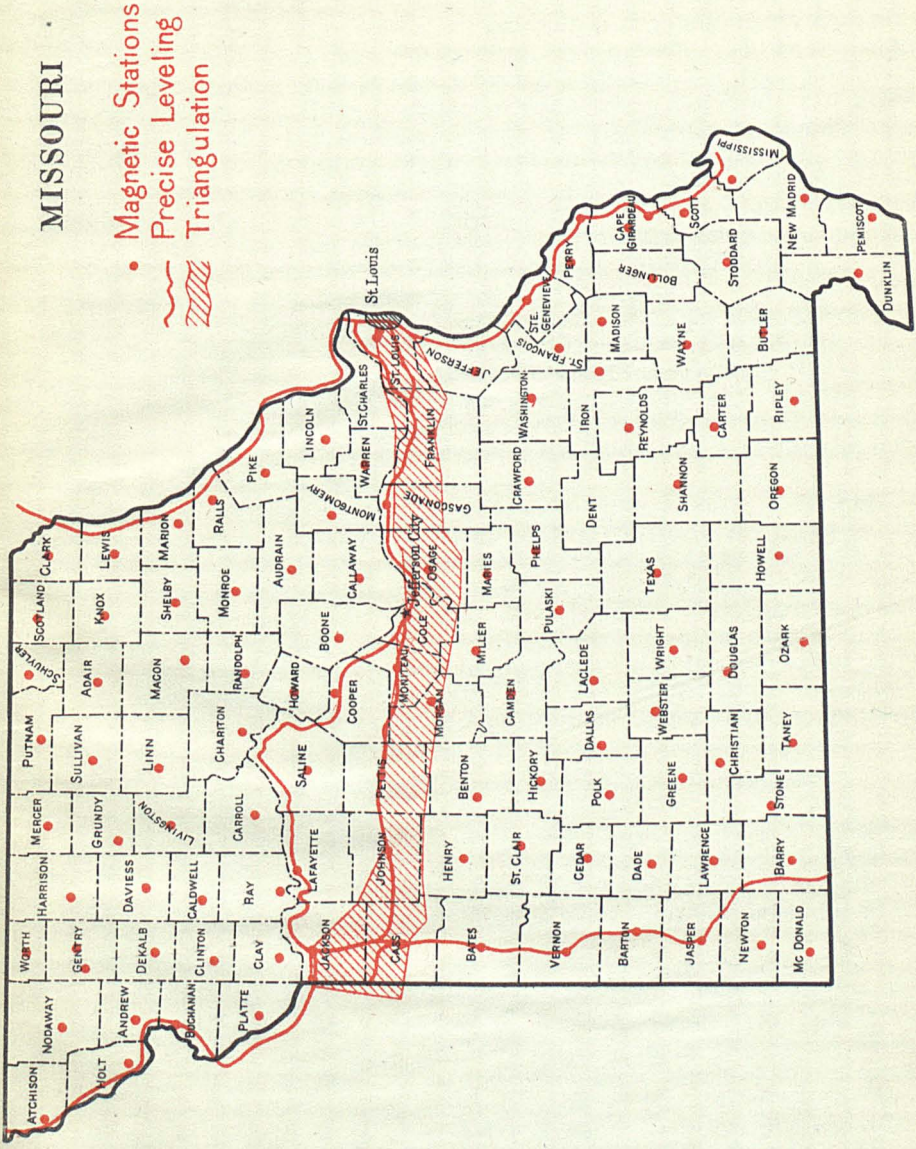
fornia and Japan positions and elevations are found to shift during earthquakes. This may occur elsewhere, and with an accuracy to 0.1 foot in determinations a very small shift would cause trouble in future surveys. Such observations would give useful information about the interior of the earth and would enable us to learn more about processes of mountain building and submergence of land. In the past the outstanding work has been done by England, Russia, and Germany, and this country has done little first-grade work.

NEED OF CLOSER COOPERATION WITH LOCAL ENGINEERS AND SURVEYORS.

This bureau has been in operation for more than 100 years. Due to the admirable geodetic control devised by Hassler and adopted by Congress under the administration of Jefferson, triangulation stations established in 1822 are, with few exceptions, as serviceable for points of control in making land surveys in 1922 as when first determined.

Primarily, geodetic control points, including precise level bench marks, were established to form the basis for surveying projects covering large areas of the country, but the needs of these large projects have necessitated the extension of the triangulation and precise level nets to such an extent that there is now a splendid opportunity for local engineers and surveyors (county surveyors, highway engineers, city engineers, etc.) to base their local surveys on these standard data which are permanently fixed with relation to all other standard points of control throughout the country. The advantages are obvious and need but little exposition. Land surveyors and city engineers who are called upon to reestablish old boundary lines frequently have great difficulty in finding and identifying old boundary monuments, such as stones, stumps, or trees. Sometimes the surveys of adjacent counties are each based on arbitrarily selected control points, and when these surveys are carried to the boundary line of the counties overlaps or gaps are developed. In many cases it is very difficult to trace out an old compass survey because the record does not show the declination of the compass at the time the original survey was made. These difficulties are not met if the surveys are based on standard geodetic control and are therefore in harmony with other control points throughout the country.

A lamentable fact that has been brought to light by our efforts to assist local engineers and surveyors is that so few of these are aware of the existence of our triangulation stations, magnetic stations, and precise level bench marks in their locality. Time and again it has come to the notice of this bureau that municipalities originally separate and distinct but which have later merged into a city have based their original surveys on control points that were not in harmony, and it has cost a great deal of time and money to bring such surveys into proper adjustment. These adjustments would have been unnecessary if the original surveys had been based on standard data. It is this consideration that has stimulated the effort being made by this bureau to induce all land surveyors and civil engineers to adopt standard control points and elevations in making surveys in the future. Our country is growing rapidly, and if surveys as now made are based on erroneous or poorly selected


MISSOURI
Magnetic Stations
Precise Leveling
Triangulation
St. Louis
Jefferson City
Mississippi
Atchison
Nodaway
Worth
Harrison
Mercer
Putnam
Schuyler
Scotland
Clark
Holt
Gentry
Grundy
Sullivan
Adair
Knox
Lewis
Andrew
Dekalb
Daviess
Livingston
Linn
Macon
Shelby
Marion
Buchanan
Clinton
Caldwell
Carroll
Chariton
Randolph
Monroe
Ralls
Pike
Platte
Clay
Ray
Lafayette
Saline
Howard
Boone
Audrain
Callaway
Montgomery
Lincoln
Warren
St. Charles
Jackson
Johnson
Pettis
Cooper
Moniteau
Cole
Osage
Gasconade
Franklin
Jefferson
Cass
Henry
Benton
Morgan
Miller
Maries
Phelps
Crawford
Washington
St. Francois
Ste. Genevieve
Perry
Cape Girardeau
Scott
Bollinger
Madison
Iron
Reynolds
Wayne
Stoddard
New Madrid
Pemiscot
Dunklin
Butler
Carter
Shannon
Dent
Pulaski
Texas
Ripley
Oregon
Howell
Ozark
Douglas
Wright
Webster
Laclede
Camden
Hickory
Dallas
Polk
Greene
Christian
Taney
Stone
Barry
Lawrence
Dade
Cedar
St. Clair
Bates
Vernon
Barton
Jasper
Newton
Mc Donald
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data the error will be augmented as our population increases and other surveys are based on the same erroneous data, until finally it will be necessary to make a costly readjustment of all these surveys.

In an endeavor to correct this situation special effort has been made to bring to the attention of civil engineers, city engineers, and surveyors the standard data available in this bureau. Three mediums have been used: (1) Digests are being prepared, one for each State in the Union. In these digests the counties in the State are listed in alphabetical order and under each county are shown the stations established in the county with direct reference to the publications of the bureau containing the results. Each digest is accompanied by a base map of the State showing graphically the kind of surveys made in the State and where made. (See illustration No. 2, opposite p. 18.) (2) A circular has been prepared pointing out the advantages of using standard data in making land surveys. This circular contains a base map of the United States showing the extent and nature of the surveys by this bureau throughout the country. (3) A canvass is being made of county surveyors throughout the United States calling their attention to the need of having accurate information as to the declination of the magnetic needle for both the date when the original compass surveys were made and also for the date when the resurvey is made.

These efforts have brought forth gratifying results. Letter after letter has been received commending our efforts in bringing to the attention of local engineers and surveyors the data available in this bureau and in encouraging the use of standard data on which to base surveys throughout the country. It is believed that there is a still wider field of service for the bureau in this connection and an opportunity for much closer cooperation between those in need of standard data and those in this bureau who have specialized in certain classes of land surveys. This cooperation will be undertaken in the near future.

ALASKA'S CHARTS AND MAPS SHOULD NOT BE DELAYED.

The work being done in Alaska by the Coast and Geodetic Survey should receive all possible support, as Alaska is entirely dependent upon water-borne transportation for its connection with the outside world, and adequate charts are needed to protect the lives and property entering and leaving the Territory.

It has always been the policy of the Coast and Geodetic Survey to expedite the surveys as rapidly as funds are made available, but these have never been furnished in sufficient amounts to enable the survey to meet the urgent demands made upon it as a result of the rapid economic development of the Territory. Much of the information shown on our present charts consists of mere adaptations from the work of early explorers and navigators, wholly inadequate to insure the safety of vessels traversing the waters. Lives and property have been lost as a result of this condition, and the fact that the losses have not been much greater must be attributed to the knowledge and skill of the local navigators rather than to the safeguards furnished them by the Government.

The rapid development of Alaska along commercial lines is well illustrated by the growing number of requests for surveys and for

information pertaining to areas where sites for proposed industries have been newly selected. In the past scattering surveys have been made in the strenuous effort to meet the needs of commerce, but the industries have far outstripped the progress of these surveys, wholly through lack of sufficient personnel and equipment with which to keep pace. One of the most urgent present demands is for a further extension of the much-needed wire-drag surveys. These should be pushed with all possible haste, as in the deep, fiordlike channels of southeastern Alaska a survey by this method is the only means of insuring that all dangers have been located.

The hydrographic and topographic surveys commenced in 1917 from Dixon Entrance along the outer coast have been extended northward to Noyes Island. The largest survey vessel operated by the Coast and Geodetic Survey is now engaged in extending this work northward toward Sitka. This work not only includes a detailed survey of the shore line but depths are obtained from the beach to the 1,000-fathom curve. The locations of fishing banks in this vicinity are obtained on these sounding lines.

Three vessels have recently been transferred to the Coast and Geodetic Survey by the Navy Department. These vessels were built for mine-sweeping duty by the Navy and will be altered to make them suitable for surveying work. They will take the place of two vessels of the service already condemned and sold and one other which will be disposed of this winter. These new vessels, on account of their size, power, and seaworthiness, will help materially in expediting the charting of the open waters of western Alaska. Surveys are much needed for the development of the oil fields in this locality. There should be a revision made of Cook Inlet north of Fire Island, where great changes have occurred since the last surveys were made. In addition there are surveys needed in Prince William Sound and of the outside coasts from Latouche and Montague Islands westward to Seward.

For some time one of the most urgent needs in Alaska surveys has been a system of control which would connect and coordinate the scattered hydrographic, topographic, and cadastral surveys of the Territory. Such control surveys were especially needed in preparing navigating charts of coastal Alaska and in placing upon a proper datum the many scattered surveys in the interior river valleys.

The report of the Governor of Alaska for 1921 mentioned the proposed extension, in cooperation with Canada, of an arc of precise triangulation from Puget Sound through British Columbia, southeast Alaska, and Yukon territory to the Yukon River at Eagle. The United States will then extend the work down the Yukon to Fairbanks, where it will eventually meet another arc which is being extended northward from the head of Cook Inlet toward the upper Yukon. A speedy linking up of these two sections is to be hoped for. Had such control been available 15 years ago, much time and money could have been saved in surveys made during that period, and the development of the interior region of Alaska would have been hastened, for many Federal surveying operations have been postponed for lack of such control.

Extensions of this single arc of triangulation are also needed badly. One branch should extend from Fairbanks to Valdez, along

the route of the stage road, with a spur to connect to the Alaska-Canada boundary near the upper waters of the Tanana. Another should extend from Fairbanks down the Yukon to Norton Sound. It is to be hoped that these main routes can be spanned by control surveys as rapidly as possible.

Of only slightly less importance to interior surveys is the line of precise levels which the Coast and Geodetic Survey began in the spring of 1922 and which will be extended as rapidly as possible to Fairbanks and from there along the stage routes to Valdez. Lines from Fairbanks to Eagle and from Fairbanks to Nome are also promised as soon as the funds for such work will permit them to be run. These levels will furnish basic elevations for a large area, which will be of great assistance to local industrial surveys.

The importance of current data can not be overestimated, and the situation is not yet satisfactory. It is essential to note that while a knowledge of the behavior of the currents is in all waters a matter of prime importance in the safeguarding of navigation in Alaskan waters it is doubly so, for in Alaskan waters in many cases deep water extends to within a few feet of the shore, and soundings are therefore of comparatively little value to the navigator in apprising him of the imminence of danger. In thick weather, therefore, when the navigator can not determine his position by lights or other landmarks, it is a matter of the utmost importance that he know the velocity and direction of the currents to which his vessel may be subject and which may, unknown to him, be carrying his valuable cargo of life and property to destruction.

Carried on by itself a current survey entails considerable expense. Fortunately, however, in connection with other hydrographic work, current observations may be made at comparatively small cost, and the Coast and Geodetic Survey is now working out a plan which will permit a small party to make current observations in connection with each of the surveying vessels operating in Alaskan waters.

During the past fiscal year the magnetic declination was determined at a large number of triangulation stations in southeastern Alaska, and the area of local disturbance about Port Snettisham was examined in detail. Here observations on board ship showed that even in mid-channel the effect on the compass was sufficient to endanger a vessel passing through in thick weather. A similar survey was made of the area of local disturbance near Haines in the main channel to Skagway. Though mariners have been aware of this source of danger and have made allowance for it, this is the first time that an accurate survey has been made. These observations will be extended to other areas where the presence of local disturbance is indicated.

Magnetic observations are also needed along the northern and western shores of Alaska and in the interior. During the past year observations were made along the Bering Sea coast of Alaska and Siberia and along the Arctic coast of Alaska at St. Michael, Nome, Teller City, Point Hope, Point Barrow, and Demarcation Point, in Alaska, and at Emma Harbor (Providence Bay) and Whelen (East Cape) in Siberia. This work had great value for two reasons: It connected the magnetic work of the Amundsen expedition with previous magnetic work in Alaska, and it provided values of the magnetic declination in Alaska at places where our previous

knowledge was very indefinite, and accordingly makes it possible to provide more accurate magnetic information on the charts of Bering Sea and the Arctic. Correct magnetic values are of great importance because at best, owing to the nearness to the magnetic pole, the compass is far more uncertain than in southern regions. The results brought out, however, the great need of a real magnetic survey in the interior of Alaska. The present situation of magnetic stations, existing only along the main lines of travel, leaves vast areas without observations of any kind. Observations are needed also in the Aleutian Islands to meet the needs of the commerce from the west coast to the Orient.

The Coast and Geodetic Survey has maintained an observatory at Sitka since 1902. Observations of the magnetic declination, dip, and intensity have been made since that time without a single break in their continuity. The disturbances known as magnetic storms which affect the direction and intensity of the magnetic elements occur with great frequency in Alaska. These storms are apparently related to unusual difficulties in submarine cable transmission and also to operation of radio stations.

CHAPTER III.

PURCHASE OF DUTCH HARBOR, ALEUTIAN ISLANDS, AS A FEDERAL GOVERNMENT FUEL AND SUPPLY BASE.

Nine years ago I strongly recommended in a special report that the Federal Government purchase from the North American Commercial Co. their property at Dutch Harbor, Aleutian Islands, Alaska, as a fuel and supply base. In subsequent reports I reiterated my recommendation, but to date no action has been taken. There is stronger argument now than ever before for again advocating the purchase of this property for a Federal Government base. Under present conditions temporary or permanent headquarters for Government vessels must be at Unalaska, close to Dutch Harbor, and there is hardly an argument in favor of the continuation of this arrangement. The harbor at Unalaska is a poor one, and the means of reaching it is through a narrow channel which is more or less dangerous even to small vessels.

The Government has already paid many thousands of dollars to private companies for coal transported from Australia, Canada, and other places, and in addition has paid for various privileges in connection with docking where private interests are involved. There is a very poor supply of fresh water at Unalaska, and the buildings for storage are entirely inadequate. Commerce is increasing and the activities in western Alaska are marked, so that it is good business, especially from the point of view of economy, to look for a permanent Federal supply base.

Dutch Harbor, which is an abandoned village of the North American Commercial Co., seems clearly to be the outstanding and logical place for the Federal Government to acquire. The only wireless station in the section is located close to this village and affords easy means of communication. The harbor is excellent, has additional room for modern wharves, and has a liberal supply of fresh water. While the buildings of the company are rather old, no doubt many of them can be restored to fairly good condition. There are coal yards and trackage for handling coal and bins already built.

The Department of Commerce would be materially helped by having such a Government station in this more or less isolated section of Alaska, as its maritime bureaus would find it of great benefit. In addition to having a place to take on coal and oil fuel, as well as water and other supplies, conditions are such that without a great outlay of money certain repairs to vessels could be undertaken. The Bureau of Fisheries, with its important interests in and almost year-round contact with the Pribilof Islands, would find such a base of great help in expediting the moving of supplies to the islands and bringing back sealskins and other furs. The Lighthouse Bureau and the Coast and Geodetic Survey, both of which are engaged in important work in the Pacific Ocean, Bering Sea, and waters adjacent to the Aleutian Islands, would find this supply and fuel base

of great assistance in expediting their work. But this is not all. The Navy Department, with vessels moving back and forth between the Orient and western waters, could no doubt use this Government base to advantage, as could also the Coast Guard of the Treasury Department, which has vessels carrying on patrol duty in the waters adjacent to Dutch Harbor during a number of months of each year.

The Government vessels in the past have managed to get along in an uncertain and at times expensive way, but if this property were acquired they would immediately feel the beneficial effects of the purchase. Many tons of fuel are used by Government vessels in this section, including both coal and oil, the latter coming into more general use each year, and the prices that have been charged by private-owned companies have been out of all reason. With the opening of the coal and oil fields in Alaska, shipments could be made frequently and at small cost to Dutch Harbor, so as to insure an adequate and cheap supply to Government vessels the year round. I recommend that consideration be given to this matter, as it is a long step toward conducting the operations of the vessels of the Department of Commerce and other departments of the Government in a more economical and businesslike manner.

CHAPTER IV.

CENTRAL BUREAU OF INFORMATION IN WASHINGTON NEEDED.

One of the best ways to serve the people of the country who come to Washington to do business with the Federal Government is to direct them to the department, commission, or bureau where their business calls them, and the agency by which this service can best be rendered is a central bureau of information. One important consideration involved in this suggestion is the fact that when, as too often happens, these people are misdirected, they waste not only their own time but that of officials and employees of the Government. In the aggregate many working hours, amounting during the year to weeks and months for almost any one of the Federal bureaus, is unnecessarily devoted to ascertaining for these visitors just where they can best transact their business.

It is clearly evident that the most efficient and economical way to obviate this situation is to establish a bureau as suggested above, where everyone who desires definite information from the Government can either secure it at once or else be directed to the proper department or bureau where the desired information can be obtained readily and quickly.

Part II.—THE WASHINGTON OFFICE.

CHAPTER I.

ACCOMPLISHMENTS OF THE WASHINGTON OFFICE DURING THE FISCAL YEAR.

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

CHIEF CLERK.

The principal duties of this division are the care, custody, and upkeep of the buildings occupied by the bureau; the supervision of the expenditures from the appropriation for office expenses, including the purchase of supplies for the office, for chart printing work, and to some extent for the field; the care and custody of most of the original records of the field surveys, as well as the library of printed publications kept for the use of the bureau; the general supervision of all matters relating to the personnel work of the bureau, including reports of leaves of absence taken; the custody and accounting for the receipts from the sale of charts and publications, etc.; and the direction of the engineer, electrician, watch, messenger, and labor forces of the bureau, and other employees whose duty has to do with the care and protection of the buildings.

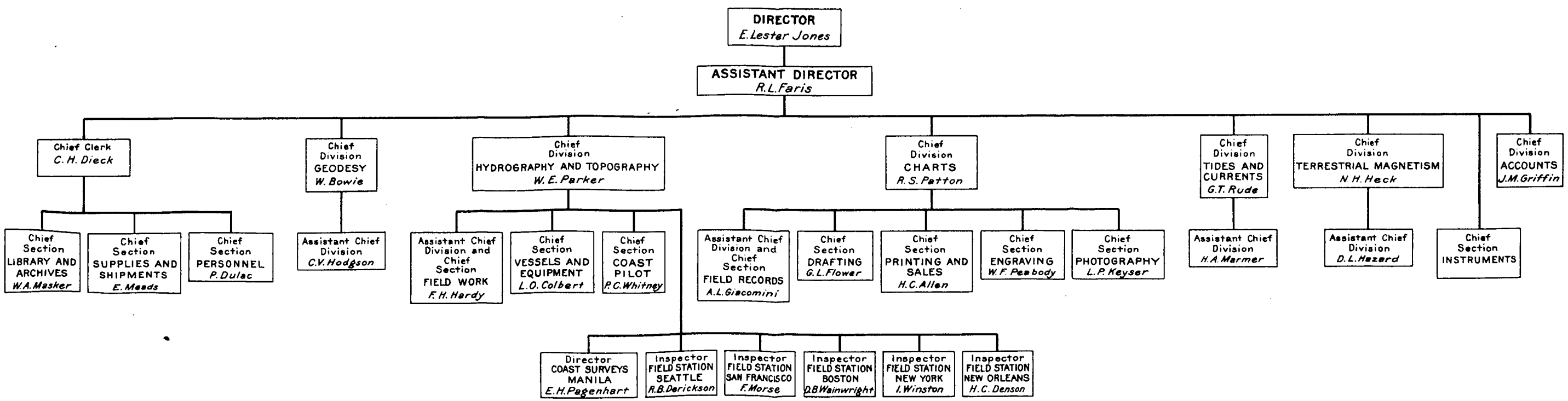
The more important accomplishments during the year have been a continuation of the plan to make a thorough renovation of the buildings occupied by the bureau. This work is still in progress. During the fiscal year 30 rooms, the walls of 4 stairways, and 1 hall were painted, involving a total of 39,753 square feet, and linoleum was laid on the floors of 15 rooms and 3 halls, a total of 654 square yards.

Previous to the fiscal year for which this report is made, drinking water was supplied in practically all of the buildings occupied by the bureau by the inverted bottle type of cooler. In the realization that a great deal of time of messengers and laborers was consumed in cleaning, icing, and filling the water bottles of this type of cooler, an effort was made to install a more sanitary cooler and one that required less care to keep in working order. Accordingly a stack of drinking fountains supplying five different floors in one building was installed, cold water being piped from a single large cooler. This has eliminated considerable of the work formerly performed in keeping the inverted bottle type of water cooler in operation, but has led to the conclusion that a more economical and satisfactory method is the installation of an ammonia cooling plant to supply drinking water to the seven different buildings occupied by the bureau. At the end of the fiscal year negotiations were under way for the procurement of a satisfactory water-cooling plant.

During the year the changes necessary were completed whereby the bureau obtains electric current and steam necessary for heating the buildings from the Capitol power plant. In this installation many improvements and adjustments have been made that render the

Effective Oct. 15, 1915
Revised to Oct. 5, 1922

CHART SHOWING ORGANIZATION OF THE
U.S. COAST AND GEODETIC SURVEY
1922



C&G.S. Print

heating system in the buildings much more satisfactory than in the past.

During the year the front and side walls of the portion of the Richards Building adjoining New Jersey Avenue, and the side wall of the south Butler Building were painted; also, all-metal library shelving was installed in rooms 340 and 347.

The cost of care, maintenance, upkeep, and operation of the buildings occupied by the bureau has been reduced from 29 cents per square foot for the fiscal year 1921 to a little less than 26 cents per square foot for the fiscal year 1922.

In the office of the chief clerk the preparation of digests of the geodetic publications of the bureau has continued. By the close of the fiscal year ended June 30, 1921, digests had been prepared and published for 8 States, and at the close of the fiscal year for which this report is made, such digests had been published for 21 States. That these digests fill a need is attested by numerous letters from civil engineers, surveyors, and others expressing appreciation that the information has been brought to their notice.

In the library and archives 52 hydrographic and 98 topographic sheets, each representing new surveys made by the bureau, were received.

Other additions to the library and archives were blue prints (mostly showing results of surveys by Army engineers), 518; maps, 2,347; charts, 2,898; field, office, and observatory records, 5,784.

During the year the expenditure from the appropriation for general expenses of the bureau was $101,585.26.

The total number of permanent and temporary officers and employees in the office and field force, which includes the commissioned officers and all employees appointed through civil-service certification, is, office force, 224; field force, 163; total, 387.

These figures do not include persons engaged as rodmen, chainmen, heliotropers, and others, in the field parties, nor any enlisted men on vessels of the bureau.

The statistics in regard to leaves of absence during the calendar year are as follows: Annual leave, 8,448 days; sick leave, 1,845; without-pay leave, 1,682; and accrued leave, 1,888.

While the number of employees naturally varied on account of resignations and vacancies, calculated on the number actually in the service on June 30, 1922, as a basis of computation, the average annual leave taken during the year by each employee was approximately 26.7 days and sick leave 4.8 days.

The receipts from the sale of charts, publications, etc., amounted to $41,689.14.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

This division is composed of the sections of field work, vessels and equipment, and coast pilot, each under the immediate supervision of a section chief and all under the direction of the chief of the division.

The section of field work has supervision over all hydrographic and topographic surveys, plans the work to be accomplished by the field parties, prepares instructions for the chiefs of parties, and keeps track of the progress of their field work. The principal accomplish-

ment of the section during the fiscal year has been the preparation of a comprehensive plan for expediting the survey of those parts of the United States waters as yet unsurveyed and for making resurveys and supplementary surveys where required. In the spring of 1921, the section began a comprehensive study of the needs for surveys of the waters of continental United States, Alaska, Hawaii, and the West Indies; and resulting from this study, a program was adopted this year by which all hydrographic and topographic work will be carried on more systematically, and new work will be taken up successively in the order of its importance and the need for new and better charts. This coordination of effort should result in a greater annual accomplishment of field work and, therefore, a reduction in the unit cost of work. A secondary accomplishment of the section was the preparation of a new Plane Table Manual which is now in the hands of the printer.

The section of vessels and equipment has supervision over the floating equipment of the bureau and over the personnel employed in connection with the operation of that equipment. During the fiscal year the section prepared plans and specifications for reconditioning two vessels transferred to the bureau from the Navy, and directed the work of converting these vessels, which were constructed for mine sweeping, to surveying vessels. The section also designed a new type of deep-sea sounding machine, three of which were in use this summer. These activities were carried on in addition to the usual work of maintaining in efficient operating condition the vessels and other floating equipment of the bureau.

The coast pilot section published the United States Coast Pilot of the West Indies, second edition, field work for which was done during the previous fiscal year; the fifth edition of the Inside Route Pilot, New York to Key West, from field work performed partly in this fiscal year and partly in the last; and prepared the manuscript for the United States Coast Pilot, Atlantic coast, Section D, Cape Henry to Key West, from field work also performed partly in this and partly in the last fiscal year.

DIVISION OF GEODESY.

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

The computation and adjustment of the following pieces of triangulation:

1. Precise triangulation, from the vicinity of Waco, Tex., to Mansfield, La.
2. Precise triangulation, Little Rock westward to the ninety-eighth meridian.
3. Precise triangulation, El Reno, Okla., to Needles, Calif.
4. Precise triangulation, Huntsville, Ala., to Memphis, Tenn.
5. Precise triangulation, southern end of the one hundred and fourth meridian.
6. Precise triangulation, California-Oregon arc.
7. Along the Potomac River.
8. Umpqua River, Oreg.
9. Anacostia speed trial course, District of Columbia.
10. In North Carolina.
11. In Louisiana.
12. In New Jersey.
13. In Florida.
14. In Washington.
15. In Alaska.

In connection with the triangulation listed above the computation of the following base lines:

1. Alki base, Wash.
2. Admiralty Bay base, Wash.
3. Little Rock base, Ark.
4. Prescott base, Ariz.
5. Vega base, Tex.
6. Belen base, N. Mex.
7. Savanna base, Okla.
8. West End base, La.
9. South Point base, La.
10. Pass Manchac base, La.
11. Several bases in Alaska.
12. Santo Domingo base (computed at request of United States Geological Survey).

The computation of the following lines of precise traverse:

1. Pascagoula to Booneville, Miss.
2. Wilmington to Sanford, N. C.
3. Green Bay to Duluth, Wis.
4. Ladysmith to Wisconsin Rapids, Wis.
5. Memphis, Tenn., to Little Rock, Ark.
6. Savannah, Ga., to Norfolk, Va.

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

1. Louisville, Ky., to Nashville, Tenn.
2. Hinsdale-Canadian boundary, Mont.
3. Flagstaff to Lee's Ferry, Ariz.
4. Green River, Utah, to Lee's Ferry, Ariz.
5. Bend to Prineville, Oreg.
6. Portland, Oreg., to Wallula, Wash.
7. Portland to Astoria, Oreg.
8. Revision in New York State.

The computation of the following astronomic work:

1. Time and azimuth for stations along the precise traverse, Pascagoula to Booneville, Miss. (completed).
2. Time and azimuth for stations along the California-Oregon arc of precise triangulation (completed).
3. Time and azimuth for 26 stations along the precise traverse, Green Bay to Duluth, Wis.
4. Time at seven stations in the Mississippi Delta, in connection with the gravity stations.
5. Time and azimuth for four stations along the Little Rock westward arc of precise triangulation.
6. Time and azimuth for five stations along the El Reno-Needles arc of precise triangulation.
7. Latitude at nine stations in the Mississippi Delta, La.
8. Time and azimuth for one station on the southern end of the One hundred and fourth meridian arc of precise triangulation.
9. Radio longitude for two stations in connection with the investigation for lag of wireless signals.

The preparing of the manuscript and proof reading of the following publications:

1. Special publication No. 13 (reprint): California-Washington Arc of Precise Triangulation.
2. Special publication No. 76: Triangulation in Massachusetts.
3. Special publication No. 77: Precise Leveling in Texas.
4. Special publication No. 78: Precise Triangulation in Texas, Rio Grande Arc.
5. Special publication No. 79: Precise Traverse and Triangulation in Indiana.
6. Special publication No. 80: An Investigation of the Latitude of Ukiah, Calif., and of the Motion of the Pole.
7. Special publication No. 81: Geodetic Operations in the United States, January 1, 1912, to December 31, 1921.
8. Special publication No. 84: California-Oregon Arc of Precise Triangulation.

Besides these, Special publication No. 86, Precise Traverse, Racine, Wis., to Vandalia, Ill., and Special publication No. 88, Triangulation

Along the Ninety-eighth Meridian, Kansas-Oklahoma Boundary to Alice, Tex., have been sent to the printer.

The manuscript for several other publications is in course of preparation, two of these being nearly ready for the printer, namely, Instructions for Reconnaissance and Signal Building and Use of Geodetic Control for City Surveying.

The two special problems, a study of the movements of the earth's crust in the earthquake region of California and a study of the earth's dynamics in connection with the Stokes theorem, which were carried on last year, were continued during the year.

The average force during the year was 18 persons. This number includes the field officers when engaged on office computations, although most of the time of these men was spent on field work.

DIVISION OF CHARTS.

During the year the division has worked with three objects in mind: (1) To keep the charts in print and to keep them corrected promptly for all new information received; (2) to complete the program of new chart production and of chart reconstruction adopted at the beginning of the year; (3) to seek further improvements in the mechanical processes involved in chart production and thus effect a reduction in the labor necessary to effect that end.

(1) Correction of Existing Charts.—It is the policy of the bureau that this task shall take precedence over all others. The charts must be kept in print; they must be printed in small editions in order that frequent reprints will enable us to apply corrections reaching the office from time to time, and whenever information of importance is received all charts affected must be reprinted immediately, and all existing prior copies, either in this office or in the hands of our agents, must be destroyed.

This policy has been strictly adhered to. Back orders have been kept at a minimum, and the few charts that have been back ordered have been printed promptly thereafter.

The program for 1922 called for the production of 24 new charts or maps, and the reconstruction of 10 existing charts to make them conform to the present standards that all charts shall be on the Mercator projection, oriented with the meridan and with all soundings in a single unit for each chart. The program was adopted June 1, 1921, and called for the completion of the last chart listed by August, 1922.

The division's accomplishments during the year exceeded in both amount and speed that contemplated in the program.

(*a*) By reason of a suddenly awakened interest in the North Pacific Ocean resulting from the Conference on Limitation of Armament, a map of that ocean was added to the program in September and rushed to completion.

(*b*) The program as originally adopted was to be completed in August. The last chart on the program was delivered from the press on June 27.

The following table compares this new chart production with similar work during the recent past:

Produced at—	1916	1917	1918	1919	1920	1921	1922
Washington	10	11	12	7	12	18	25
Manila	2	1	3	2	3	4	2
Total	12	12	15	9	15	22	27

The successful completion of this program confirms the conclusion reached last year that the adoption of such a program results both in expediting the completion of new chart work and in the accomplishment of a greater amount of such work in a given time.

To summarize the present situation, the division of charts has temporarily caught up with the field work to the extent that we have complete or in hand all new charts for which adequate data are available or in sight. The Atlantic coast as far south as the Cape Fear River is now adequately charted except that various local areas along the New England coast require additional surveys to replace work of doubtful value done many years ago, upon which our charts are at present based.

I have said that we have temporarily caught up. As soon as the primary triangulation through southeast Alaska is completed and adjusted, the chart division must take up practically the complete reconstruction of the charts in the area reached by the adjustment. This is an exceedingly difficult task which will take years to complete. Because of the crudeness of the original work, which must now be distorted to fit the new triangulation, it will take fully three times as long to complete the average Alaska chart as is required for the average chart of the United States coast.

Because of the magnitude of this task, the work which we undertake this time should be final. Hereafter when we produce one of these new charts we do not want that portion of it which is immediately adjacent to the new triangulation to be correct, while more remote portions are still on the old erroneous datums. For that reason the policy will be to undertake the reconstruction of only those charts which are controlled by adjusted triangulation.

On the Atlantic coast south of the Cape Fear River and on the Gulf coast the division of charts can not take up the production of further new charts until additional field work has been completed. In other words, I do not think we should publish as new charts which are actually constructed from surveys made many years ago—in many cases prior to the Civil War—and which we know are no longer correct.

The situation in the Virgin Islands is similar to that just described. We have published one general chart of the islands, using topography from our own recent surveys, and hydrography from United States Hydrographic Office and British Admiralty charts. A series of three topographic maps covering the islands is now in hand. We have no hydrography adequate for the production of large-scale charts, so such additional harbor charts as are required must await the completion of hydrographic and wire-drag surveys now in progress.

On the Pacific coast of the United States the remaining task for the chart division consists principally in the application to existing charts of the general hydrographic survey now in progress.

IMPROVEMENTS EFFECTED IN METHOD OF CORRECTING ENGRAVED PLATES.—In the past it has been recognized that certain technical processes long inherent in the engraving method were time consuming and laborious, and that if these processes could be improved the result would be of material benefit.

The permanence of the engraved plate is one of the strong points commending its use. This very permanence has, however, also a disadvantage, as it renders correction difficult. A practical means of overcoming, or at least greatly minimizing, this difficulty has been devised during the year, and the required apparatus is now being constructed.

By reverting to the alto and scraping changed areas, corrections have always been possible by making a new basso. This, however, is a time-consuming process. Also, small areas have, in the past, been corrected by scraping out the work and leveling with a hammer on a special anvil. This is likewise a slow process. Our first undertaking was, therefore, to seek a readier means of making corrections on copper.

After careful study, appeal was made to the Director, Bureau of Standards, who detailed to the study of the problem a chemist, W. E. Bailey. Mr. Bailey, in his experiments, had the cooperation of the engraving and electrotype sections of this bureau.

These experiments led to the adoption of an interesting, and it is believed novel, adaptation of the galvanoplastic method of electrotyping, by means of which it is possible to remove quickly small or large areas from the surface of the plate to the depth of the engraved work.

An electrode is inserted in the nozzle of a hose through which a solution of copper sulphate is thrown under pressure against the plate on the area where the correction is to be made. An electric circuit from a generating source is formed between the plate and the electrode in the nozzle, through the stream of solution impinging on the plate. A current pressure of from 12 to 15 volts has been found satisfactory. This voltage is far in excess of pressure ordinarily used in depositing copper, and the action is very rapid. By making the plate the positive electrode, copper is removed from it to any desired depth. The cut portions of the plate are not affected since they are filled with ink or any nonconducting substance.

By this erasing method a depression as deep as the engraved lines is made. By the use of a hammer on the back of the plate the depressed area may be leveled with the surface and, after polishing, the plate is ready for the application of new work.

Although the solution after striking the plate flows over it, the only point affected is that against which the stream is directed. Small areas of the surface are quickly removed as the engraved lines are not cut deeply.

The removal of about one twenty-fifth of the thickness of the plate usually erases all work likely to need correction. After this depression is transferred to the back of the plate by bumping up, it may, if desired, be filled in on the back by using the same process with the direction of the current reversed.

As indicated above, the electrolytic action is rapid. An area about 2 inches square can be removed from a plate to the depth of the engraving in six minutes.

DIVISION OF TERRESTRIAL MAGNETISM.

The previous activities of the division were expanded to some extent during the year and additional activities were taken up. The work is now divided under the following heads: Computation of field and observatory results and preparation for publication, whether in book form or as charts; distribution of information to the public on request; also systematic efforts to inform users of magnetic data that valuable information is available. Research and experiment with the special purpose of improvement of instruments. Training of observers. Seismology.

Because of various special investigations, the assignment of one computer to field duty for nearly four months, and because the demand for information had greatly increased, the output of routine work was slightly less than last year. Demand for information in regard to magnetic stations, the values of the magnetic elements, especially declination, has increased steadily throughout the year, the increase being due chiefly to the use and distribution of digests of geodetic publications for a number of States; these are issued to engineers of each State and usually requests begin to arrive from that State in increased numbers.

The Cheltenham Observatory results for 1917–18 were prepared for publication and printed. Those for 1919–20 were computed and prepared for publication.

The Porto Rico Observatory results for 1917–18 were computed, prepared for publication, and printed. The computation of the 1919 results was nearly completed and work on the 1920 results was begun.

The Honolulu Observatory results for 1919–20 were computed, prepared for publication, and sent to the printer.

The Sitka Observatory results for 1919 were computed, and those for 1920 were nearly finished.

The Tucson Observatory results for 1919 were about half computed and a beginning was made on those for 1920.

Observations at field stations and comparison of field instruments at the observatories were computed as soon as the records were received and the results for the year 1921 were prepared for publication and sent to the printer.

The earthquakes recorded at the five magnetic observatories were tabulated month by month as the records were received and the results were sent to the Monthly Weather Review for publication.

Proof was read of the following publications: Directions for Magnetic Measurements, second edition; Porto Rico Observatory Results, 1917–18; Cheltenham Observatory Results, 1917–18; and Results of Field Observations in 1921.

The secular change data secured since 1915 were tabulated, the secular change tables were revised and brought up to 1920, and a new isogonic chart of the United States, showing the lines of equal magnetic declination and of equal annual change for January 1, 1920, was prepared. A new publication to contain this chart and the secular change tables, and also directions for determining the true meridian, was nearly completed. This is intended primarily for the use of surveyors who have occasion to work with a compass.

An isogonic chart of the Philippine Islands for 1920 was prepared for use of the Manila suboffice.

It is realized that the chief output of the division which has economic value is the value of the magnetic declination, which is useful to local surveyors who use magnetic instruments, especially county surveyors. This division prepared a pamphlet and several special forms, the chief purpose being to call the attention of county surveyors and others to the need of more care in making magnetic surveys, especially in obtaining compass correction at magnetic stations. The forms were prepared to aid them in finding their compass correction, and also to furnish the values of the magnetic declination and report the conditions of the magnetic stations, if they so desired. This program was started in June, and by the end of the fiscal year it was clear that this information is in great demand. The requests for information during June were double those of previous months, and only a quarter of the States had been reached.

Excellent cooperation in reporting conditions of stations has resulted, thereby making our information more useful to other local users and giving this bureau information on which to base a program of revision of stations. One of the many letters received is quoted, from a county superintendent of highways:

> I should be very glad to have the description of the magnetic station in this locality and the forms mentioned in your leaflet. I assure you that you will have my full cooperation in this matter, and I believe that more information on this subject will be of great value to anyone concerned.

Instruction in the use of magnetic instruments was given three field officers prior to their departure for the field. In this connection efforts were made to find a suitable place for a magnetic station in Potomac Park but without success, and one was finally established on the grounds of the University of Maryland at College Park. A demonstration of the instruments and methods of observing was given to some of the students of that university.

The true and magnetic meridians were established at Bolling Field at the site of the turntable to be used in determining the deviations of airplane compasses.

A paper on "Horizontal intensity variometers," written by George Hartnell, magnetic observer, was prepared for publication and sent to the printer.

A new form was prepared for use in determining the magnetic declination on shipboard by means of a 3-point fix of position and azimuth.

A report on the magnetic work of the bureau was prepared for submission to the Rome meeting of the section of terrestrial magnetism of the International Geodetic and Geophysical Union and memoranda were prepared setting forth the views of the bureau regarding the subjects to be considered at that meeting.

Magnetic data for special investigations were supplied to the department of terrestrial magnetism of the Carnegie Institution of Washington and to Father Luis Rodes, director of the Observatorio del Ebro, Tortosa, Spain.

A table giving values of the magnetic declination and annual change for places in all parts of the United States was prepared for the 1923 edition of the World Almanac.

As a result of the digests and other circulars being sent out to engineers and surveyors, there has been a marked increase in the number of requests for information, and the greater part of the time

of one computer is now devoted to the preparation of replies to such requests.

Compass data were supplied for 112 charts.

SPECIAL INVESTIGATIONS.—In connection with the determination of the constants of the new Milne-Shaw seismograph, a study was made of the general theory of the seismograph.

A meeting of those experienced in the use of field magnetic instruments was held at which the various instruments and methods were discussed. A small electric light for illuminating the scale of the suspended magnet of the magnetometer was one of the improvements suggested, and this has been provided for one of our instruments.

Experiments were made with a telephone receiver in place of a galvanometer for use with the earth inductor, which indicated a possibility of successful development.

A study was made of methods heretofore used in locating and determining the extent of iron-ore deposits in preparation for experimental work along this line, first at the request of J. Ross Corbin, associate State geologist of Pennsylvania, and later in connection with work along the same lines by W. R. Crane, of the Bureau of Mines.

Careful study was given to the problem of improving and extending the seismological work of the bureau. In this connection the chief of the division visited the Tucson Obesrvatory and conferred with scientists in California especially interested in the subject.

DIVISION OF TIDES AND CURRENTS.

The work of the division of tides and currents is comprised under the following heads: Tidal observations and computations; advance predictions of tides and currents and preparation of annual tide and current tables; current observations and computations; tidal and current surveys of our principal harbors; physical oceanography; and the preparation of technical publications dealing with tides, currents, and related phenomena.

Tidal observations and reductions were made at six principal stations on the Atlantic coast, three on the Gulf coast, five on the Pacific coast, and one in Alaska.

Observations and reductions of currents were made at nine light vessels on the Atlantic coast and five on the Pacific coast. Computations on the relation between wind and current were made for the light-vessel observations on the Pacific coast, in order to correlate wind and current for the preparation of current diagrams for the aid of the navigator in estimating the current, due both to tide and wind effects, to which his vessel is subject. The results of this work are of prime importance to shipping on the Pacific coast and will appear as a separate current table for the year 1923. The manuscripts for these current tables—Current Tables, Atlantic Coast, and Current Tables, Pacific Coast—are now in the hands of the printer and will be issued early in the next fiscal year.

The predictions of tides and currents for the 1923 tide and current tables were made and the manuscript submitted for printing in five separate parts: Tide Tables, Atlantic Coast; Tide Tables, Pacific Coast; Tide Tables, United States and Foreign Ports; Current Tables, Atlantic Coast; and Current Tables, Pacific Coast. The first three

named publications are now available for distribution and the last two are expected from the printer early in the next fiscal year.

The following table, showing the number of copies of the tide tables issued for each year since 1915, is indicative of the usefulness of these publications:

Tide tables for year.	General tide tables.	Atlantic coast tide tables.	Pacific coast tide tables.	Total.
1915	1,776	2,291	10,989	15,056
1916	1,195	2,682	10,565	14,442
1917	1,847	3,998	13,560	19,405
1918	3,331	3,997	13,959	21,287
1919	3,945	4,465	14,952	23,362
1920	3,474	5,252	15,738	24,464
1921	3,258	4,784	14,645	22,687
1922	3,056	5,704	14,902	23,662

The above table, however, does not show to the full the value of the survey's tidal and current predictions to the public, for many thousands of privately printed tide tables, copied directly from the survey tables, are annually issued all over the country. These appear as separate tide tables for different localities, and in almanacs and calendars. Some are sold and some given away in the form of advertisements, all reaching the public in useful form. In addition, the public receives the benefit of these predictions through the medium of the daily newspapers, a great many of which publish the tidal data in their columns, these data being furnished them by the Coast and Geodetic Survey directly or by means of the published annual tide tables.

During the past fiscal year the field stations of this survey located at Boston, New York, New Orleans, San Francisco, and Seattle have secured for this office statements of different firms on both coasts as to the number of these privately printed tide tables issued by each firm. The result shows that a total of 33 firms make an annual distribution of 365,000 local tide tables, and these firms are located in cities around the whole coast of the United States from Boston, Mass., to Juneau, Alaska. Of course, there are many firms from whom information has not been received and they are not included in these statements. As previously stated, many newspapers give daily or weekly tidal predictions and these reach a large number of interested people. Statistics gathered during the past fiscal year show that 35 newspapers with an estimated combined circulation of at least 4,000,000 copies published tidal data furnished by this office. These are doubtless only a few of those newspapers published which contain tidal information, being only the newspapers in Boston, New York, Philadelphia, Baltimore, Washington, New Orleans, and San Francisco.

DIVISION OF ACCOUNTS.

The total disbursements from July 1, 1921, to June 30, 1922, amounted to $1,851,960.60. This sum does not represent the total expenditures for the fiscal year, but only the amount actually disbursed during the period mentioned. In a separate report to Con-

gress is included an itemization of all expenditures by appropriations.

These expenditures are made throughout the entire United States and its possessions. From 30 to 50 chiefs of party are engaged constantly on field work, being financed through advances made to them through this office.

INSTRUMENT SECTION.

The instrument section is under the supervision of the Assistant Director. The function of this section is to design, devise improvements of, construct, repair, and purchase scientific instruments, such as are specifically demanded for the needs of the survey in all its branches. In addition, it must keep account of all of the inventoriable property of the bureau, both in the field and in the office. During the fiscal year 773 instruments, apparatus, tools, etc., were made; and 760 instruments, apparatus, and tools were repaired in the section.

PUBLICATIONS ISSUED DURING THE YEAR.

Serial No. 153. Tide Tables, Pacific Coast: North America, Eastern Asia, and Island Groups, Including Data on Currents, 1922. (Reprinted from Tide Tables, United States and Foreign Ports.) 191 pp. Gives predicted times and heights of tide for each day in the year for large number of stations on Pacific coast of North America and coast and islands of eastern Asia, besides tables by means of which tidal data may be obtained for many other ports, and other information useful to mariners. Information is given of currents on Pacific coast and in Alaska. Tables also give local mean time of sunrise and sunset and moonrise and moonset for many important cities in the United States and at Manila, P. I.

Serial No. 163. Tide Tables, United States and Foreign Ports, Including Data on Currents, for 1922. 497 pp. 7 text fig. Contains full tidal predictions for every day in year for 81 tidal stations and 9 currrent stations and differences and constants for more than 3,500 subordinate tidal stations and 200 subordinate current stations; 7 current diagrams; predicted moonrise and moonset for 10 places; and much other information useful to mariners.

Serial No. 164. United States Coast Pilot, West Indies: Porto Rico and Virgin Islands. Second edition. 183 pp. 7 pl. 1 litho. First edition of this publication (Porto Rico, 1906) covered only islands of Porto Rico, Mona, and Vieques, but present edition has been enlarged to cover recently acquired American possessions in Virgin Islands and also British Virgin Islands.

Serial No. 165. Utah-Washington Arc of Precise Triangulation; by C. V. Hodgson. Special publication 74. 76 pp. 2 pl. 4 litho. Gives results for arc of precise triangulation which extends from vicinity of Great Salt Lake, Utah, northward into Idaho, and then westward and northwestward to Columbia River and to junction near Portland, Oreg., with California-Washington arc of adjusted precise triangulation.

Serial No. 166. Directions for Magnetic Measurements; by Daniel L. Hazard. 130 pp. 6 pl. 6 text fig. Intended primarily as manual for guidance of officers of survey doing magnetic work. Endeavor made to present subject matter in such form that observer familiar with instruments but without experience in magnetic work may make in satisfactory manner various observations incident to determination of magnetic elements without other assistance than obtained from directions.

Serial No. 167. Radio-Compass Bearings; by Oscar S. Adams. Special publication 75. 39 pp. 2 text fig. Gives practical method by which navigator locating his position at sea by means of radio compass may plot his bearings correctly on either Mercator or gnomonic projection.

Serial No. 168. Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory at Vieques, P. R., 1917 and 1918; by Daniel L. Hazard. 104 pp. 23 diag. One of regular series of publications containing results of observations made at magnetic observatories maintained by survey.

Serial No. 169. Triangulation in Massachusetts. Special publication No. 76. 283 pp. 22 text fig. This publication gives the final results on the North American datum of all the triangulation executed by the survey in the State of Massachusetts.

Serial No. 170. Results of Observation Made at United States Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1917 and 1918; by Daniel L. Hazard. 119 pp. 23 diag.

Serial No. 172. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of South Dakota. 8 pp. 1 text fig. This publication is part of the regular series of digests containing results of work by the survey in the several States of the Union.

Serial No. 173. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Florida. 21 pp. 1 text fig. Contains brief references to publications of survey giving results of triangulation, leveling, and variation of compass, and published for benefit of engineers and others interested in this work.

Serial No. 174. Tide Tables, Atlantic Coast, North America, for 1923. (Reprinted from Tide Tables, United States and Foreign ports.) 152 pp. Gives times and heights of tides for principal ports of Atlantic coast of United States and Gulf of Mexico, and tables by means of which tidal data may be obtained for other locations, with other information useful to mariners.

Serial No. 175. Revised List of Charts and Nautical Publications of Survey. December 1, 1921. 47 pp. 15 text fig.

Serial No. 176. Charts and Nautical Publications Relating to Philippine Islands, Published by Survey and Revised to Date. December 1, 1921. 16 pp. 6 text fig.

Serial No. 177. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of North Dakota. 8 pp. 1 text fig.

Serial No. 180. Tide Tables, Pacific Coast, North America, Eastern Asia, and Island Groups for 1923. 173 pp. This publication contains predicted tides and other useful data for Pacific coast ports for the calendar year 1923, with tables by means of which the times and heights of the tides may be deduced for many other ports.

Serial No. 181. Inside Route Pilot, New York to Key West. Fifth edition, 1922. 95 pp. 8 charts in inside pocket. Gives directions for inside route from New York to Beaufort entrance and New River inlet, seacoast and inlets between Beaufort Inlet and Winyah Bay, S. C., and inland water route from Winyah Bay to Key West, Fla.

Serial No. 182. Precise Traverse and Triangulation in Indiana. Special publication 79. This report contains the geographic positions of all points located by precise triangulation and precise traverse in the State of Indiana. The precise triangulation across the southern part of the State is a portion of the transcontinental triangulation along the 39th parallel. Extending south from it is a small arc which connects with a base line at Louisville, Ky. Connecting with the 39th parallel triangulation and extending from North Vernon to South Bend is a precise traverse, the results of which are discussed in this publication. At South Bend the traverse joins the Lake Survey arc of precise triangulation which runs along the northern boundary of the State and by permission of the Chief of Engineers U. S. Army the results of the last-mentioned arc are included in this publication.

Serial No. 185. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in West Virginia. 9 pp. 1 litho. Contains brief references to publications of survey giving results of triangulation, leveling, and variations of compass, and published for benefit of engineers and others interested in this work.

Serial No. 186. Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory at Vieques, P. R., 1917 and 1918; by Daniel L. Hazard. 104 pp. 23 diag. One of the regular series of publications containing results of observations made at magnetic observatories maintained by the survey.

Serial No. 187. Digest of Geodetic Publications Issued by United States Coast and Geodetic Survey Resulting from Surveys in Nevada. 10 pp. 1 litho. Contains brief references to publications of survey giving results of triangulation, leveling, and variation of the compass, and published for the benefit of engineers and others interested in the work.

Serial No. 189. Digest of Geodetic Publications Issued by United States Coast and Geodetic Survey Resulting from Surveys in Alabama. 11 pp. 1 litho. Contains brief references to publications giving results of triangulation, leveling, and variation of the compass, and published for benefit of engineers and others interested in this work.

Serial No. 190. Digest of Geodetic Publications Resulting from Surveys by the United States Coast and Geodetic Survey in the State of Wyoming. 7 pp. 1 text fig. This publication gives brief references to results of work of triangulation, leveling, and observations of magnetic declination in the State of Wyoming.

Serial No. 191. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Utah. 5 pp. 1 text fig. This digest gives references to publications of the survey containing results of geodetic, magnetic, and leveling work done in Utah.

Serial No. 195. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Idaho. 6 pp. 1 text fig. This publication contains brief references to publications of the survey containing results of geodetic work in Idaho.

Serial No. 197. Compass Surveys. 7 pp. This leaflet is intended to place at the disposition of county surveyors the information obtained from magnetic observations made by the survey, and to enlist the cooperation of the county surveyors in developing a more thorough knowledge of the declination of the magnetic needle at different localities throughout the country.

Serial No. 198. Digest of Geodetic Publications Issued by the United States Coast and Geodetic Survey Resulting from Surveys in the State of Kentucky. 11 pp. 1 text fig.

Serial No. 202. Catalogue of Charts, Coast Pilots, Tide Tables and Current Tables, June 1, 1922. 47 pp. 15 text fig. The current tables formerly published as part of the tide tables are now issued separately.

Serial No. 203. Catalogue of Charts, Coast Pilots, and Tide Tables of the Philippine Islands, June 1, 1922. 15 pp. 6 maps. This is a revised list of charts and nautical publications relating to the Philippine Islands.

Annual Report of the Director, 1921. 147 pp. 36 litho.

Circular No. 30. Specifications for Horizontal and Vertical Control Surveys. February 15, 1922. 5 pp.

Circular No. 31. Specifications for Bench Marks and Station Marks. February 15, 1922. 6 pp.

Notice to Mariners. Issued weekly, jointly with the United States Bureau of Lighthouses.

Philippine Islands Notices to Mariners.

Coast and Geodetic Survey Bulletin. Issued monthly.

NEW CHARTS.

4230. Laguna de Bay, Luzon, P. I. October, 1921. Scale, 1 : 60,000; dimensions, 29 by 34 inches. Plan of Napidian Channel, Pasig River approach. Scale, 1 : 10,000. Shows, on convenient scale for launches and motor boats, results of surveys made in 1919.

1277. Vermilion Bay and approaches, La. November, 1921. Scale, 1 : 80,000; dimensions, 33 by 43 inches. One of new series of 1 : 80,000 scale charts on Mercator projection and replaces chart 200 of old series. Soundings are expressed in feet.

4334. Anchorages, east coast of Palawan, P. I. October, 1921. Scale, 1 : 40,000; dimensions, 28 by 39 inches. Contains plans for Honda Bay and Panacan and Malanao anchorages, east coast of Palawan, all on scales of 1 : 40,000, and shows results of surveys made in 1917 and 1918 covering the areas charted.

905. Virgin Islands. Virgin Gorda to St. Thomas and St. Croix, W. I. November, 1921. Scale, 1 : 100,000; dimensions, 32 by 43 inches. One of series of Mercator charts on mean scale of 1 : 100,000 covering United States West Indies. Extends from St. Thomas on west to Virgin Gorda on east and south to include St. Croix. Topography of possessions of United States is from recent surveys by Coast and Geodetic Survey; other data charted is from latest available information. Soundings are expressed in fathoms and heights in feet.

6004. Umpqua River, Entrance Bar to Reedsport, Oreg. November, 1921. Scale, 1:20,000; dimensions, 24 by 28 inches. Shows results of resurvey made in 1920. Soundings are in feet at mean lower low-water level. Replaces chart 6003.

230. Boothbay Harbor to Bath, Me. January, 1922. Scale, 1:15,000; dimensions, 26 by 33 inches. This is a chart showing in two sections the inside route between Boothbay Harbor and Bath, Me. The soundings are in feet at mean low water. This chart is oriented with the meridian and replaces the diagonal chart 315a, having soundings in feet and fathoms.

533. Sabine and Neches Rivers, Tex. December, 1921. Scale, 1:40,000; dimensions, 17 by 42 inches. Extends from head of Sabine Lake to Beaumont on Neches River and Orange on Sabine River. Overlaps chart 517, same scale, which extends southward to Gulf of Mexico. Plan on chart 203, covering same area on one-half the scale, will be canceled next time chart is printed.

1240. St. Helena Sound to Savannah River, S. C. and Ga. February, 1922. Scale, 1:80,000; dimensions, 32 by 41 inches. One of new series of 1:80,000 coast charts on Mercator projection, replacing chart 155 of old series. New chart gives soundings in feet instead of in feet and fathoms, as on old chart, and shows results of recent surveys of coast and entrances to inland waters and of Beaufort River up to Beaufort.

1278. Constance Bayou to Calcasieu Pass, La. January, 1922. Scale, 1:80,000; dimensions, 33 by 43 inches. One of new series of 1:80,000 scale coast charts constructed on Mercator projection and, together with new chart 1279, replaces charts 201 and 202 of old series. Soundings are charted in feet instead of feet and fathoms, as on old series.

1279. Calcasieu Pass to Sabine Pass, La. and Tex. February, 1922. Scale, 1:80,000; dimensions, 33 by 42 inches. One of new series of 1:80,000 scale coast charts constructed on Mercator projection and, together with new chart 1278, replaces charts 201 and 202 of old series. Soundings are charted in feet instead of feet and fathoms, as on old series.

6449. Seattle Harbor and Lake Washington, Wash. January, 1922. Scale, 1:25,000; dimensions, 32 by 40 inches. Supersedes chart 6445, Seattle Harbor, and chart 6446, Lake Washington, which became obsolete on account of change of water level of Lake Washington and numerous improvements in vicinity of Seattle Harbor. Soundings are in feet. Recent surveys of short line of Lake Washington are shown.

1280. Sabine Bank to East Bay, including Heald Bank, Tex. March, 1922. Scale, 1:80,000; dimensions, 31 by 42 inches. One of new series of coast charts on Mercator projection and replaces chart 203 of the old series. Soundings are charted in feet instead of fathoms and feet as on chart 203.

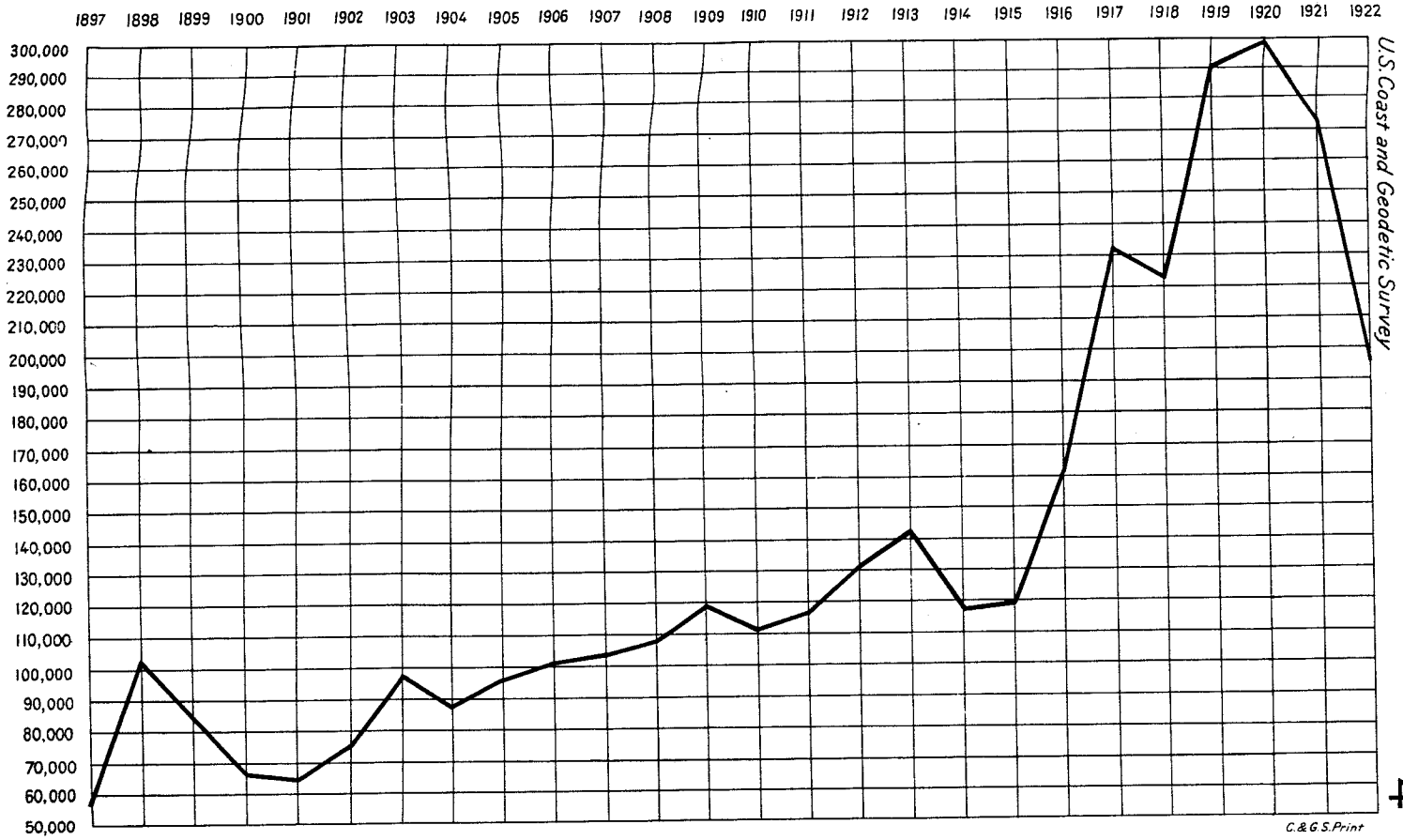
1265. Pensacola Bay and approaches, Fla. March, 1922. Scale, 1:80,000; dimensions, 31 by 42 inches. One of new series of coast charts on Mercator projection and replaces charts 186 and 187a of old series. Soundings are in feet. Results of recent survey in Gulf covering approaches to Pensacola Bay are shown on this chart.

5146. Los Angeles and Long Beach Harbors, Calif. April, 1922. Scale, 1:10,000; dimensions, 34 by 40 inches. Shows results of resurvey of Los Angeles and Long Beach Harbors and approaches. Extends from Point Fermin to West Long Beach and replaces chart 5145.

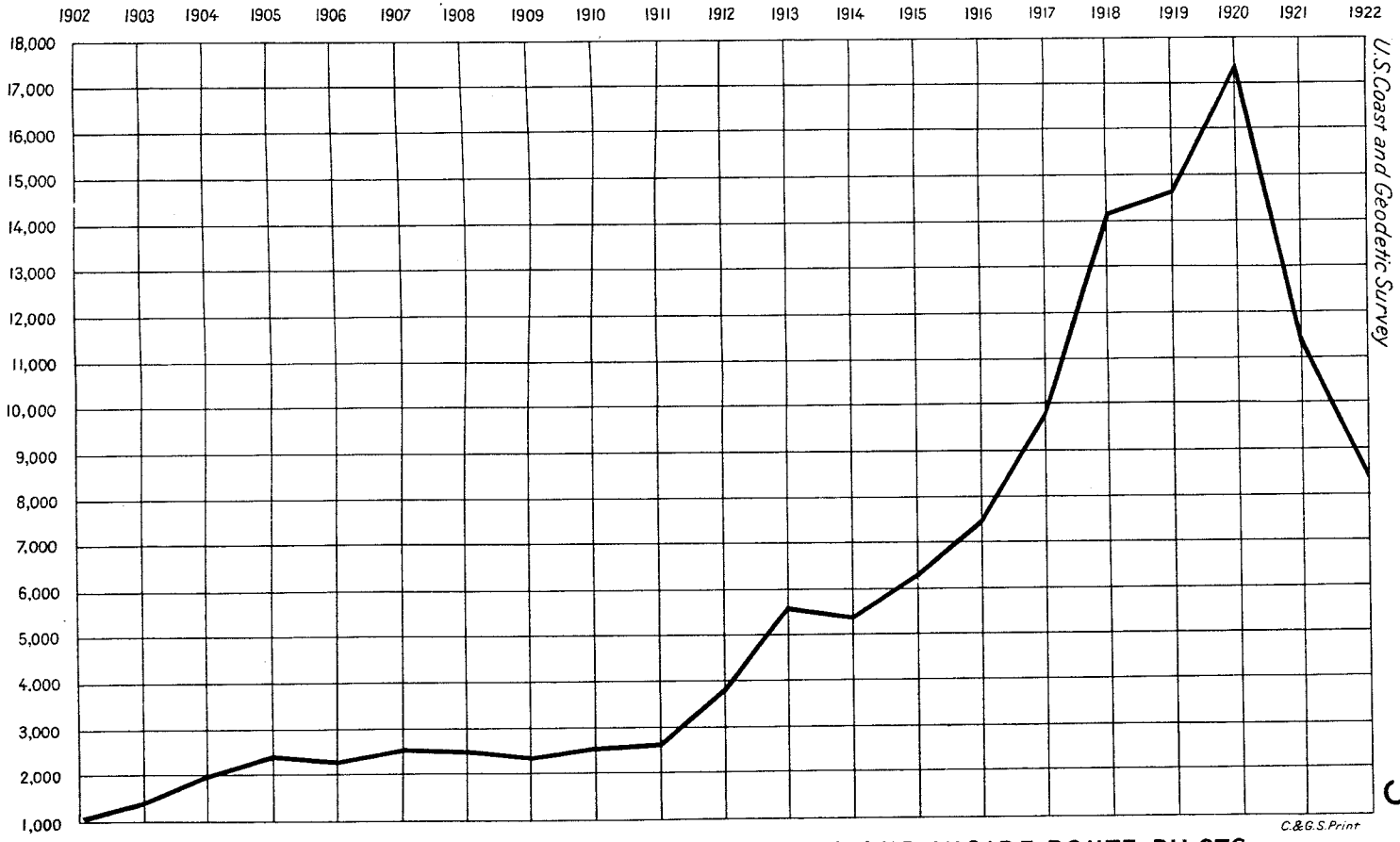
1284. Matagorda Bay and approaches, Tex. May 1922. Scale, 1:80,000; dimensions, 32 by 42 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection, and replaces chart 207 of the old series on the polyconic projection. It is oriented with the meridian and the soundings are charted in feet, instead of feet and fathoms, as on the old series of charts.

1350. Fowey Rocks to American Shoal, Fla. May, 1922. Scale, 1:180,000; dimensions, 33 by 37 inches. This chart is issued to meet a growing demand for sailing charts along the Florida Reefs on a larger scale than previously issued. It is on the Mercator projection, scale 1:80,000 in latitude 24° 50′, and extends from Fowey Rock to the American Shoal. The soundings are expressed in fathoms. A companion chart, extending from the American Shoal to the Dry Tortugas is in preparation and will be issued soon.

1283. San Luis Pass to Matagorda Bay, Tex. May, 1922. Scale, 1:80,000; dimensions, 32 by 44 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection. The soundings are in feet instead of fathoms, as on chart 1281, which it supersedes.



ISSUE OF CHARTS FROM 1897 TO 1922



ANNUAL DISTRIBUTION OF COAST PILOTS AND INSIDE ROUTE PILOTS

1285. Matagorda Light to Aransas Pass, Tex. May, 1922. Scale, 1:80,000; dimensions, 33 by 42 inches. This is one of the new series of coast charts on the Mercator projection, scale 1:80,000. It extends from Matagorda Light to Aransas Pass and includes San Antonio, Aransas, and Copano Bays. The soundings are charted in feet instead of feet and fathoms, as on the old series. With chart 1284 recently published, it replaces charts 206 and 209 of the old series.

223. Long Island Sound and East River, Hempstead Harbor to Tallman Island, N. Y. June, 1922. Scale, 1:20,000; dimensions, 28 by 36 inches. This is one of the new series of charts of Long Island Sound on a scale of 1:20,000. It is oriented with the meridian and replaces the chart 366, Hempstead Harbor, scale 1:20,000 and diagonal chart 272, New Rochelle to Throgs Neck, scale 1:10,000. The soundings are expressed in feet at mean low water.

1282. Galveston Bay and approaches, Tex. June, 1922. Scale, 1:80,000; dimensions, 32 by 43 inches. This is one of the new series of 1:80,000 scale coast charts on the Mercator projection and supersedes chart 204, same scale, polyconic projection, of the old series. The soundings are charted in feet at mean low water. The results of a recent survey by the United States Engineers from the whistling buoy to the shore end of the jetties are shown.

226. East River—Tallman Island to Queensboro Bridge, N. Y. June, 1922. Scale 1:10,000; dimensions, 30 by 44 inches. This new chart is oriented with the meridian and overlaps chart 369[4], same scale, on the southwest and chart 223, scale 1:20,000, on the east. It supersedes diagonal charts 369[5] and 273. The soundings are expressed in feet at mean low water.

NEW EDITIONS OF CHARTS.

369[5]. Hell Gate and East River from Blackwells Island to Lawrence Point, N. Y.
273. Throgs Neck to Randall Island, East River, N. Y.
369. New York Harbor, N. Y. and N. J.
509. St. Johns River, Lake George to Lake Harney, Fla.
1208. Cape Cod Bay, Mass.
1212. Long Island Sound, eastern part, Conn. and N. Y.
284. Hudson River, Coxsackie to Troy, N. Y.
287. Passaic and Hackensack Rivers, N. J.
549. Baltimore Harbor and approaches, Md.
1222. Chesapeake Bay entrance, Va.
4706. Philippine Islands, central part.
5602. Point Arena to Trinidad Head, Calif.
6153. Columbia River, Grims Head to St. Helens, Oreg. and Wash.
187[a]. Western approach to Pensacola Bay, Fla. and Ala.
250. Eastern entrance to Nantucket Sound, Mass.
413. Pensacola Bay entrance, Fla.
583. Miami Harbor and approaches, Fla.
929. Guanica Harbor, P. R.
1115. Cape St. George to Mississippi Passes.
5819. Entrance to Eel River, Calif.
6151. Columbia River—Entrance to Harrington Point, Oreg. and Wash.
6447. Lake Washington Ship Canal, Puget Sound to Lake Washington, Wash.
424. Cape Fear River, entrance to Reeves Point, N. C.
520. Galveston entrance, Tex.
538. Neuse River and upper part of Bay River, N. C.
1216. Sea Girt to Little Egg Inlet, N. J.
1217. Little Egg Inlet to Hereford Inlet, N. J.
1248. Jupiter Inlet to Fowey Rocks, Fla.
1266. Mobile Bay and entrance, Ala.
4309. Balabac Strait, P. I.
5145. Los Angeles Harbor, Calif.
6023. Siuslaw Inlet, Oreg.
150. Old Topsail Inlet to Shallote Inlet, including Cape Fear, N. C.
379. Cape Henlopen and Delaware breakwater, Del.
420. Beaufort Harbor, N. C.
490. Pensacola Bay, Fla.
1267. Mississippi Sound and approaches, Dauphin Island to Cat Island, Ala. and Miss.

4109. Honolulu Harbor, Oahu, Hawaii.
5534. Suisun Bay, Calif.
5832. Humboldt Bay, Calif.
5971. Coquille River entrance, Oreg.
6058. Yaquina River and approaches, Oreg.
6112. Tillamook Bay, Oreg.
6146. Columbia River, Vancouver to Reed Island, Oreg. and Wash.
6185. Willapa Bay, Wash.
6195. Grays Harbor, Wash.
1231. Pamlico Sound, western part, N. C.
584. Key Harbor and approaches, Fla.
254. Connecticut River—Deep River to Higganum, Conn.
1002. Straits of Florida and approaches.
1219. Cape May to Fenwick Island Light, N. J.
5984. Coos Bay, Oreg.
6112. Tillamook Bay, Oreg.
8229. Slocum and Limestone Inlets and Taku Harbor, Alaska.
904. Virgin Passage and Vieques Sound, W. I.
5525. Mare Island Strait, Calif.
185. Choctawhatchee Bay, Fla.
330. Isles of Shoals, Me. and N. H.
4312. Cuyo Islands, P. I.
5618. Tomales Bay, Calif.
6152. Columbia River, Harrington Point to Grims Island, Oreg. and Wash.
440. Tybee Roads, Savannah River, and Wassaw Sound, Ga.
1109. Cape May to Cape Hatteras.
571. Port Royal Sound and inland passages, S. C.
352. Providence Harbor, R. I.
8340. Sitka Sound, Alaska.
6122. Nehalem River, Oreg.
369[4]. Hudson and East Rivers, from West Sixty-seventh Street to Blackwells Island, N. Y. and N. J.
331. Newburyport Harbor, Mass.

CHAPTER II.

PROGRAM FOR THE CURRENT FISCAL YEAR IN THE WASHINGTON OFFICE.

CHIEF CLERK.

The program for this division will be, in addition to routine duties of the division, the completion of the renovation of the buildings occupied by the bureau, and the preparation and distribution of digests of geodetic work of the bureau for as many States of the Union as time permits.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY.

The program for office work in this division for 1923 includes—

(*a*) Further study of field work projects to include work that has been urged by shipping and commercial interests because of new activities, particularly in Alaska.

(*b*) Continued study of cost analysis of field work to determine wherein further economies can be effected.

(*c*) Preparation of plans for the execution of such oceanographic investigations as can be made by three vessels during their passage from the Atlantic to the Pacific coast and by one vessel bound from the Pacific to the Atlantic. The acquisition of three mine sweepers from the Navy has necessitated a redistribution of vessels for economic and other reasons, the mine sweepers going to the Pacific coast and one vessel, now on the Pacific coast but not entirely suitable for work there, coming to the Atlantic coast. A limited amount of physical oceanographic work can be accomplished by these four vessels while going to their several stations and without materially increasing the cost of the passages.

(*d*) Preparation of plans for reconditioning a third mine sweeper.

(*e*) Further study along the lines of standardization of surveying equipment and of improvement of equipment.

(*f*) Investigation of methods for fixing positions of vessels at sea beyond the limit of visibility of shore objects.

(*g*) Preparation and publication of United States Coast Pilot, Section C, Sandy Hook to Cape Henry, and the United States Coast Pilot of the Hawaiian Islands.

(*h*) Study and discussion of survey of the Mississippi River Delta by aerophotography. Correction of charts that include the Delta from information furnished by these photographs.

DIVISION OF GEODESY.

The program of office computations for the division of geodesy for 1923, by project, is as follows:

(*a*) Triangulation and traverse: Huntsville, Ala., to Memphis, Tenn.; Memphis-Little Rock-ninety-eighth meridian; El Reno, Okla.-Needles, Calif.; Pecos, Tex., to Colorado Springs, Colo.; Green Bay-Duluth; Louisiana; Maryland; in North Carolina, South Carolina, and Georgia; any special piece of work that may be requested.

(*b*) Levels: Rouses Point, N. Y., to Portland, Me.; Duluth-Green Bay, Wis.; Centralia-Cairo, Ill.; Anchorage-Fairbanks, Alaska.

(*c*) Astronomic: Azimuths, latitudes, and longitudes along the arcs of triangulation and lines of traverse given under (*a*).

(*d*) Gravity: Final computation of the gravity results for the stations determined during 1921; computation of gravity results and isostatic compensation for stations determined during 1922.

Publications.—Triangulation in North Carolina; Triangulation in Louisiana; Triangulation in Maryland; Triangulation, Memphis-Ninety-eighth Meridian; Precise Leveling in Georgia; Instructions for Precise Leveling; Instructions for Precise Triangulations; Instructions for the Computation and Adjustment of Triangulation.

DIVISION OF CHARTS.

The program for 1923 calls for the production of 10 new charts, 3 topographic maps of the Virgin Islands, and the reconstruction of 13 existing charts. An important item of work to be undertaken by the drafting section during the year, but which has not been included in this program, is the reproduction of such original topographic and hydrographic sheets as, through age and constant use, are approaching the point of illegibility. They have passed beyond the stage when it is possible to reproduce them photographically, and so must be copied by our draftsmen.

DIVISION OF TERRESTRIAL MAGNETISM.

The program for the fiscal year ending June 30, 1923, is as follows: Reduction of observatory work—Complete Tucson 1919–1920. Complete Vieques 1919–1920 (all five observatories, 1921). Computation of field observations as received. Tabulation of earthquake records as received. Supplying information to surveyors and engineers. It is expected that the issue of additional digests of geodetic publications and the sending of the pamphlet Compass Surveys to county surveyors will result in an increasing number of requests for magnetic data, and that more time will be required to furnish the desired information than has been the case in past years. It is planned to start the issue of local isogonic charts. It is planned, in cooperation with the division of hydrography and topography, to establish a compass school for the instruction of the young officers of the bureau.

Measured by the unit of what an average computer can do in one day the routine work on hand on July 1, 1922, was as follows:

Observatory results:	Days.
Vieques 1919	12
1920	60
Tucson 1919	30
1920	50
Sitka 1919	5
1920	20
Five observatories, 1921	450
Five observatories, first half 1922	225
Total, July 1, 1922	852
Total, July 1, 1921	765
Increase in the year	87

The time spent on routine computations during the fiscal year 1922 was distributed as follows:

	Days.
Observatory results	435
Computation and revision work of J. T. Watkins	154
Computation of other field work	95
Earthquake tabulations	53
Total	737

New work accruing during fiscal year 1922:

	Days.
Observatory results	450
Field work	249
Earthquake tabulations	53
Total	752

DIVISION OF TIDES AND CURRENTS.

The program for this division for the year ending June 30, 1923, is as follows:

The tide tables for 1924 will be completed, scanned for the detection and removal of small errors, and submitted to the printer.

The current tables for 1924 will be completed and sent to the printer.

The sounding records received from the hydrographic parties will be checked as received, so that no delay will be occasioned to the chart division in the publication of charts.

Of the tidal records received, those upon which the determination of planes of reference depend will be computed immediately and the computation of the other records kept up to date as the force will allow.

The publication on the bench marks for the State of New York, now in the hands of the printer, will be issued early in the year.

A publication on the relation between winds and currents on the Pacific coast, together with an abridged publication of the same, written especially for the mariner, the manuscripts of both of which are almost completed, will be sent to the printer early in the year.

The manuscript of a publication on the harmonic analysis and prediction of tides will be completed during the year and sent to the printer, provided the time of the mathematician engaged on its preparation may be spared from the work absolutely necessary to the proper functioning of the division. The preparation of the remainder of this manuscript will require about three months of uninterrupted work by one mathematician.

The observations secured on the current and tidal survey of New York Harbor will be analyzed immediately upon their receipt from the field, the results discussed and interpreted, and a publication on this important piece of work prepared for early distribution to engineers and the interested public. In addition, the improvement to our current predictions made possible by this survey will be incorporated in the present current tables for the use of the mariner.

In general, the work of the division will be so arranged as to take up immediately the work upon which the publication of charts and the prosecution of the general field work of the bureau depend.

After that the energies of the division will be directed toward keeping its tabulations and computations up to date and to issuing in the form of publications the large mass of material that has accumulated in this division and which is of very great value to the navigator, the engineer, the scientist, and the public generally.

DIVISION OF ACCOUNTS.

The program for this division for the current fiscal year will be the performance of all the duties in connection with the division of accounts, including the disbursements of funds for the support of the survey and the financing of all chiefs of parties at work in the field, together with the verification of all other accounts arising under such advances.

INSTRUMENT SECTION.

The program for the ensuing fiscal year will be to continue to keep up the instrumental equipment, to improve the same in harmony with modern progress, to maintain the system of accounting for property belonging to the bureau, and to continue to improve the method of accounting in adjustment with necessity and convenience.

Part III.—IN THE FIELD.

CHAPTER I.

ACCOMPLISHMENTS IN THE FIELD DURING THE PAST FISCAL YEAR.

HYDROGRAPHIC WORK.

The following is a statement of vessels at the disposal of the U. S. Coast and Geodetic Survey at the beginning of the fiscal year: *Bache*, *Cosmos*, *Explorer*, *Fathomer*, *Hydrographer*, *Lydonia*, *Marinduque*, *Natoma*, *Pathfinder*, *Ranger*, *Surveyor*, *Wenonah*, and *Yukon;* total, 13. The steamers *Discoverer* and *Pioneer* were transferred to this service from the Navy Department on April 7, 1922, and during the remainder of the fiscal year were undergoing alterations to convert them to surveying vessels, having been built for mine-sweeping duty by the Navy.

The following is a brief statement of the assignment of vessels at the disposal of the U. S. Coast and Geodetic Survey within the fiscal year:

Bache.—On July 1 this vessel was engaged in the hydrographic survey at the entrance of Chesapeake Bay. The survey extended from close inshore to the 100-fathom curve. At the close of this work the *Bache* took up work in the Gulf of Mexico, extending the offshore work accomplished during the previous year by the steamer *Ranger* westward to the Delta of the Mississippi River. Completing this work the *Bache* proceeded to Norfolk and was undergoing repairs at the end of the fiscal year and taking on necessary supplies for continuing the hydrography in the vicinity of Chesapeake Bay entrance.

Cosmos.—Was operated by the party on the steamer *Surveyor*, and the work accomplished by this vessel is covered in the statement of the *Surveyor.*

Explorer.—On July 1 this vessel was engaged in combined operations in Stephens Passage and Lynn Canal, Southeast Alaska. These operations include precise triangulation, wire-drag work, magnetic work, topography, and inshore hydrography. The larger launches, *Helianthus* and *Scandinavia*, as well as the smaller launches which customarily make up the survey equipment of the vessel, were used in the execution of this work. The wire sweep which was developed during the preceding year was used for drag work and proved exceedingly efficient. Its use resulted in covering a greater area than would have been possible with a wire drag at a corresponding reduced unit cost. The field work was closed during the first part of October and the vessel returned to Seattle on October 22. While in Seattle the party was engaged in completing the survey records of the season's work, making necessary repairs to vessels and equipment, purchasing outfit, etc., for next season's work. On March 14 the vessel left Seattle to resume this work and was en-

gaged at the end of the fiscal year in continuing it through Lynn Canal westward through Cross Sound and Icy Straits to Cape Spencer.

Fathomer.—This vessel was employed in surveys in the Philippine Islands. On July 1 she was engaged in surveys in the vicinity of Cagayan Island. Later she was engaged in surveys in the southeast coast of Palawan Island and west coast of Zamboanga Peninsula, in which work she was engaged at the end of the fiscal year.

Hydrographer.—On July 1 this vessel was engaged in hydrographic work off the passes of the Mississippi River. This work, including the observation of triangulation, base measurement, and azimuth observation, in addition to hydrographic work to the 100-fathom curve, was completed the first part of June. The vessel was engaged in making an inshore hydrographic survey in the vicinity of Chandeleur Islands, Gulf of Mexico, at the end of the fiscal year.

Lydonia.—Was engaged in offshore work in the vicinity of Cape Mendocino, Calif., which work was completed as far north as Redding Rock. On May 24 headquarters were changed to Marshfield, Oreg., from which place as a base the survey of the Oregon coast line in the vicinity of Cape Blanco was accomplished during the remainder of the fiscal year. The survey in the vicinity of Cape Mendocino was much needed for the safe navigation of vessels on the Pacific coast. The work on which this vessel was engaged in the vicinity of Cape Blanco is also in an important area, as no hydrographic work has been previously accomplished in this locality.

Marinduque.—This vessel was employed the entire year in surveys in the Philippine Islands. On July 1 the vessel was engaged in combined operations in the vicinity of Lagonoy Gulf. This work was completed on October 18. After completing this work and undergoing repairs in Manila this vessel took up work in the vicinity of Basilan Island, on which work it was engaged at the end of the fiscal year.

Natoma.—On July 1 the *Natoma* was undergoing repairs at San Francisco. A detached party made a resurvey of Los Angeles Harbor while these repairs were being made. On August 18 a resurvey of San Pedro Bay was commenced, and a special survey of Tomales Bay was also made by a detached party. The latter work was completed during the latter part of September. The work in San Pedro Bay, including Carquinez Strait, was completed during the latter part of May. The vessel was undergoing repairs at San Francisco during the entire month of June, and these repairs were in progress at the end of the fiscal year.

Pathfinder.—This vessel was engaged during the entire year in surveys in the Philippine Islands. At the beginning of the fiscal year this vessel was engaged in the continuance of offshore hydrography from Polillo Island group to Catanduanes Island. An extensive bank, with depths of 30 to 40 fathoms, extending 30 to 50 miles offshore, was developed. Beyond this bank sounding lines were extended to the 1,000-fathom curve. An uncharted rock in Lamit Bay was located, and offshore hydrography was executed between Catanduanes and Samar Islands, the approach to San Bernardino Straits. This work was completed on October 10, and the *Pathfinder* arrived at Manila October 14 for annual repairs. During the latter

part of October a special wire-drag survey was made in the vicinity of Corregidor Islands. A short season was spent in triangulation between Basilan and Jolo Islands. During the first part of April general survey operations were taken up on the west coast of Palawan Island, and this work was in progress at the end of the fiscal year.

Ranger.—At the beginning of the fiscal year this vessel was en route from Key West, Fla., to San Juan, P. R., having in convoy the two wire-drag launches *Marindin* and *Mitchell*. The *Ranger* and convoy arrived at San Juan July 5. During the remainder of the fiscal year the *Ranger* was engaged in wire-drag operations in Porto Rican waters. In addition to the regular boat equipment of the vessel the launches *Mitchell* and *Marindin* were assigned to this party for wire-drag work. In addition to wire-drag operations additional soundings have been taken where needed to supplement the work previously accomplished.

Surveyor.—This vessel was employed at the beginning of the fiscal year on general survey of the outside coast of southeast Alaska, in the vicinity of Noyes Island. The hydrography extended from the beach to the 1,000-fathom curve, the topography of the islands being accomplished, and the necessary triangulation for control being executed. This work continued until November 3. After completing the necessary repairs and procuring outfit the vessel left Seattle on January 7, 1922, and was engaged until March 22 in making current observations along the outside coasts of Oregon and Washington. On April 22 this vessel arrived on the working grounds in southeast Alaska and was engaged from that date until the end of the fiscal year in continuing north the surveys of the outside coast accomplished during 1921.

Wenonah.—This vessel was engaged at the beginning of the fiscal year in combined operations in Clarence Strait, which was continued until the middle of October. On October 24 the vessel arrived in Seattle, annual repairs were made, and the field records of the previous season's work completed and forwarded to the office. On March 16 the vessel left Seattle and on March 22 arrived in Ketchikan, and combined operations were commenced in Clarence Strait and Ernest Sound. In addition to the hydrographic and topographic work a section of an arc of precise triangulation is being accomplished.

Yukon.—Was not operated during this year.

The following launches were operated independent of vessels during the fiscal year:

Mikawe and *Elsie.*—These two cruising launches, with two open power boats, were used by a double hydrographic party in resurveying the coast of South Carolina from St. Helena Sound to Bull Bay. The survey was carried offshore to a junction with ship hydrography recently completed on this coast, generally to a depth of 3 fathoms, and into the important inlets to a distance of at least 1 mile or to a point where the present depths agree with those obtained by earlier surveys. Shore-line revision surveys were made wherever changes had taken place since the last previous survey, and a revision hydrographic survey was also made of Charleston Harbor. Work was suspended on November 5, and both launches were hauled out for the winter. Since June 5, 1922, the *Mikawe* has been in use with a

Coast Pilot party which is revising Section C, Sandy Hook to Cape Henry, of the United States Coast Pilot. Launch *Elsie* was turned over to the division of tides and currents for use in connection with the current survey of New York Harbor.

Wildcat.—Party on the *Wildcat* was engaged in making a complete survey of Icy Bay, southwest Alaska, from May 22 to the end of the fiscal year, at which time the work was still in progress. The *Wildcat* left Seattle on April 25, it having been thoroughly repaired during the winter. Icy Bay is a small indentation in the outside coast line between Yakutat Bay and Cape St. Elias and is of commercial importance, as oil has been reported in this vicinity. If a survey develops that Icy Bay is a practical harbor, it would be the logical place to load this oil. There is a great demand for this survey.

Dora.—A shore party working on the chartered launch *Dora* made a survey of the bar at the entrance to Willipa Bay and of the bay as far east as the dredged cut leading to the cities of South Bend and Raymond. This work was commenced the latter part of January and was completed on June 15. The depths of the bar at the entrance to Willipa Bay are continuously changing, and the party erected signals of a permanent character which will be used in the future for making a resurvey of this bar at frequent intervals, so that the charts may be kept up to date.

Shore party.—A detailed survey was made in the vicinity of Cape Hatteras Lighthouse, N. C., at the request of the Lighthouse Service. This work was accomplished during the latter part of August. A survey was made to determine the extent of the erosion of the ocean beach front and includes the shore line three-quarters of a mile above the light, as well as a detailed hydrographic examination of the water area from the shore line to the 3-fathom curve.

Aerial Surveying (1922).—The aerial survey of the Mississippi River delta was completed by the Naval Air Service in April and May, 1922, 530 square miles having been photographed in the 16 days when photography was possible, covering a marshy area that would require many months of arduous labor to survey by the ordinary ground methods. A preliminary study of the photographs indicates that favorable results should be expected from the office reduction. It also indicates that this project will be a strong argument in favor of an extensive program of aerial mapping along our coast line.

As in past years, this bureau has been ready to cooperate to the limit in aerial surveying, but the Air Service of the Army and the Navy have been hampered by either lack of funds, equipment, or personnel, necessitating a curtailed program. It is hoped that this new branch of applied science will receive its proper support in the near future, and that its importance as an accurate, rapid, and economical method of surveying and that its value as a training school for the personnel of the air forces will be recognized.

SHIP AND LAUNCH HYDROGRAPHY PERFORMED DURING THE FISCAL YEAR.

Ship hydrography:	Area, square miles.
Chesapeake Bay approach	1,590
Vicinity of Gulf of Mexico, Mississippi River approach and offshore	848
Porto Rico	38

	Area, square miles.
Ship hydrography—Continued.	
California—	
Cape Mendocino (offshore)	2,538
Trinidad Head (offshore)	8
Trinidad Head to Reading Rock (offshore)	772
San Pablo Bay	110
Tomales Bay	15
Los Angeles Bay	5
Southeast Alaska (outside coast near Noyes Island)	2,764
Clarence Straits and Earnest Sound	322
Stephens Passage and Lynn Canal	9
Philippine Islands	7,961
Total	16,980
Wire-drag surveys:	
Porto Rico	233
Stephens Passage and Lynn Canal	396
Total	629
Launch hydrography:	
North Carolina coast	70
South Carolina coast	201
Willapa Bay, Wash	42
Icy Bay, Alaska	8
Total	321

Topography.	Shore line, miles.	Area, square miles.
hesapeake Bay approach	16	.....
North Carolina	6	2
South Carolina	166	40
Mississippi	99	15
California—		
Cape Mendocino offshore	19	.....
San Pablo Bay	56	138
Tomales Bay	12	8
Clarence Straits and Ernest Sound	317	196
Stephens Passage and Lynn Canal	230	168
Icy Bay	19	10
Willapa Bay, Wash	22	16
Porto Rico	2	1
Philippine Islands	469	992
Total	1,433	1,586

GEODETIC WORK.

	Length of scheme.	Area covered.
Triangulation, precise:		
Oklahoma, Texas, and New Mexico, ninety-ninth meridian to Albuquerque, N. Mex. (El Reno-Needles arc)	*Miles.* 450	*Sq. miles.* 10,970
Washington, Seattle to Canada (Tacoma-Canada arc)	75	550
Texas and New Mexico, Pecos, Tex. to thirty-fifth parallel (Pecos-Colorado Springs arc)	300	7,000
Idaho, Pocatello to Montana boundary (Pocatello-Canada arc)	75	4,000
Alaska, Lynn Canal (1921)	15	55
Alaska, Clarence Strait (1921)	25	480
Alaska, Lynn Canal (1922)	20	100
Alaska, Clarence Strait (1922)	60	430
Alaska, Cook Inlet (Cook Inlet-Fairbanks arc)	5	25
Total	1,025	23,610
Triangulation, primary:		
Louisiana, Mississippi River Delta	30	200
Triangulation, secondary:		
New York, Amagansett radio compass station	7	9
New Jersey, Sandy Hook radio compass station	1	

GEODETIC WORKS—Continued.

	Length of scheme.	Area covered.
	Miles.	*Sq. miles.*
Triangulation, secondary—Continued.		
District of Columbia, zero monument on Ellipse	1	1
District of Columbia and Virginia, Anacostia trial course	3	3
Virginia, Cape Charles	20	20
Virginia, Hog Island and Virginia Beach radio compass stations	1	1
North Carolina, Cape Hatteras	3	2
North Carolina, Poyners Hill radio compass station	5	20
South Carolina, Bull Bay, Price Inlet, and Charleston Harbor	25	60
South Carolina, Stono Inlet and Folly Island radio compass station	15	40
California, San Pablo Bay (1921)	15	105
California, Humboldt Bay	5	25
California, San Pablo Bay (1922)	20	60
Oregon, Coquilla River to Coos Bay	25	30
Washington, Ocean Park, and Port Angeles radio compass stations	10	5
Washington, Willapa Bay	10	35
Tennessee, vicinity of Knoxville	1	1
Porto Rico, northeast coast	5	20
Porto Rico, Vieques Sound	15	75
Alaska, Lynn Canal (1921)	35	150
Alaska, Lynn Canal (1922)	45	130
Alaska, Ernest Sound	5	5
Alaska, West Coast of Prince of Wales Island	50	720
Alaska, Icy Bay	10	65
Total	332	1,583
Traverse, precise:		
Wisconsin, Mountain to Duluth (Green Bay-Duluth line)	270	.....
Wisconsin, Ladysmith-Wisconsin Rapids line	100	.....
Total	370	.....
Base lines, precise:		
Washington, Alki base	2.0	.....
Washington, Admiralty Bay base	2.4	.....
Texas, Vega base	7.8	.....
Total	12.2	.....
Base lines, secondary:		
Louisiana, Quarantine base	3.7	.....
Alaska, Icy Bay base	1.1	.....
Total	4.8	.....
Reconnaissance:		
Wisconsin, Green Bay-Duluth precise traverse line	270	.....
Wisconsin, Ladysmith-Wisconsin Rapids precise traverse line	100	.....
Wisconsin and Minnesota, Wisconsin Rapids-Spring Valley precise traverse line	150	.....
Montana, Canadian boundary, one hundred and ninth meridian to one hundred and eleventh meridian	140	3,500
Minnesota, Canadian boundary, Lake of the Woods to Basswood Lake	230	1,400
Total	890	4,900
Recovering and remarking stations and revising descriptions:		
Illinois, Kansas, and Missouri, Thirty-ninth parallel	445	52,000
Georgia, Macon-Savannah, Savannah-Everett City, Brunswick-Columbus, Columbus-Albany-Valdosta precise traverse lines	700	.....
Total	1,145	52,000
Precise leveling lines:		
Green River, Utah, to Lees Ferry, Ariz	189	.....
Flagstaff to Lees Ferry, Ariz	176	.....
Portland, Oreg., to Wallula, Wash	211	.....
Bend to Prineville, Oreg	39	.....
Duluth, Minn., to Green Bay, Wis	81	.....
Rouses Point, N. Y., to Portland, Me	27	.....
Anchorage to Fairbanks, Alaska	161	.....
Total	884	.....
SUMMARY.		
Precise triangulation	1,025	23,610
Primary triangulation	30	200
Secondary triangulation	332	1,583
Precise traverse	370	.....
Precise base lines	12.2	.....
Secondary base lines	4.8	.....
Reconnaissance	890	4,900
Recovering and remarking stations and revising descriptions	1,145	52,000
Precise leveling lines	884	.....

In addition to the leveling listed in the above table, about 250 miles of single-line check levels were run in New York to locate small errors in certain precise level lines in the northern part of the State, and about 75 miles of flying levels were run in Kentucky to discover a meter blunder in a precise level line between West Point and Oakland. Numerous astronomic azimuths were determined in connection with the triangulation listed above. Other astronomic work done during the fiscal year includes 9 astronomic latitudes determined in Louisiana and Texas, 2 in Wisconsin, and 1 radio longitude determination in Wisconsin. The longitude mentioned is the first one to be determined by radio in the United States. It marks a great advance over all previous methods for longitude work.

Gravity determinations were made during the fiscal year at 10 stations in the general region of the Mississippi delta and at one station in Wisconsin. The new invar pendulums were used for the first time for this work and gave satisfactory results, although precautions had to be taken to control the magnetic effect. At several of the stations it would have been impossible to use the bronze pendulums on account of the lack of constant-temperature rooms and the impracticability of building them. For the gravity determination in Wisconsin, which was made in connection with the longitude work mentioned above, radio time signals were used for obtaining the rates of the gravity chronometers.

Geodetic Field Work Accomplished.—As usual, the field work consisted of the extension of the systems for precise horizontal and vertical control, the determination of the intensity of gravity, and geodetic astronomic observations. Outstanding features of the work done during the year are:

(1) The great arc of horizontal control which extends from Huntsville, Ala., to the vicinity of Phoenix, Ariz., by way of Memphis, Tenn.; Little Rock, Ark.; Albuquerque, N. Mex.; and Williams, Ariz., was completed. This arc is 1,600 miles in length, and may be considered as one of the great arcs of the world. It furnishes accurate geographic positions in seven States and crosses an area that has been very badly in need of horizontal control for surveys, maps, and other engineering work. This arc is unique in being a combination of precise triangulation and precise traverse. The latter extends from a point on the Mississippi River just west of Memphis, Tenn., through a very flat and heavily wooded area, to Little Rock, Ark. Traverse was substituted for triangulation on this portion of the arc because of the great expense which would have been involved in erecting high observation towers to elevate the lines of sight between stations above the high trees. It has been found that for comparatively short distances geographic positions can be determined by traverse with all the accuracy requisite for precise horizontal control.

(2) The arc which will extend from Pecos, Tex., northward through eastern New Mexico into Colorado, where a connection will be made with the transcontinental triangulation, was begun in the late winter of 1921–22. This arc will be completed before the final adjustment is made of that portion of the Huntsville-Phoenix arc (mentioned above) between the ninety-eighth meridian in Oklahoma and Phoenix, Ariz. A number of connections will be made with

monuments of State boundaries and several pieces of detached triangulation established by the U. S. Geological Survey for the immediate control of its topographic surveys will be coordinated. This arc and the one mentioned above are parts of the general plan for the extension of horizontal control to all areas of the United States.

(3) The officials of the U. S. Coast and Geodetic Survey and the Geodetic Survey of Canada have informally agreed to carry on certain cooperative work along the boundaries of Canada, the United States, and Alaska. A part of this work is the extension of an arc of precise triangulation along the forty-ninth parallel from the Lake of the Woods to the Pacific coast and along the international boundary from the Lake of the Woods eastward to the precise triangulation which has been extended a short distance westward from Lake Superior. A party of the U. S. Coast and Geodetic Survey began work along the forty-ninth parallel, working westward from the one hundred and ninth meridian, during the summer of 1921 and another party from this bureau began the extension of precise triangulation northward from Pocatello, Idaho, toward the Canadian boundary in the spring of 1922.

The work which the U. S. Coast and Geodetic Survey will do under this cooperative plan includes the triangulation from the one hundred and ninth meridian westward to the Pacific coast; the extension of the triangulation northward from Pocatello, Idaho, to the Canadian boundary; the extension of a short arc of triangulation from northeastern Oregon through the eastern part of the State of Washington to the Canadian boundary; and a short arc of triangulation and traverse between the Lake of the Woods and the triangulation of the Canadian Geodetic Survey, extending a short distance westward from Lake Superior. A reconnaissance for the last-mentioned arc was made in the summer of 1922.

The Canadian Geodetic Survey will do the triangulation from the one hundred and ninth meridian eastward to the Lake of the Woods. It is evident that the United States and Canada will each benefit by this cooperative work, for the triangulation will be available to each country for all classes of work needing precise horizontal control. Another advantage of this arc of precise triangulation along the boundary is that it makes possible the coordination of the surveys and maps of the two countries which join at the boundary, and each boundary monument will then have the same geographic position on the maps and in the publications of the two countries. This is one of the most important and extensive pieces of cooperative geodetic work in surveying and mapping between two countries of which there is record.

(4) Observations were continued during the summer of 1921 and the spring of 1922 along the arc of precise triangulation which will extend from Dixon Entrance to White Pass, southeast Alaska. It is expected that this arc will be completed during the fiscal year 1922–23. This arc is a part of a long arc of precise triangulation which will extend from Puget Sound, Wash., northward along the coast of Skagway, Alaska, and then down the Yukon River in northwestern Canada to a point where that river crosses the one hundred and forty-first meridian, the boundary between Canada and Alaska. The Canadian Geodetic Survey is cooperating with

the U. S. Coast and Geodetic Survey on this triangulation by doing the work between Puget Sound and Dixon Entrance and will in the near future begin work on that portion of the arc extending from White Pass to the crossing of the Yukon River and the one hundred and forty-first meridian. This is another piece of cooperative work between two nations which is of great importance to each of them. It will form the basis for the coordination of surveys and maps throughout a very large area.

(5) An event of great importance to Alaska was the beginning in the spring of 1922 of precise triangulation and precise leveling to the northward of Cooks Inlet, which will be carried northward toward Fairbanks. It is planned later to carry this control work eastward to join the triangulation extending from Puget Sound to the crossing of the Yukon and the Alaska-Canada boundary. For many years Government bureaus working in the interior of Alaska have been making demands on the Coast and Geodetic Survey for the establishment of precise triangulation and leveling in the areas in which they are working. These bureaus are the U. S. Geological Survey, the Forest Service, and the General Land Office. It is hoped that the work outlined above may be expedited to such an extent that the needs of these other Government organizations may be met in the near future.

(6) Late in the previous fiscal year a party of the U. S. Coast and Geodetic Survey began work at the northern end of a line of precise levels requested by the U. S. Geological Survey, extending from Green River, Utah, southward to the Grand Canyon of the Colorado, down that canyon to Lees Ferry, and thence southward to Flagstaff, Ariz. This work was in progress at the beginning of the fiscal year 1921–22, and shortly thereafter a second leveling party began operations at the southern end of the line, working northward. Many hardships were endured by the members of these two leveling parties while working in the canyon, and many difficulties incident to the peculiar character of the land had to be overcome. The line was successfully completed late in the fall of 1921, and the results of the observations, in the form of preliminary elevations, were furnished to the Geological Survey almost immediately.

(7) Successful tests were made during the preceding fiscal year with the new nickel steel (invar) gravity pendulums. These pendulums, made at this office, are practically free from errors resulting from variations of temperature during the observations. They were used in the determination of the intensity of gravity at 10 stations in Mississippi, Louisiana, and Texas in the fall of 1921 and proved to be most satisfactory. At a few of the stations the invar pendulums were compared directly with the bronze pendulums, and the results indicated that the invar pendulums gave as accurate results as the bronze. It was found that, on account of their low coefficient of expansion, the invar pendulums could be used in a tent. The variation in temperature inside the tent and in the pendulum case itself had little effect on the observed period of the pendulum. The coefficient of expansion of the nickel-steel alloy is only about one-fifteenth that of the bronze, and, therefore, a given change in temperature affects the period of the invar pendulum only one-fifteenth as much as it would that of the bronze pendulum. In addition to the determination of the intensity of gravity at the 10 stations mentioned

above, the astronomic latitude was observed by the same party at all but one of the stations. These latitude stations were connected with the triangulation along the coast and will be of value in investigations involving the shape and size of the earth and in the determination of the distribution of densities in the earth's crust. The results of the gravity determinations at the 10 stations mentioned indicated very clearly that the earth's crust is in isostatic equilibrium under the Mississippi Delta and contiguous areas. This is a very important fact, for some scientists have thought that the delta material is an extra load on the earth's crust.

(8) The appropriation for the Coast and Geodetic Survey for the fiscal year 1922–23 contained an item of $15,000 for carrying on geodetic work in the form of triangulation and leveling in regions subject to earthquakes. Just before the end of the fiscal year 1921–22 plans were made at the Washington office to repeat observations at a number of the old triangulation stations in California to determine whether there had been any horizontal movement of the ground since the earthquake of 1906. The triangulation party planned to take the field at the beginning of the fiscal year 1922–23. Appropriations should be made for geodetic work in active earthquake regions for at least several years to come in order to test thoroughly the theory that there is a creep of the upper material of the earth's crust prior to an earthquake. The Coast and Geodetic Survey is cooperating with a committee of scientists outside the Government service making an intensive study of earthquake phenomena and theories.

(9) Prior to the fiscal year 1921–22 the Bureau of Standards constructed an apparatus for the U. S. Coast and Geodetic Survey to be used in the determination of the differences of longitude. This apparatus was designed to record automatically time signals sent by radio from the Annapolis station. After a number of tests in Washington this apparatus was sent to the field in Wisconsin and at the end of the fiscal year was being used very successfully. It is hoped that later this apparatus may be used to record radio time signals from distant stations, thus making it possible to use it in the determination of differences of longitude in Alaska. A very severe test will be given the apparatus during the coming fiscal year. Other geodetic work accomplished during the fiscal year is as follows:

(1) The traverse line which was started at Green Bay, Wis., during the latter part of the previous fiscal year was extended to Duluth by way of Ladysmith and a spur was run from the latter place southward to Wisconsin Rapids. It is planned to continue this work in the future from Wisconsin Rapids to the Mississippi River and then westward across Minnesota to a junction with the ninety-eighth meridian triangulation.

(2) A line of precise levels was run along the Columbia River from Portland, Oreg., to Wallula, Wash. A line was also run from Bend, Oreg., northward to Prineville, Oreg.

(3) A small piece of precise leveling was done in Kentucky between Louisville and Oakland to check precise leveling which had been run between those two places in the previous fiscal year.

(4) Precise leveling was started in the spring of 1922 at Rouses Point, N. Y., and run eastward across the northern part of Vermont. Several connections were made to precise leveling of Canada. The line will be extended during the coming fiscal year to Portland, Me.

(5) A line of precise leveling was started in the spring of 1922 in Wisconsin along the same route followed by the traverse mentioned in paragraph 1.

(5*a*) A party of the survey was engaged during the summer and fall of 1921 in revising precise leveling which had previously been run in the State of New York and in connecting certain tidal bench marks along the Hudson River with bench marks of the precise level net of the country.

(6) Near the end of the fiscal year 1922 a party took the field in Kansas for the purpose of determining the intensity of gravity at a number of stations selected by the officials of the U. S. Geological Survey. This work is designed to throw light on certain geological problems.

(7) During the winter of 1921–22 a party was engaged on the revision of descriptions of bench marks and traverse stations in the State of Georgia and in stamping the adjusted elevations of the bench marks on the metal tablets. Similar work was done by another party in the State of Texas. The results of the precise leveling by the U. S. Coast and Geodetic Survey will be of much greater value to those who need elevations if the adjusted elevations are stamped on the bench marks. The results will also be of increased value if there are up-to-date descriptions of the bench marks to make them more readily recoverable.

(8) A party was engaged during the latter part of the fiscal year in re-marking and redescribing stations of the transcontinental triangulation in Missouri, Kansas, and Colorado. These stations were established more than 20 years ago, and at that time no metal tablets were inserted in the stones or blocks of concrete used in marking the stations. As a result the surface mark at some of these stations has been destroyed, thus making it difficult to recover the station. The party has been setting new surface marks where necessary and has been placing a metal tablet in each of the station marks on which is stamped the name of the station and the year in which it was established. New descriptions of the stations are being made wherever the old ones are no longer true or adequate.

Observations for the variation of latitude were continued at the station at Ukiah, Calif., throughout the fiscal year. Ukiah is one of the stations of the Neutral Geodetic Association, formerly the International Geodetic Association. The work was begun at this station more than 20 years ago and was paid for by funds provided by the International Geodetic Association until the beginning of the World War. Since then the station has been maintained with funds provided partly by Congress in appropriations made to the State Department, partly by the dues of the United States to the Reduced Geodetic Association, which were retained by the State Department, and partly by private research funds. The U. S. Coast and Geodetic Survey has had direct supervision over the station by authority of the geodetic associations, and the observations have been forwarded at the end of each month to Dr. H. G. van de Sande Bakhuyzen, secretary of the Neutral Geodetic Association.

A symposium on isostasy was held at the annual meeting of the Geological Society of America at Amherst College the last of December, 1921. The results of the investigations in the subject of isostasy or the equilibrium of the earth's crust made by the U. S. Coast and

Geodetic Survey formed the basis for most of the nine papers presented at the symposium. These papers will appear in a single number of the Proceedings of the Geological Society of America in the near future.

MAGNETIC WORK.

The reoccupation of repeat stations for bringing our secular change data up to date was given first consideration. From the beginning of the fiscal year to the end of September W. W. Merrymon, magnetic observer, occupied 25 stations in the northwestern part of the country. W. N. McFarland, computer, was assigned to field duty from July 1 to October 22 and occupied 25 stations from North Carolina to Oklahoma and back to Virginia. F. P. Ulrich, magnetic observer, between February 11 and April 21 occupied a series of 23 stations extending across the southern part of the country from South Carolina to Colorado and back to Indiana.

In compliance with the request of the Florida Engineering Society, Wallace M. Hill, magnetic observer, was assigned to the duty of establishing meridian lines and making magnetic observations in that State. Magnetic stations had previously been established at nearly every county seat, but many of them were found to be no longer available for the use of surveyors. Between February 11 and June 30 Mr. Hill occupied 25 stations in Florida and 1 in Georgia, 8 of them being repeat stations and 11 of them new stations in old localities, and established 17 meridian lines.

With the cooperation of the U. S. Coast Guard observations were secured at a number of places on the shores of Bering Sea and the Arctic Ocean. J. T. Watkins, hydrographic and geodetic engineer, joined the Coast Guard steamer *Bear* at Nome at the end of June, 1921, and established magnetic stations at Emma Harbor and Whalen, Siberia, and at Teller, Point Hope, Point Barrow, and Demarcation Point, Alaska. He also occupied two stations at Nome and two at St. Michael.

During the summer of 1921 declination observations were made with compass declinometer at a large number of stations in southeastern Alaska in connection with the triangulation, and the parties operating in that region in 1922 received instructions to continue the work.

Declination observations were made on the steamer *Explorer*, J. H. Hawley commanding, in Chilkat Inlet, Chilkoot Inlet, and Lynn Canal, which showed the presence of local disturbance and the need of additional observations.

MAGNETIC OBSERVATORIES.—The magnetic observatories at Vieques, P. R.; Cheltenham, Md.; Tucson, Ariz.; Sitka, Alaska; and near Honolulu, Hawaii, have been in operation throughout the year, and practically continuous records have been secured on the magnetographs and seismographs. The necessary absolute observations and scale-value determinations have also been made. The earth inductor at Tucson got out of adjustment during June and had to be sent to the office for overhauling.

Instruments used in magnetic survey work were standardized at Cheltenham, either before or after the season's work, or both. A magnetometer and dip circle to be used this summer at stations between Seattle, Wash., and Tucson, Ariz., were compared with

the Sitka Observatory instruments in June and will later be compared with the Tucson and Cheltenham instruments.

Extensive repairs were made to the office building at Vieques. At Honolulu the well was cleaned and the pump repaired, thus materially improving and increasing the water supply. Improvements were also made to the hands' quarters. At all of the observatories painting and repairing were done as needed to keep the buildings in good condition.

In addition to the routine observatory work various special investigations have been made as follows: H. E. McComb made a study of the Milne-Shaw seismograph under working conditions, remeasured the parts and redetermined the constants, and prepared a special report on the subject. In the course of his work a number of improvements to the instrument suggested themselves, and these were made so far as possible under existing conditions. He also prepared plans for a new seismograph house.

SUMMARY OF RESULTS.

State.	Localities.	Stations.	Old localities reoccupied.	Declination results.	Dip results.	Intensity results.
Alabama	2	2	2	2	2	2
Alaska	63	65	3	65	9	9
Arkansas	1	1	1	1	1	1
Colorado	1	2	1	2	2	2
Florida	25	27	18	27	27	27
Georgia	5	6	4	4	6	6
Idaho	3	3	3	3	3	3
Illinois	2	2	2	2	2	2
Indiana	2	2	2	2	2	2
Iowa	2	2	2	2	2	2
Kansas	3	3	3	3	3	3
Kentucky	2	2	2	2	2	2
Louisiana	1	1	1	1	1	1
Minnesota	3	3	3	3	3	3
Mississippi	2	2	2	2	2	2
Missouri	3	3	3	3	3	3
Montana	5	5	5	5	5	5
Nebraska	3	3	3	3	3	3
New Mexico	1	1	1	1	1	1
North Carolina	7	15	7	15	8	8
North Dakota	2	3	2	3	3	2
Oklahoma	3	3	3	3	3	3
Oregon	1	1	1	1	1	1
South Carolina	1	1	1	1	1	1
Tennessee	3	4	3	4	3	3
Texas	8	8	8	8	8	8
Virginia	3	3	3	3	3	3
Washington	2	2	2	2	2	2
Wisconsin	1	1	1	1	1	1
Wyoming	3	3	3	3	3	3
Siberia	2	2	0	2	2	1
Total	165	182	95	182	116	115

George Hartnell prepared papers on the Horizontal Intensity Variometer (now in the hands of the printer), The Physics of the Earth Inductor, Elementary Magnet, and Suspended Type of Vertical Intensity Variometer.

The year, as a whole, was quiet magnetically. Earthquakes were recorded as follows:

Porto Rico	22
Cheltenham	27
Tucson	32
Sitka	14
Honolulu	89

TIDE AND CURRENT WORK.

TIDAL OBSERVATIONS, PRINCIPAL STATIONS.—Automatic tide gauges were in operation throughout the year at the following stations:

1. Portland, Me.
2. Boston, Mass.*
3. Breakwater Harbor, Del.
4. Aberdeen Proving Grounds, Md.
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. Olympia, Wash.
13. Seattle, Wash.
14. Anacortes, Wash.
15. Ketchikan, Alaska.
16. Honolulu, Hawaii.

TIDAL OBSERVATIONS, SECONDARY STATIONS.—Tidal observations were made at the following stations during a part of the year:

1. New Bedford, Mass.
2. New York City, barge office.
3. Philadelphia, Pa.
4. Washington, D. C.
5. Assateague, Va.
6. Charleston, S. C.
7. Lighthouse Inlet, S. C.
8. Chandeleur Light, La.
9. Burrwood, La.
10. Southwest Pass, La.
11. San Juan, P. R.
12. Fajardo, P. R.
13. Bay Farm, Calif.
14. Eureka, Calif.
15. Toke Point, Wash.
16. Bay Center, Wash.
17. Port Angeles, Wash.
18. Menefee Anchorage, Alaska.
19. Taku Harbor, Alaska.
20. Steamboat Bay, Alaska.
21. Portage Cove, Alaska.
22. Skagway, Alaska.
23. Point Johnson, Alaska.
24. Hidden Bay, Alaska.
25. Moira Sound, Alaska.
26. Gardiner Bay, Alaska.
27. Vallenar Bay, Alaska.
28. Skowl Arm, Alaska.
29. Juneau, Alaska.
30. William Henry Bay, Alaska.
31. Sullivan Island, Alaska.
32. Haines, Alaska.
33. Port Santa Cruz, Alaska.
34. Hobart Bay, Alaska.
35. Anchorage, Alaska.
36. Clover Bay, Alaska.
37. Kailna, Hawaii.
38. Kannakakai, Hawaii.

Automatic tide gauges were kept in operation throughout the year at 6 stations on the Atlantic coast, 3 stations on the Gulf coast, 4 stations on the Pacific coast, 1 station in Alaska, and 1 station in the Hawaiian Islands, a total of 16 years of records. In addition tidal observations in connection with hydrographic surveys were made at 15 stations in the United States, with a combined length of 3½ years; 2 stations in Porto Rico, with an aggregate length of 1½ years; 19 stations in Alaska, with a combined length of 2½ years; 2 stations in the Hawaiian Islands, with a combined length of one-half year; and 12 stations received from outside sources with a combined length of 4¾ years of record, making a grand total of 28¾ years of tidal records received. At the principal tidal stations the relation of tide staff to bench mark was verified with spirit levels, insuring accurate data for precise level net connections and also for the detection of emergence or subsidence of coast.

Standard tide staffs and backing pieces, an improvement inaugurated during the past year in connection with the observation of tides, eliminating a great deal of trouble heretofore experienced in maintaining a fixed relation between tide curve and zero of staff, were established at 7 principal tidal stations, making a total of 10 stations so equipped.

Current observations during the year were made on 9 light vessels on the Atlantic coast and on 5 light vessels on the Pacific coast. In addition short series of observations were made at 5 stations. The combined current observations total 6¾ years of record.

Another improvement worthy of mention here is the compact field automatic tide gauge, which was devised during the past year, constructed at this office, and is now being tested on the Potomac at Washington for minor improvements, which will make it a valuable surveying instrument. This new gauge, which is portable, will aid in securing better observations for use in connection with hydrographic surveys and obviate the necessity of maintaining one or more paid tide observers with each hydrographic party, thus securing increased accuracy at considerably decreased cost.

During the year current observations were made on the following vessels:

Light vessel.	State.	Station.	Time employed.	
			Years.	Months.
Pollock Rip Slue	Massachusetts	1		3
Nantucket Shoals	do	1	1	0
Scotland	New York	1		3
Ambrose Channel	do	1		4
Overfalls	Delaware	1		3
Diamond Shoals	North Carolina	1	1	0
Frying Pan Shoals	do	1		3
Charleston	South Carolina	1		5
Brunswick	Georgia	1		4
San Francisco	California	1		3
Blunts Reef	do	1	1	0
Columbia River	Oregon	1		5.0
Umatilla Reef	Washington	1		5.5
Swiftsure	do	1		5.5
Total		14	6	8

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

Locality.	Stations.	Time employed, months.
Southwest Pass, Mississippi River, La	1	0.1
Off Hecata Bank, Oreg	1	.3
Off Columbia River, Oreg	2	.5
Off Grays Harbor, Wash	1	.1
Fuca Strait Entrance, Wash	2	.2
Total	7	1.2

In the early part of the calendar year 1922 an important work on the currents on the Pacific coast was begun. The *Surveyor* between Alaskan seasons occupied four stations along the coasts of Washington and Oregon between light vessels in order that the current conditions on these long stretches may be correlated with the principal stations on these light vessels and furnished the mariner. A station was occupied in the Straits of Juan de Fuca, one near the 100-fathom curve off Grays Harbor, near the 100-fathom curve off Columbia River, and one on Hecata Bank, working southward; then working northward repeat observations were made at these stations. These observations furnished data for 2 days at the Strait of Fuca station and 14 days at the ocean stations. This program should be repeated during the next fiscal year on stations farther down the coast if funds permit, so that finally the whole coast will be covered.

CHAPTER II.

PRESENT CONDITION OF HYDROGRAPHIC, GEODETIC, MAGNETIC, AND TIDAL AND CURRENT SURVEYS.

HYDROGRAPHIC WORK.

It has been found convenient to arrange this work in the form of separate projects. These projects may be divided into two classes, as follows: (1) Unchangeable areas, (2) changeable areas which will require continuing operations for an indefinite period.

In the first class there are the offshore hydrography of the Atlantic and Pacific coasts; wire-drag work on the Atlantic, Gulf, and Pacific coasts, including Porto Rico and southeast Alaska; the first complete survey of certain sections of southern and western Alaska, which are of immediate commercial importance. No estimate is made of the Aleutian Islands west of Unalaska, most of the area in Bering Sea or Arctic Alaska, since their commercial development seems to belong to the distant future. For the offshore work we have planned to go seaward to a depth of 100 fathoms in the Atlantic Ocean and Gulf of Mexico and to a depth of 1,000 fathoms in the Pacific Ocean. When these ocean surveys have been accomplished in accordance with present standards, there will be no necessity for additional work inside of the 100-fathom depths on the Atlantic Ocean and Gulf of Mexico and the 1,000-fathom depths on the Pacific Ocean except in those places of comparatively shallow depths, such as Georges Bank, Nantucket Shoals, Diamond Shoals, and the shallow coastal waters which are subject to constant changes. Likewise, after the surveys of the designated sections of Alaska, the Hawaiian and Philippine waters have been completed, the only additional work that will be required in these areas will be such as may result from changes in localities of shallow depth, or where greatly increased commercial importance necessitates more detailed surveys of small bodies of water, or where changes have resulted from public works undertaken subsequent to the original survey, and work in the Bering Sea and Arctic Ocean.

The second class of work—chart revision and the resurvey of the bays and inside waters of the Atlantic and Pacific coasts of the United States and, to a lesser extent, of Alaska and the insular possessions—must be carried on indefinitely, just as we are to-day resurveying waters that have been adequately surveyed several times in the past. This is due to the fact that the forces of nature are continuously cutting out and building up along the entire shore where the formation is not solid rock, and also to the fact that the industrial development of the country is continuously changing both the waterways and shore line by dredging channels, filling in, constructing piers, and other works. In order that the charts may be kept up to

date and be of real service to the mariner, it is necessary that they be corrected from time to time to show these changes.

The oceanographic work which the bureau should carry on can not be treated as a project on which any time limit for completion can be given. At the present time there is an urgent need for the detail of one able vessel on this work on the Atlantic coast, for the exploration of the Gulf Stream is one of the problems that was laid down in the organic act creating the Coast Survey. We have done very little work of this kind in the hundred and more years of the existence of the survey, and no work of any consequence has been done within the last 30 years.

These projects do not include all of the work that should be performed by the bureau in the line of hydrography and topography, but it is believed that they do include all the projects that should be undertaken at this time or in the near future, the other work to be deferred until the completion of some of these projects. After the completion of any of these projects the personnel and equipment that had been employed on the project will be available for other work.

This other work includes hydrographic investigations beyond the limits of the present projects and other special investigations. It is clearly the duty of this country to perform its share of ocean investigation, and there is a large field for such investigation in the Atlantic Ocean and Gulf of Mexico contiguous to our coast but outside of the 100-fathom contour. There is a like need for such work in the Pacific Ocean outside of the 1,000-fathom contour, which is comparatively close to our coast. There are fishing banks seaward of the 1,000-fathom contour in the Pacific Ocean that should be investigated for the benefit of our fisheries. There is a stretch of unexplored water extending hundreds of miles west of the Hawaiian group through which our ships are required to pass. These waters are known to contain many shoals, reefs, and rocks that are a menace to navigation. The survey of these waters, together with resurveys of the shallow changeable offshore waters, would fully employ any equipment and personnel that would be released on the completion of any of the projects which require similar equipment.

Wire Drag, Atlantic and Gulf Coasts.—Area to be dragged, 5,000 square miles (3,000 square miles of this area is on the coast of Maine and includes much deep water). Owing to lack of appropriations it has been impossible to do any work on this project during the last fiscal year.

Atlantic and Gulf Coasts.—Area of offshore work required, 166,000 square miles.

Porto Rico and Virgin Islands.—Area wire-drag work required, approximately 600 square miles, mostly in Vieques Sound. All harbors should be surveyed and coastal waters should be dragged.

Pacific Coast, California, Washington.—Area wire-drag work required, 1,360 square miles. No work has been done on this project, owing to lack of equipment and money.

California, Washington, Oregon.—Area offshore surveys, 67,800 square miles. This project is divided into the following three sections, owing to the different conditions existing in each:

San Diego to Point Conception.—Area, 21,000 square miles. No work has been accomplished during this fiscal year, but it is expected that work will be taken up there during next year.

POINT CONCEPTION TO CAPE BLANCO.—The area required to be covered is 18,300 square miles.

CAPE BLANCO TO PUGET SOUND.—The area required to be covered is 28,500 square miles. No work has been accomplished during this fiscal year and none is contemplated for the next year.

SOUTHEAST ALASKA.—There are approximately 6,500 square miles to be covered by wire drag.

DIXON ENTRANCE TO CAPE SPENCER.—On the outer coast the inshore and protected work to be covered has an area of 4,120 square miles, and the offshore work has an area of 9,230 square miles.

PACIFIC COAST OF ALASKA.—Cape Spencer to Attu Island. Incomplete hydrography area, 26,250 square miles. The surveys of a large part of this are sufficient for present navigational needs. For administrative purposes it should be considered in the same class as the changeable areas on the continental coasts of the United States. Additional surveys will be made in response to the demand, and the ideal arrangement would be to assign one or more parties each year to this class of work. No work under this project was undertaken during the present fiscal year, nor is any contemplated during the next.

Exploratory or unsurveyed area, 120,465 square miles. Of this area there are 40,000 square miles of immediate importance to navigation. This includes the stretch of coast from Prince William Sound to Unalaska Island. The party should be prepared to undertake all classes of surveys. The type of organization would be that of the *Surveyor* in 1920.

ALASKA, BERING SEA, AND ARCTIC OCEAN.—Area unsurveyed, 427,345 square miles. Most of this area is of such a distance from land that its survey is of no present navigational importance. The stretch of coast on the north side of the Alaskan Peninsula and extending from Unalaska Island to the mouth of the Kuskokwim River promises to be of increasing commercial importance due to the large fishing industries and the possibility of the discovery of gold-bearing sands, the characteristics of the shores of the Kuskokwim being similar to those found at Nome. No work was accomplished on this project during the present fiscal year nor is any contemplated during the next year.

HAWAIIAN ISLANDS.—The unsurveyed area is 10,280 square miles. Most of this area is deep water which could be done by a steamer of the *Discoverer* and *Pioneer* type. The hydrography of the bays and close alongshore, as well as the topography, would be done by a detached party from the steamer living ashore and assigned a launch. This work is much needed, but owing to lack of appropriations it has been impossible to do any work on this project during the fiscal year nor is any contemplated during the next.

In the present and previous annual reports there are printed diagrams of the condition of field operations. These diagrams are intended to show in a graphic manner where our surveys are at present adequate, or where surveys are needed, and the type of survey required to make our charts up to date and thoroughly reliable for safe navigation.

To facilitate reference to the text and to the locality, diagrams are inserted showing the important steamer courses, the courses being numbered to correspond to the paragraphs of descriptive matter.

Using these sketches as base maps, I have endeavored to show the progress that has been made in the hydrographic and topographic work, using the same sequence in numbering the courses and descriptive matter pertaining thereto.

A detailed analysis of the conditions and the progress of the work can not be given in this limited space, but there are shown on the base maps the areas covered during the past year.

1. Deep-Draft Alongshore 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. The thoroughfares affording an exit to the Bay of Fundy from Passamaquoddy Bay and St. Croix River have been wire dragged; also an area 15 miles in length between Machias Seal Islands and Petit Manan Island. There is still remaining a large area as yet untouched by the wire drag. There are a number of towns along this course that depend on waterborne traffic for shipping out their produce and receiving their supplies. The commerce consists of lumber, fish, fuel, and miscellaneous merchandise, constituting the supply of the smaller and larger fashionable 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 that now endanger the safety of commerce over this course. (See Fig. 6, opposite p. 66.)

2. Frenchmans 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, Southwest Harbor, Northeast Harbor, and many small villages and naval coaling stations on the north side of Eastern Bay. The bay is frequented by many passenger steamers, yachts, small craft, fishing vessels, and a few cargo vessels. This area has been dragged to a line extending westward from Schoodic Island whistle buoy, 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. 6, opposite p. 66.)

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 in particular most likely to be obstructed by pinnacle rocks of the extension of narrow ridges out into the channel. The only part of these channels which has been dragged lies between Bluehill Bay and the western entrance of Penobscot Bay. The results obtained have been so startling that they clearly indicate dangers in the use of channels that have not been dragged. (See Fig. 6, opposite p. 66.)

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 steamers drawing about 10 feet, and many vessels trading to Bangor draw as much as 18 feet. Practically the entire river above Bangor is

used in lumbering. From the mouth of the river to Bangor there will be no positive certainty of the absence of all dangers to navigation until the area has been dragged. (See Fig. 6, opposite.)

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. 6, opposite.) 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 which was covered during the development of the wire-drag apparatus will later have to be dragged to a greater depth.

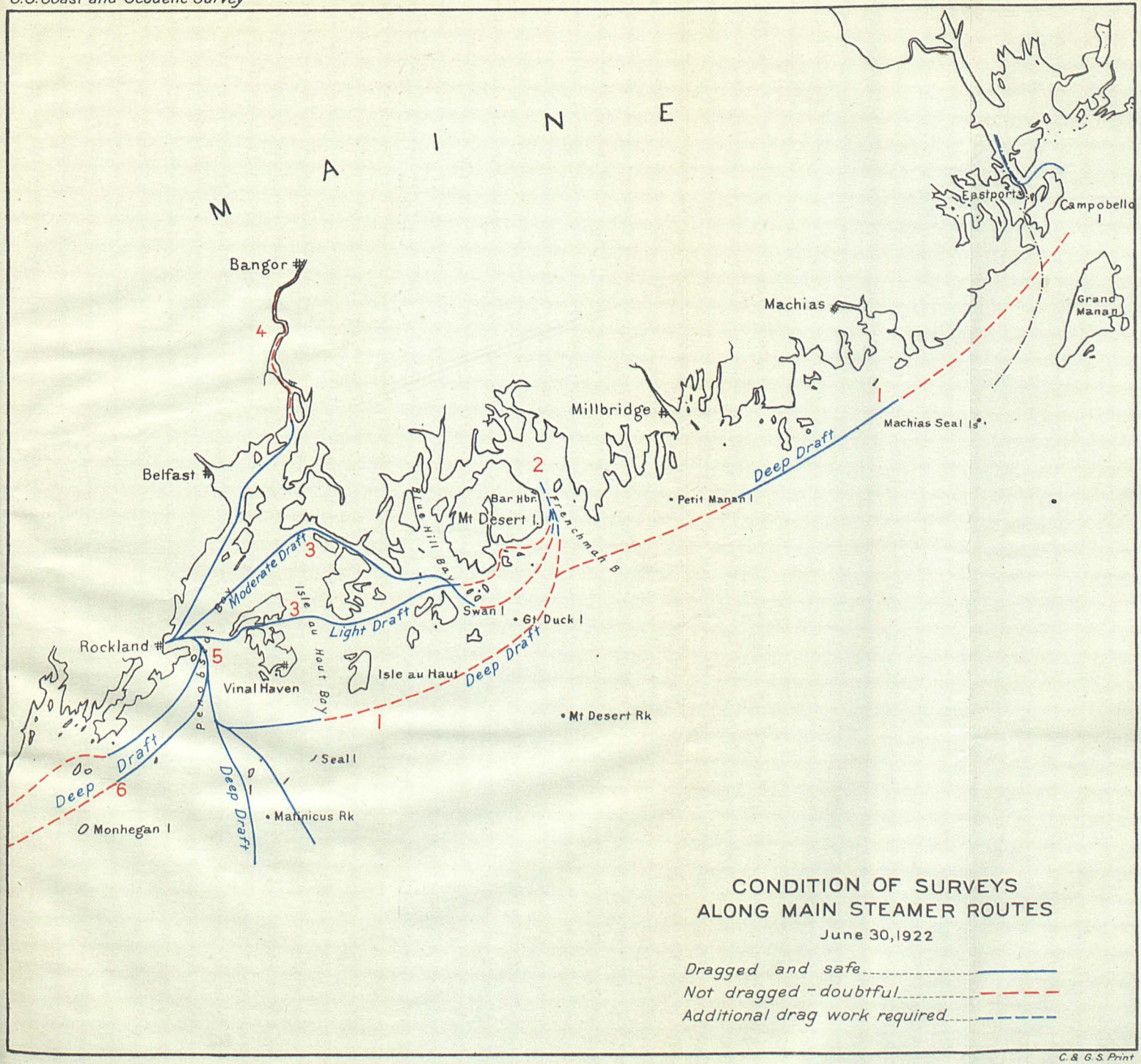
6. PENOBSCOT BAY TO CASCO BAY (DEEP DRAFT).—The coast of New England throughout its length presents practically one uniform problem to the hydrographic engineer. Surveys of varying degrees of completeness have been made of the entire area, and it is possible for navigators to select channels which are 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. 6, opposite.)

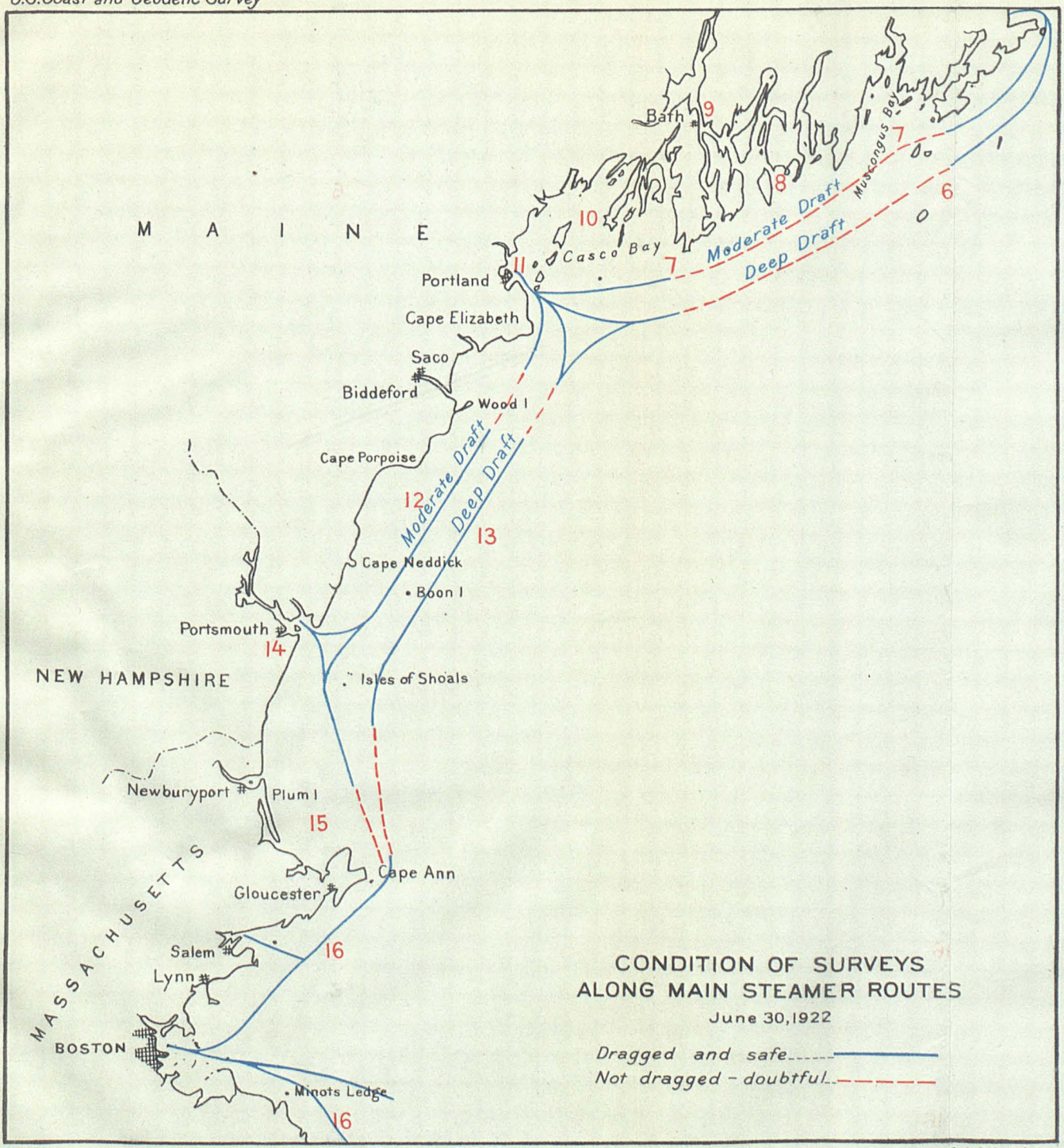
7. PENOBSCOT BAY TO CASCO BAY (MODERATE DRAFT).—From the western entrance of Penobscot Bay to Casco Bay there has been no wire-drag work done. The inside route is constantly used by coasting steamers, but it is certain that it has within its limits many uncharted rocks, some known locally and some unknown. (See Fig. 7, opposite.)

8. BOOTHBAY HARBOR.—This forms the approach to the town of Boothbay Harbor and numerous smaller summer resorts. It is frequented 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. 7, opposite.)

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 to Augusta. There is urgent need for a wire-drag survey of this river. (See Fig. 7, opposite.)

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 carrying the survey to the eastward and westward to a junction with completed work. A resurvey of inner Casco Bay is badly needed, the glaciers having left a series of long, narrow, and dangerous ledges, which require closer examination. (See Fig. 7, opposite p. 66.)


MAINE
Bangor
Belfast
Rockland
Vinal Haven
Isle au Haut
Swan I
Gt Duck I
Mt Desert I.
Bar Hbr.
Blue Hill Bay
Frenchman B
Millbridge
Machias
Machias Seal Is
Petit Manan I
Eastport
Campobello I
Grand Manan
Mt Desert Rk
Seal I
Mannicus Rk
Monhegan I
Penobscot Bay
Isle au Haut Bay
Moderate Draft
Light Draft
Deep Draft
1
2
3
4
5
6
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Dragged and safe
Not dragged - doubtful
Additional drag work required


MAINE
NEW HAMPSHIRE
MASSACHUSETTS
Bath
Casco Bay
Portland
Cape Elizabeth
Saco
Biddeford
Wood I
Cape Porpoise
Cape Neddick
Boon I
Portsmouth
Isles of Shoals
Newburyport
Plum I
Cape Ann
Gloucester
Salem
Lynn
BOSTON
Minots Ledge
Moderate Draft
Deep Draft
Muscongus Bay
6
7
8
9
10
11
12
13
14
15
16
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Dragged and safe
Not dragged - doubtful

11. PORTLAND HARBOR AND APPROACHES.—These have been dragged, and all dangers to navigation are shown on the charts. (See Fig. 7, opposite p. 66.)

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. There is a gap in the wire-drag surveys between Cape Porpoise and Cape Elizabeth which must be completed to make this portion safe. (See Fig. 7, opposite p. 66.)

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 well recognized. The area has been covered by the wire drag, which now forms a continuously dragged area from Cape Porpoise to within 10 miles of Cape Ann. (See Fig. 7, opposite p. 66.)

14. PORTSMOUTH HARBOR.—This area has been dragged, and all dangers to navigation are known. (See Fig. 7, opposite p. 66.)

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. 7, opposite p. 66.)

16. CAPE ANN TO CAPE COD CANAL.—A completely dragged area extends from Cape Ann to Cape Cod Canal and from the head of Buzzards Bay to Sakonnet Point, R. I. With the exception of the areas near the shores of Buzzards Bay this important survey is complete. This work was made especially necessary by the opening of the Cape 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. It was important not only to find those shoals of less than the proposed canal depth, but also those which might become a menace at some future date in case it should be 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. 7, opposite p. 66.)

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 requires frequent revision work. 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 part of this route is needed every few years to insure safety to navigation. No rocks occur 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. 8, opposite.)

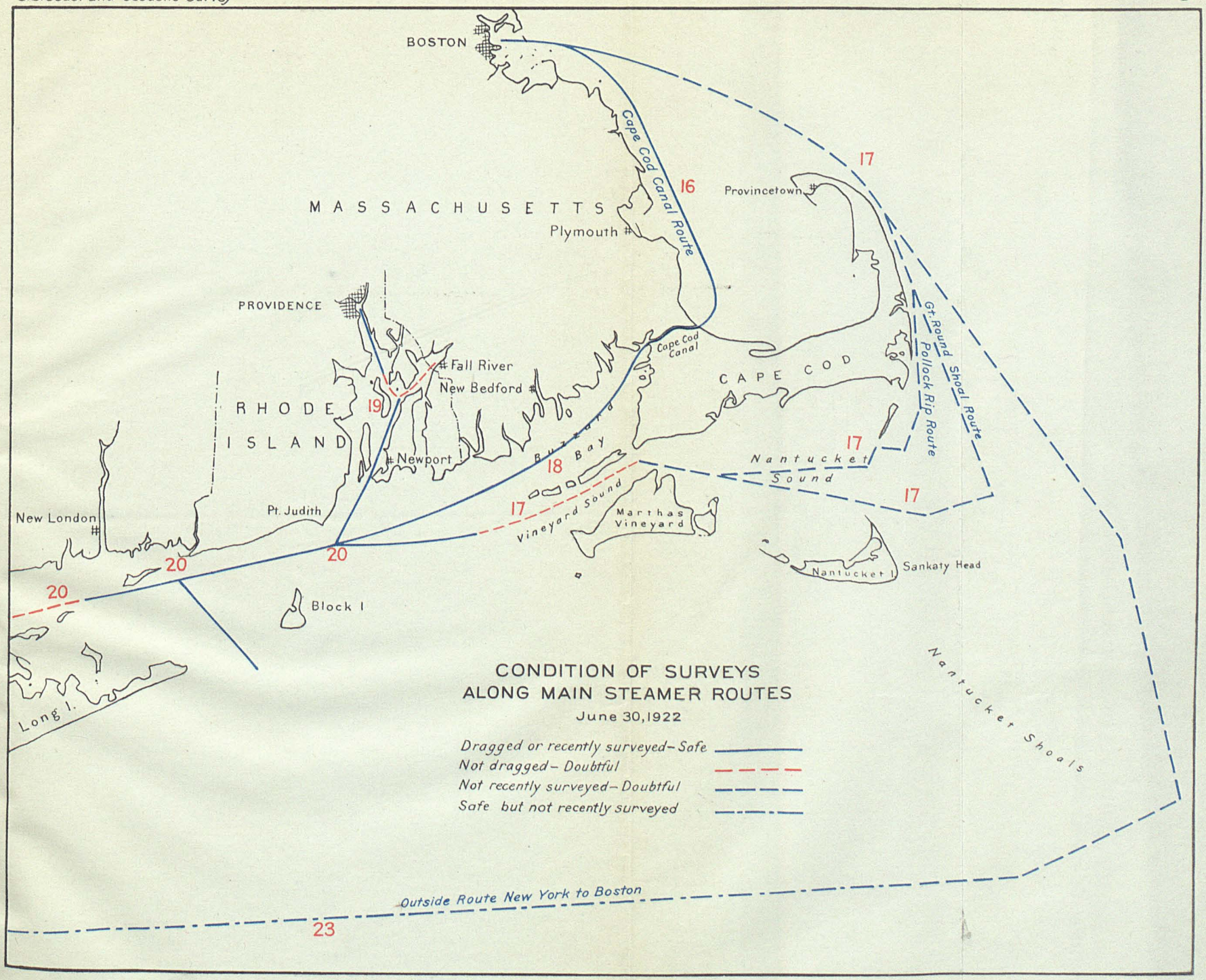
18. From Cape Cod Canal Through Buzzards Bay.—This route has been dragged out to the eastern limit of Long Island Sound. (See Fig. 8, opposite.)

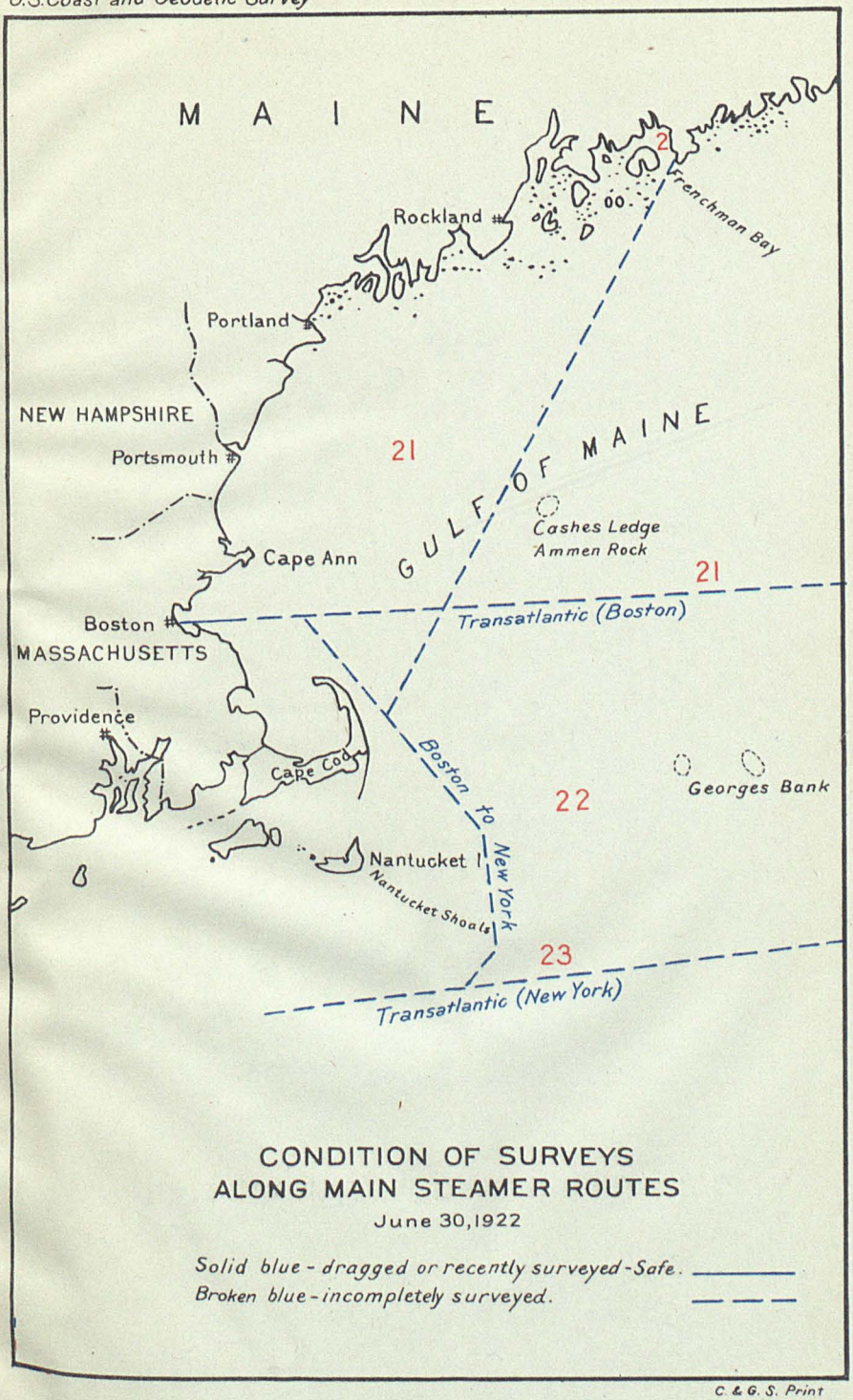
19. Narragansett Bay.—This area has been dragged with the exception of the thoroughfare leading through Mount Hope Bay to Fall River, and the small stretch to the north and east of Prudence Island. (See Fig. 8, opposite.)

20. Entrance to Narragansett Bay, Block Island Sound, Fishers Island Sound, and Eastern Part of Long Island Sound.—These areas are practically completed, with the exception of the central and western parts of Long Island Sound, which remain to be dragged. (See Fig. 8, opposite.)

21. Gulf of Maine.—The portion of the Gulf of Maine of which the 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 inadequately surveyed, as it was accomplished at an early date when both the appliances and the methods were far inferior to those of the present day. 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 Cashe 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 far out to sea and lasts for days, and 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. 9, opposite.)

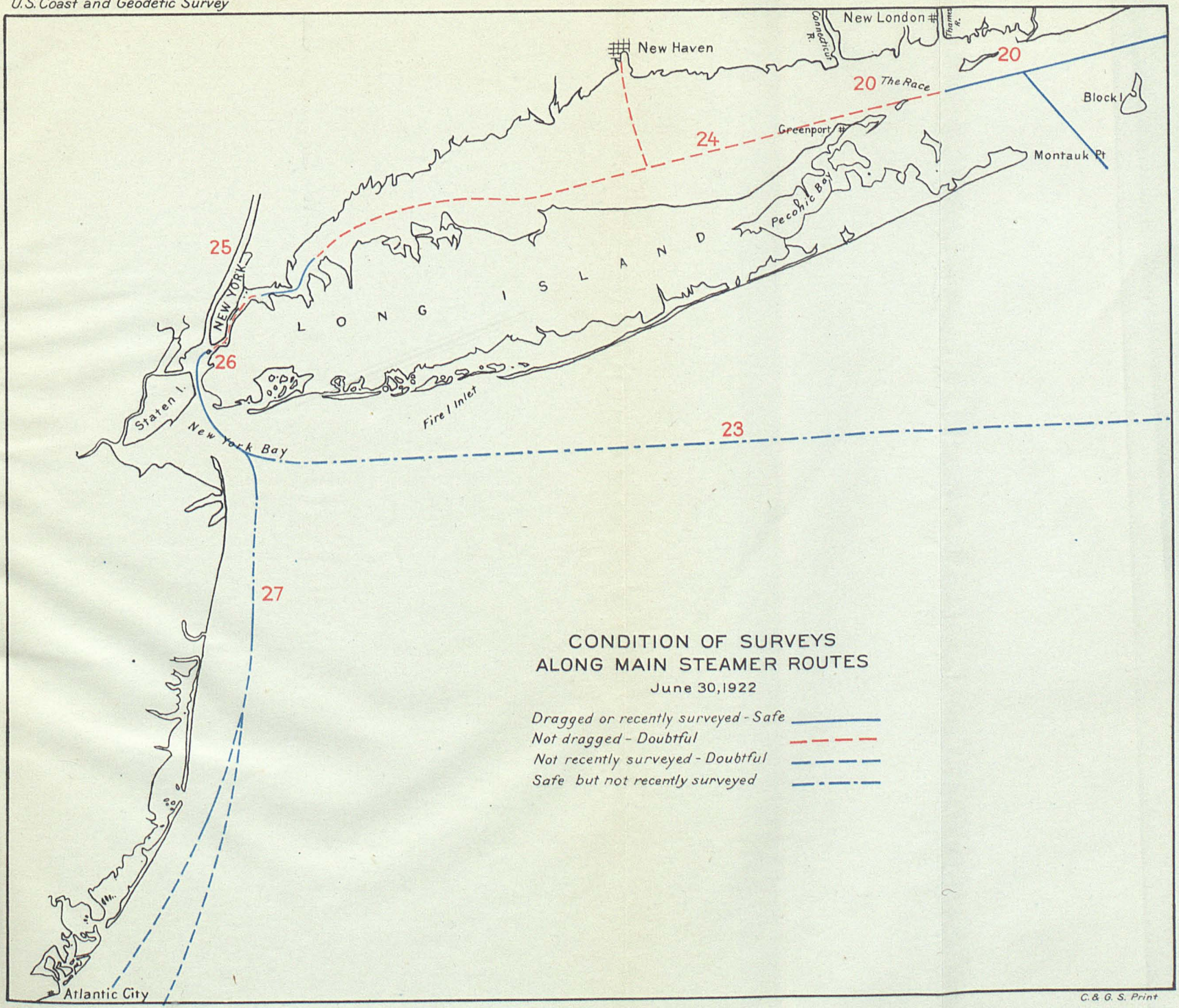
22. Nantucket Shoals to Georges Banks.—Extending eastward from Nantucket Sound there is an immense shoal area, consisting of sandy ridges which are shifted by the waves and currents. Nantucket Shoals extend about 50 miles offshore; then there is a deep channel followed by ridges. It is readily seen that 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. Due to the constant changes the existing surveys are nowhere adequate. The shoals


BOSTON
Cape Cod Canal Route
16
17
Provincetown
MASSACHUSETTS
Plymouth
PROVIDENCE
Fall River
New Bedford
Cape Cod Canal
CAPE COD
Gt. Round Shoal Route
Pollock Rip Route
RHODE ISLAND
19
Buzzards Bay
Newport
18
17
Nantucket Sound
17
17
Vineyard Sound
Martha's Vineyard
New London
Pt. Judith
20
20
20
Nantucket I.
Sankaty Head
Block I
Long I.
Nantucket Shoals
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Dragged or recently surveyed – Safe
Not dragged – Doubtful
Not recently surveyed – Doubtful
Safe but not recently surveyed
Outside Route New York to Boston
23



CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922

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.
Greenport
24
Montauk Pt
Peconic Bay
LONG ISLAND
25
NEW YORK
26
Staten I.
New York Bay
Fire I Inlet
23
27
Atlantic City
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Dragged or recently surveyed - Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed

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 ground, 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 furnished part of the food supply of the Nation. (See Fig. 9, opposite p. 68.)

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. 10, opposite p. 68.)

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. At present New York Harbor has but one exit to the sea for deep-draft vessels—by way of the Lower Bay and through Ambrose Channel over Sandy Hook Bar. The other exit—through Long Island Sound and Block Island Sound—is obstructed by ledges at Hell Gate, in the East River. The project to remove these and secure a depth of 40 feet is now in progress. Before it is completed channels of this depth in the sound should be examined with the drag to make certain they are safe. This would also apply to Fort Pound and approaches, if the proposed trans-Atlantic terminal is located at that place. 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 used extensively by motor boats, and the number in operation for a given area is probably greater than anywhere else in the United States. (See Fig. 10, opposite p. 68.)

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 parts of the Hudson should be dragged. (See Fig. 10, opposite p. 68.)

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. 10, opposite p. 68.)

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. A survey of this area in the vicinity of Cape Henlopen was made in 1920. The sounding lines were carried out to sea as far as the 100-fathom curve. (See Fig. 10, opposite p. 68.)

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. 11, opposite.)

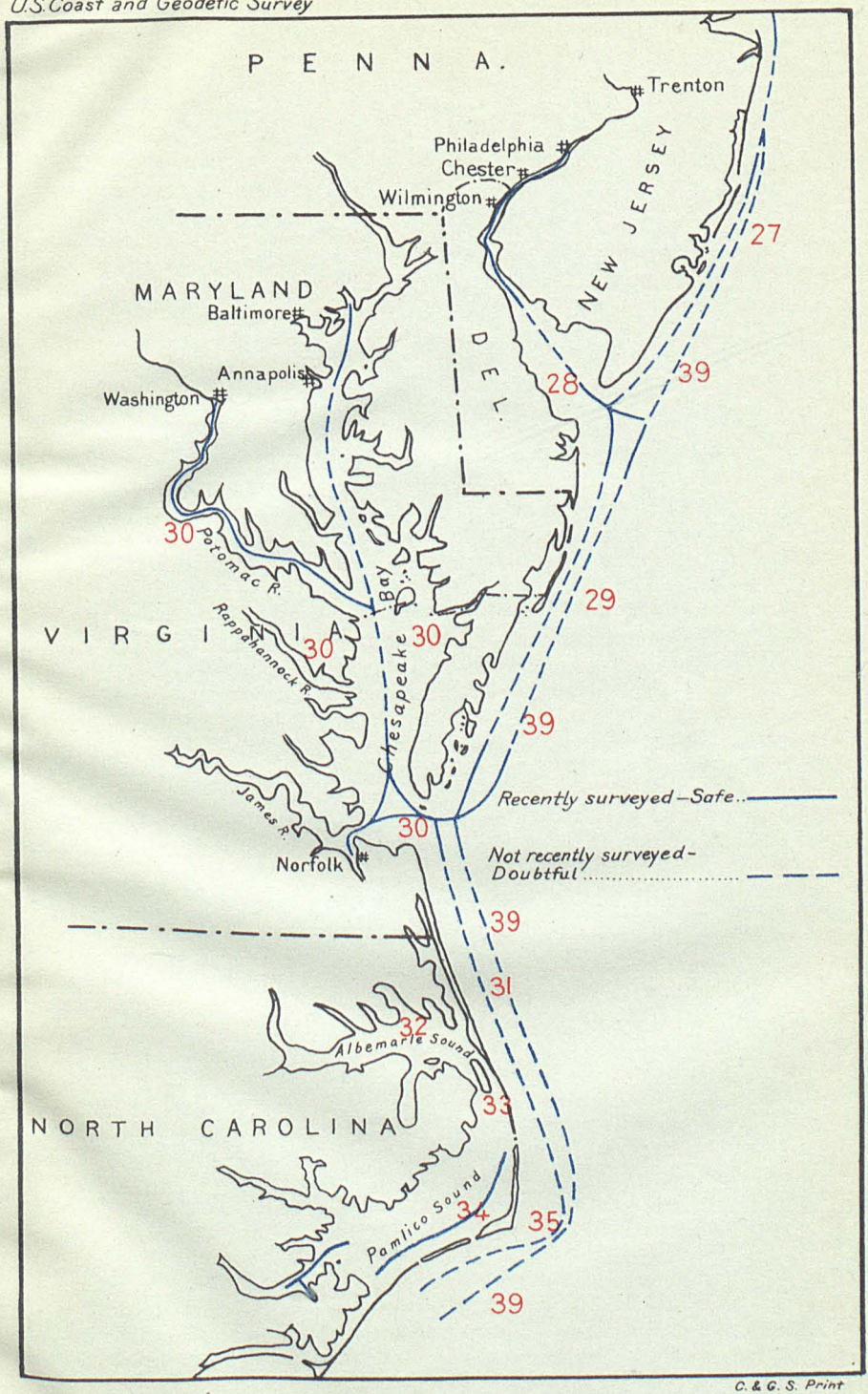
29. Delaware Bay Entance to Chesapeake Bay.—From Delaware Bay entrance to Chesapeake Bay there is a succession of shoals and banks. Many of these are buoyed so that moderate-draft vessels may pass inside of them. In certain regions it is of the highest importance that the survey should be correct and kept up to date. At only one place has a comprehensive survey been made, and this was the investigation of a reported shoal. Work in this section was performed during the fiscal year. The work extended north of Chesapeake Bay entrance.

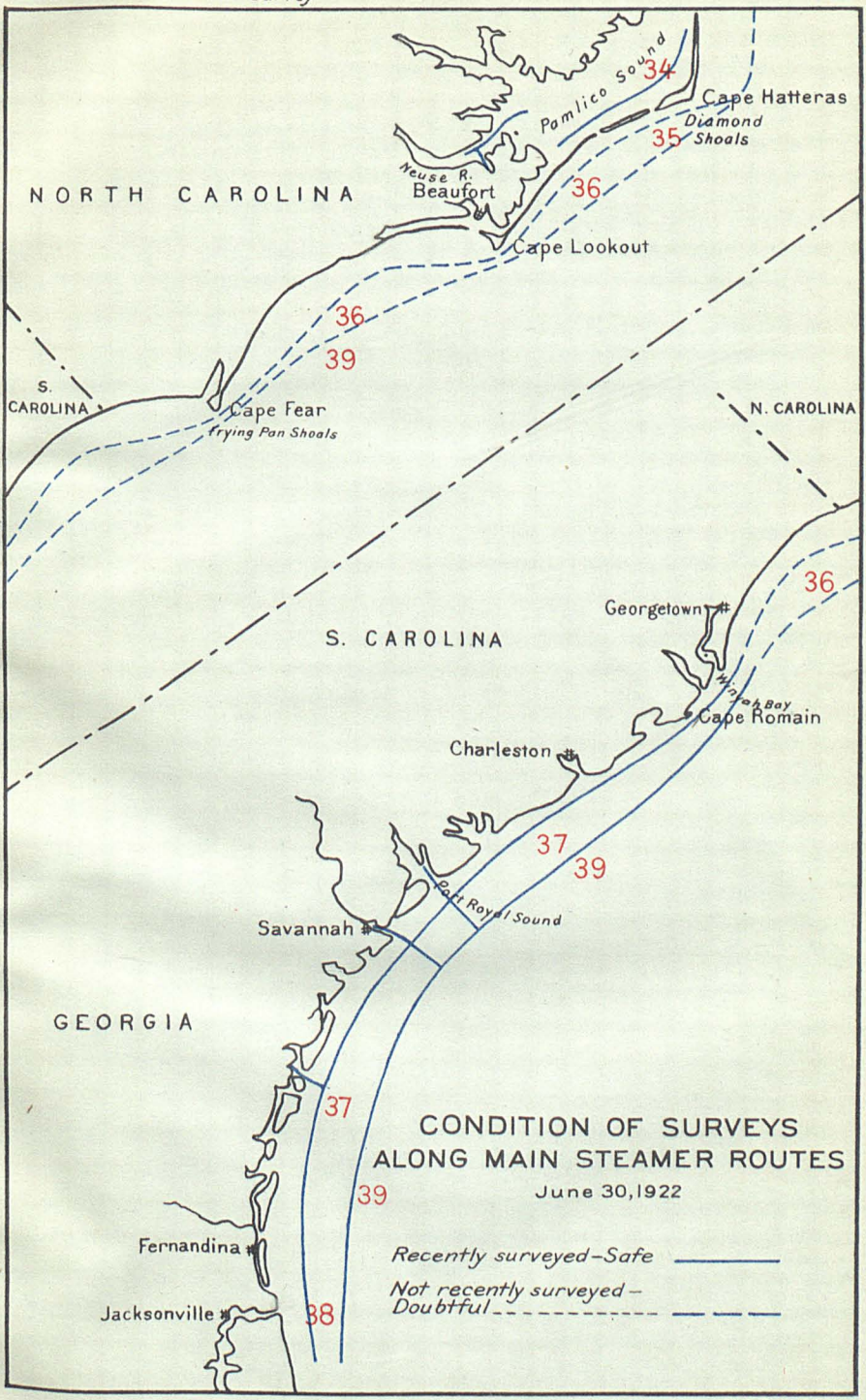
30. Chesapeake Bay and Tributaries.—These have been extensively surveyed in recent years, and a large number of tributaries will not require resurveys for many years. This is also true of the Potomac River. The parts which need resurveying are parts of the bay from Cape Charles to a point opposite Annapolis, 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. Owing to the shifting sandy bottom 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. 11, opposite.)

31. Chesapeake Bay Entrance to Cape Hatteras.—The diagram shows the tracks for both the light-draft and deep-draft vessels. A party is preparing to take up work just south of the entrance to Chesapeake Bay where shoals have been reported.

32. Albemarle Sound.—Albemarle 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 this sound, should also be finished, and then the surveys of this region would be in a most satisfactory up-to-date condition. (See Fig. 11, opposite.)

33. Croatan Sound.—Croatan Sound, connecting link between Albemarle and Pamlico Sound, has recently been resurveyed, but


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


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
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Recently surveyed–Safe
Not recently surveyed–Doubtful

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. 11, opposite p. 70.)

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, in addition to its local use as part of the through 10-foot channel, has not been completed. The survey was in progress up to October, 1920, when it had to be discontinued owing to the steamer proving unsuitable and too expensive to operate. (See Fig. 11, opposite p. 70.)

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. 11, opposite p. 70.)

36. CAPE HATTERAS TO WINYAH BAY, S. C.—Nearly the whole of this area is in need of a new survey, as those areas 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. 12, opposite p. 70.)

37. WINYAH BAY TO FERNANDINA, FLA.—This region has been recently surveyed, the work extending out to 100-fathom curve. The inshore limit did not include the water area inshore from the 3-fathom curve or the entrances to the harbors and inlets. Resurveys of this shoal water area have been in progress during the fiscal year. The topography of the immediate coast line has also been revised, the work extending from Bull Bay south to Savannah. The results show many changes of importance to small craft.

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 referred to in paragraph 37 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. 70.)

39. GENERAL, ATLANTIC, AND GULF COASTS.—An explanation of the method used in verifying the location of vessel by sounding when objects on shore are obscured by distance or thick weather 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 verifying the ship's 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.

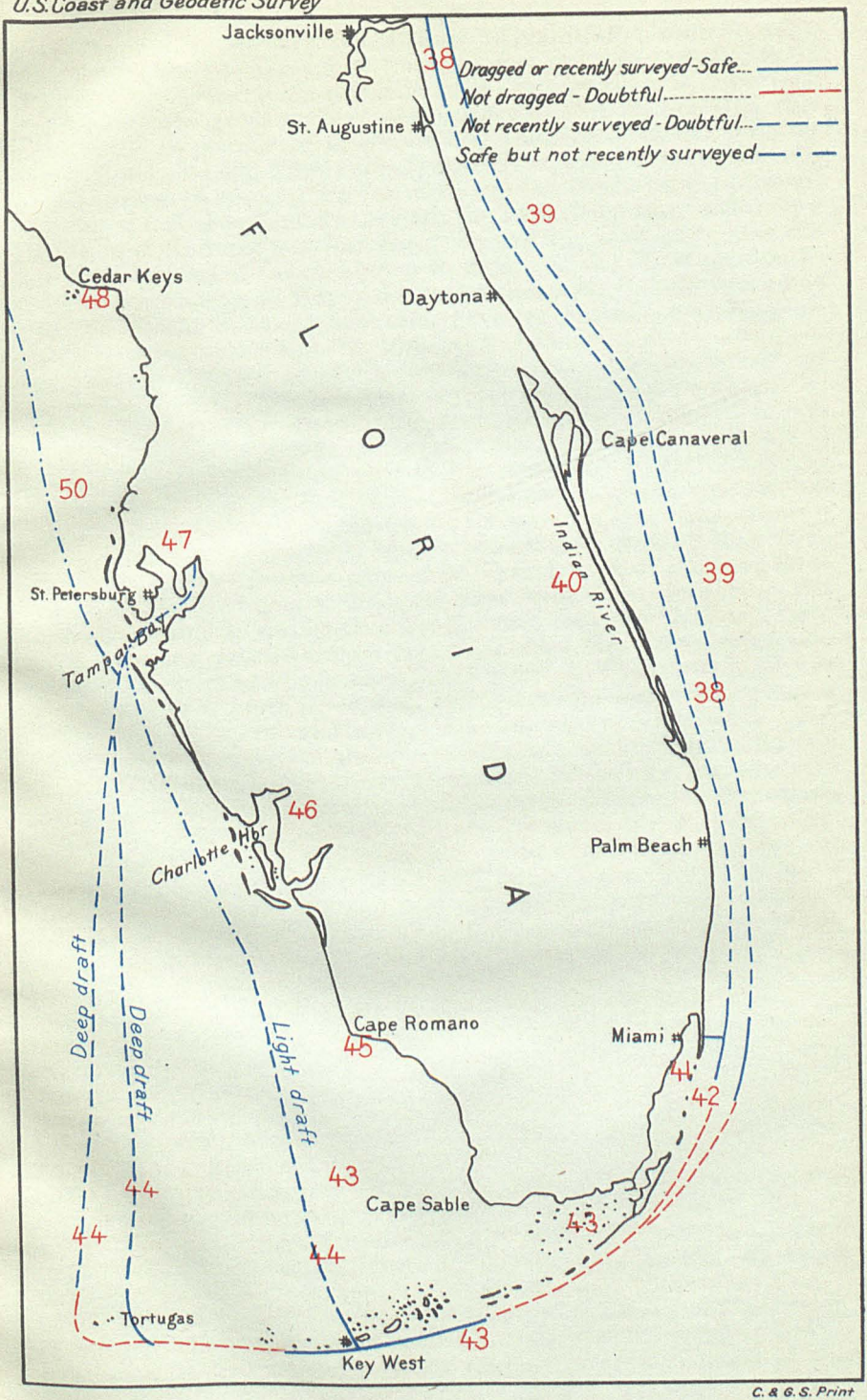
From New York to Cape Hatteras the charts, while fairly good, are by no means good enough to meet the full needs of navigation, but the work required to bring them up to date has been postponed, as the need for resurveys has been more urgent farther south. Up to a few years ago the offshore surveys from 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 season, and by working north in the summer and south in the winter the cost of the work will be greatly reduced. (See Fig. 12, opposite p. 70.)

40. Indian River.—There have been no recent surveys of these waters. Revisionary work is needed. (See Fig. 13, opposite.)

41. Biscayne Bay.—Recent surveys have been made of this area out to the 100-fathom curve in the vicinity of Miami and as far south as Fowey Rocks. (See Fig. 13, opposite.)

42. Vicinity of Fowey Rocks Light.—No recent surveys have been made. The present surveys are not sufficient in detail.

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, due to the fact that they are so numerous and that the region is so large, an effort has been made to first 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 the stream and close to the reefs the current is very weak. 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


Jacksonville
St. Augustine
Dragged or recently surveyed-Safe
Not dragged - Doubtful
Not recently surveyed - Doubtful
Safe but not recently surveyed
38
39
FLORIDA
Cedar Keys
48
Daytona
Cape Canaveral
50
47
St. Petersburg
Tampa Bay
Indian River
40
39
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

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 have 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. During 1920 a vessel was employed on surveys of the Florida reefs between the Marquesas Keys and Fowey Rocks. This includes supplementary surveys of the channels through the reefs from deep water into the inside route lying between the reefs and the mainland; also the close development of the shoal area westward of Key West and southward of the Marquesas Keys. In connection with this the work has been carried out to the 100-fathom curve for a distance of 50 miles along the reefs. (See Fig. 13, opposite p. 72.)

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 necessity of this is emphasized by the fact that the U. S. S. *Ellis*, while steaming northward of the Marquesas Keys, struck a coral head which proved to have only 7 feet over it. This coral head was directly out of a depth of 35 feet, with no indication of its existence until struck by the naval vessel, which was severely damaged. The channel between the keys and the reef known as the Hawk Channel is important for moderate-draft vessels. It will be necessary to drag the axis of the channel to insure against dangers to the vessels making use of it.

45. Cape Romano.—This area is in need of surveys. An inspection of the existing maps and charts of the State of Florida show practically a blank area for that part of the peninsula south of Lake Okechobee. There are but few areas of the United States of like size about which so little definite information can be obtained. Northward of this unknown region drainage canals are opening up the country for development. It is not unlikely the same means will be extended southward. At the present time the bureau should prepare to meet a demand in the near future for the delineation of a broader belt of country back of the shore from Cape Sable to Punta Rosa than is now shown on our charts. Tourists and land prospectors are now exploring this intricate system of island and waterways. (See Fig. 13, opposite p. 72.)

46. Charlotte Harbor.—No recent surveys have been made of this area, and it should be resurveyed. (See Fig. 13, opposite p. 72.)

47. Tampa Bay and Approach.—The existing surveys at present meet the needs of navigation of these waters. (See Fig. 13, opposite p. 72.)

48. Cedar Keys.—No recent surveys have been made of this region. Wire-drag surveys are badly needed. (See Fig. 13, opposite p. 72.)

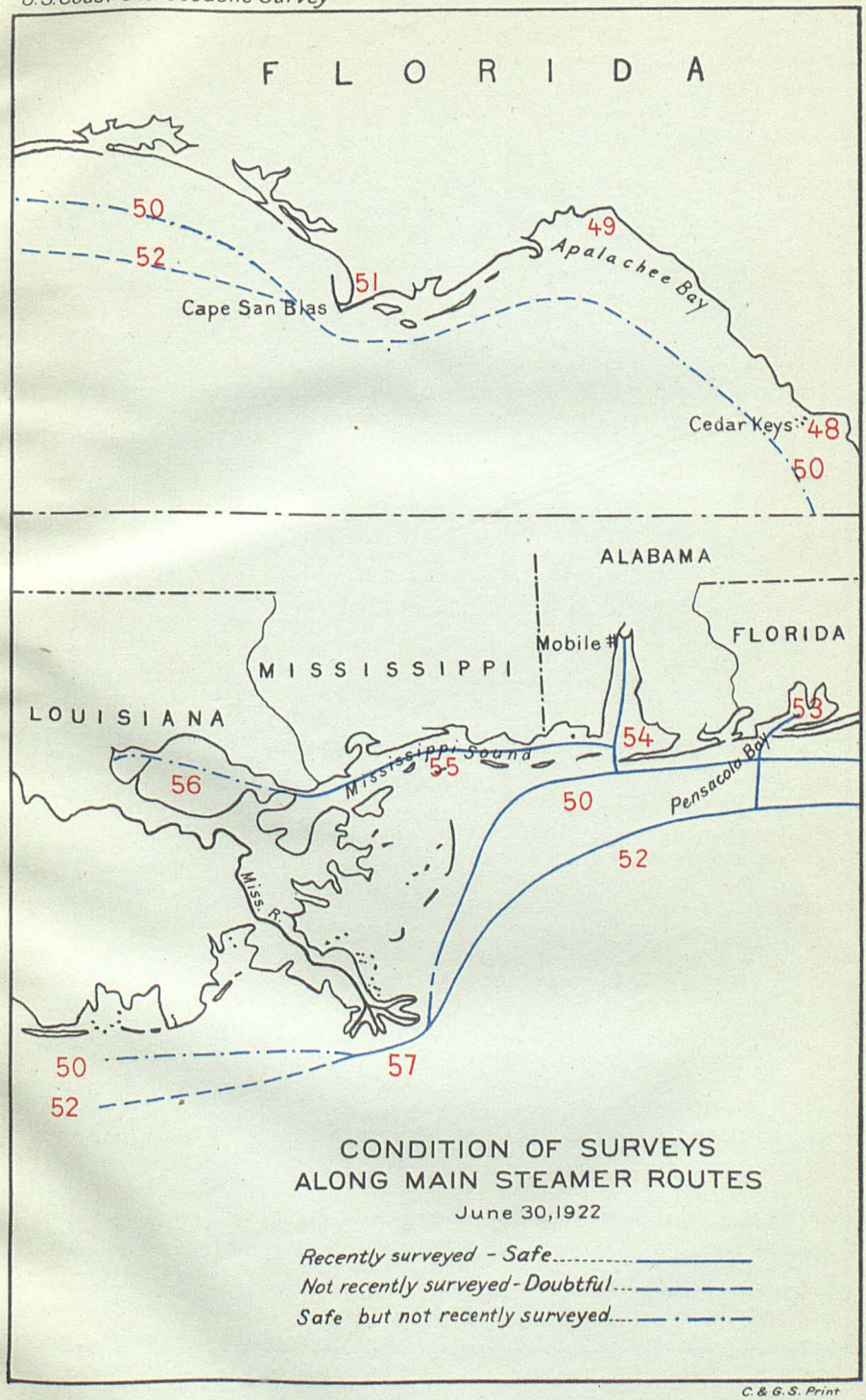
49. Apalachee Bay.—No recent surveys have been made of this region, and revision work is needed. (See Fig. 13, opposite p. 72.)

50. INSHORE WATERS, GULF COAST.—The chief characteristics of the west coast of Florida are the distances to which shoal water extends offshore between Cape Sable and Cape Romano and from Tampa Bay to Apalachicola and the existence of a large number of 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 differ somewhat, 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 deposits result 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 region 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. 72.)

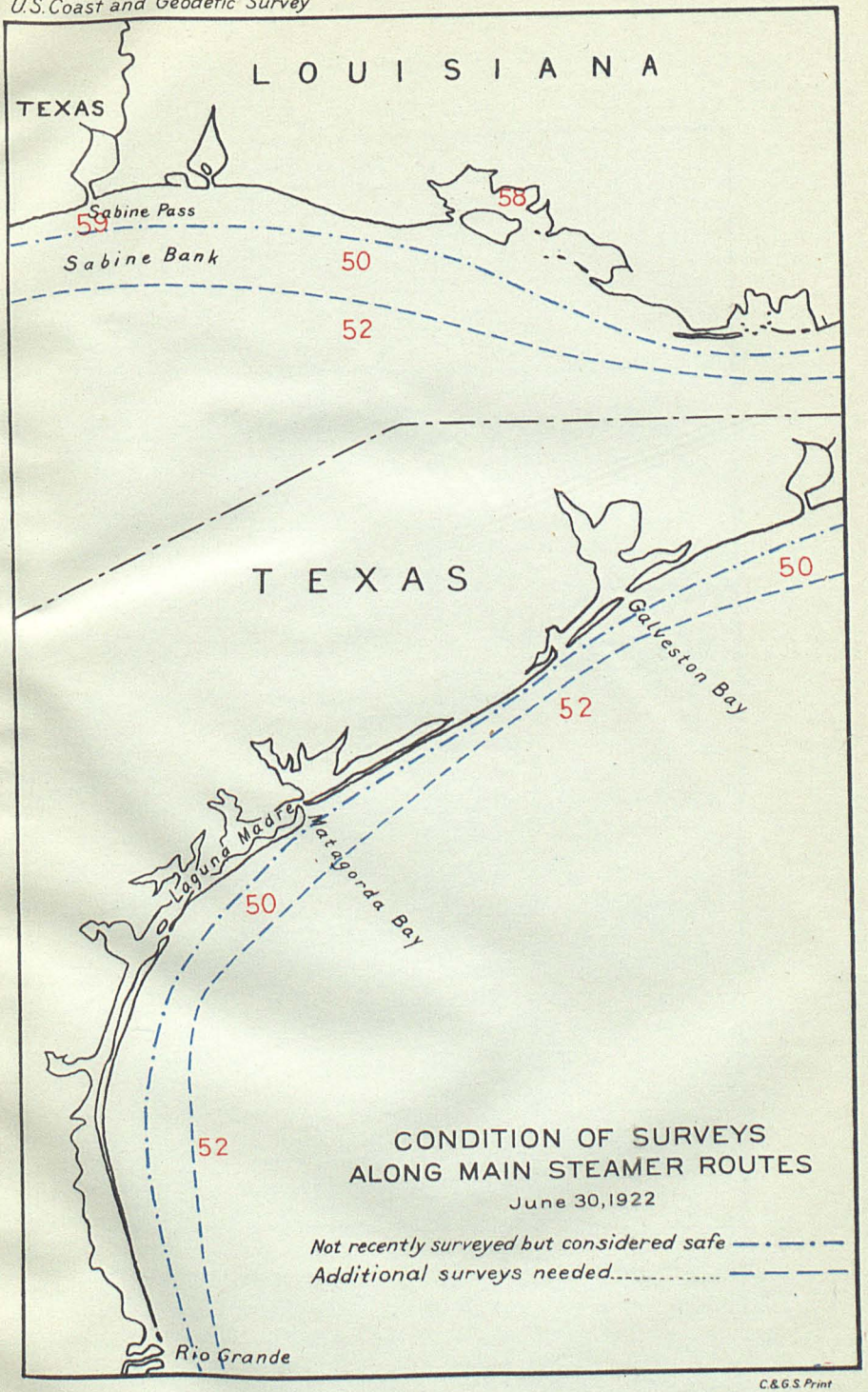
51. ST. JOSEPHS BAY.—No recent surveys have been made of this area, and a reexamination is needed. (See Fig. 14, opposite.)

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 reconnaissance 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. 14, opposite.)

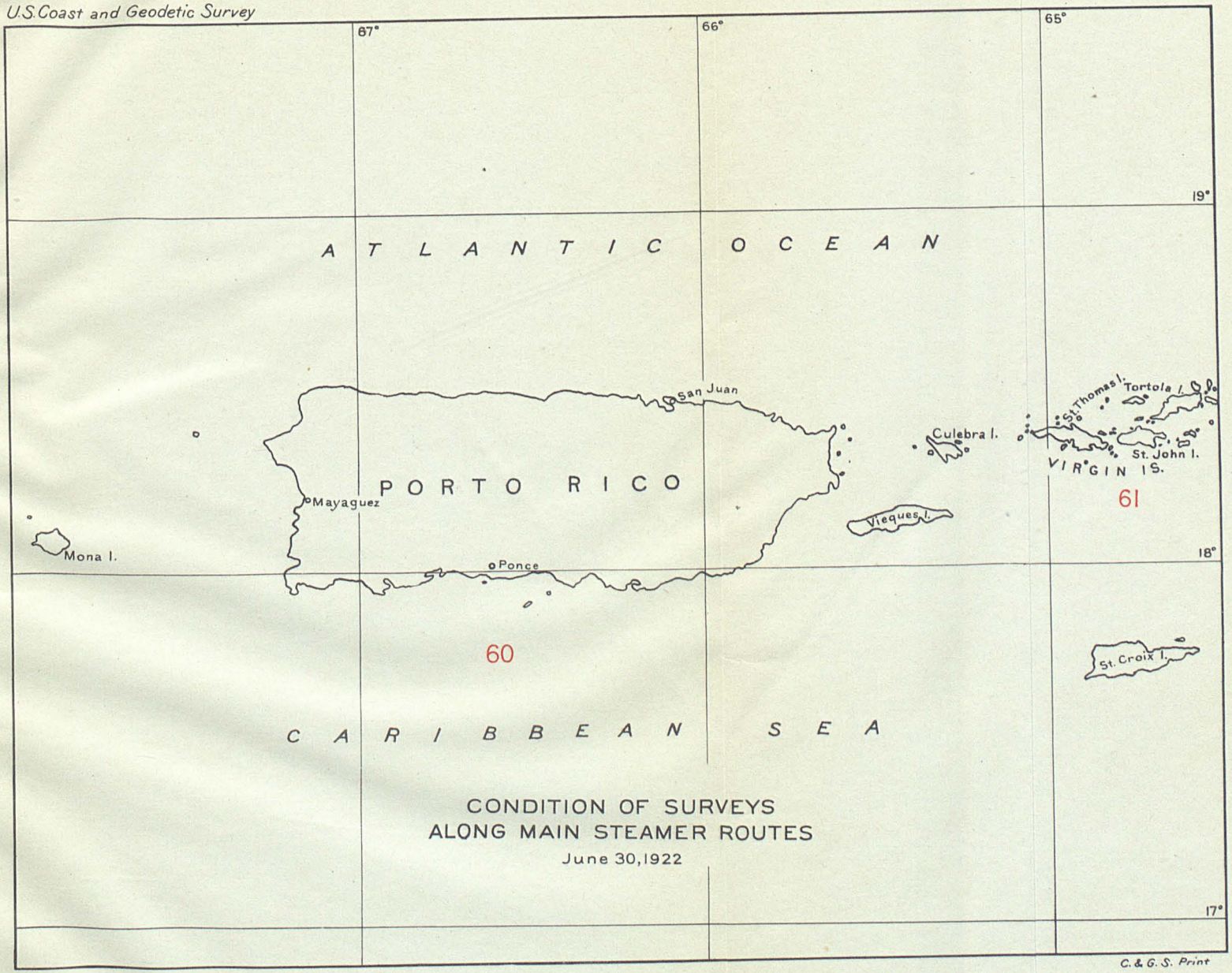
53. PENSACOLA BAY.—Surveys have recently been completed in the entrance to the bay. The entire bay requires reexamination. (See Fig. 14, opposite.)


FLORIDA
50
52
51
Cape San Blas
49
Apalachee Bay
Cedar Keys
48
50
ALABAMA
Mobile
FLORIDA
MISSISSIPPI
LOUISIANA
53
54
Mississippi Sound
55
56
50
Pensacola Bay
52
Miss. R.
50
57
52
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Recently surveyed - Safe
Not recently surveyed - Doubtful
Safe but not recently surveyed

C. & G. S. Print


LOUISIANA
TEXAS
Sabine Pass
Sabine Bank
59
58
50
52
TEXAS
Galveston Bay
50
52
Laguna Madre
Matagorda Bay
50
52
Rio Grande
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Not recently surveyed but considered safe
Additional surveys needed

U.S. Coast and Geodetic Survey



CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922

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54. MOBILE BAY.—A resurvey of this bay has been completed. (See Fig. 14, opposite p. 74.)

55. MISSISSIPPI SOUND.—A resurvey of this sound has been completed. (See Fig. 14, opposite p. 74.)

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. 14, opposite p. 74.)

57. APPROACHES TO MISSISSIPPI PASSES.—The hydrography of this area from close inshore to the 100-fathom curve has been completed during this year. The offshore work which has been in progress from Pensacola entrance westward has been extended during the present fiscal year to Mississippi River Passes, leaving a small area of inshore hydrography in the vicinity of the Chandeleur Islands yet to be accomplished. A vessel will complete this work during the next fiscal year.

58. VERMILION BAY AND COTE BLANCHE.—No recent surveys have been made of these areas. Surveys are needed. (See Fig. 15, opposite p. 74.)

59. APPROACH TO SABINE PASS.—No recent surveys have been made here; revisionary surveys are needed. (See Fig. 15, opposite p. 74.)

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 reef 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. A vessel was engaged during the entire year in dragging the waters of Vieques Sound and its approaches. This work has resulted in finding many coral rocks, the existence of which was not discovered by the hydrographic survey of previous years. This party will remain in Porto Rico during the next fiscal year and continue the wire-drag work of this area. (See Fig. 16, opposite p. 74.)

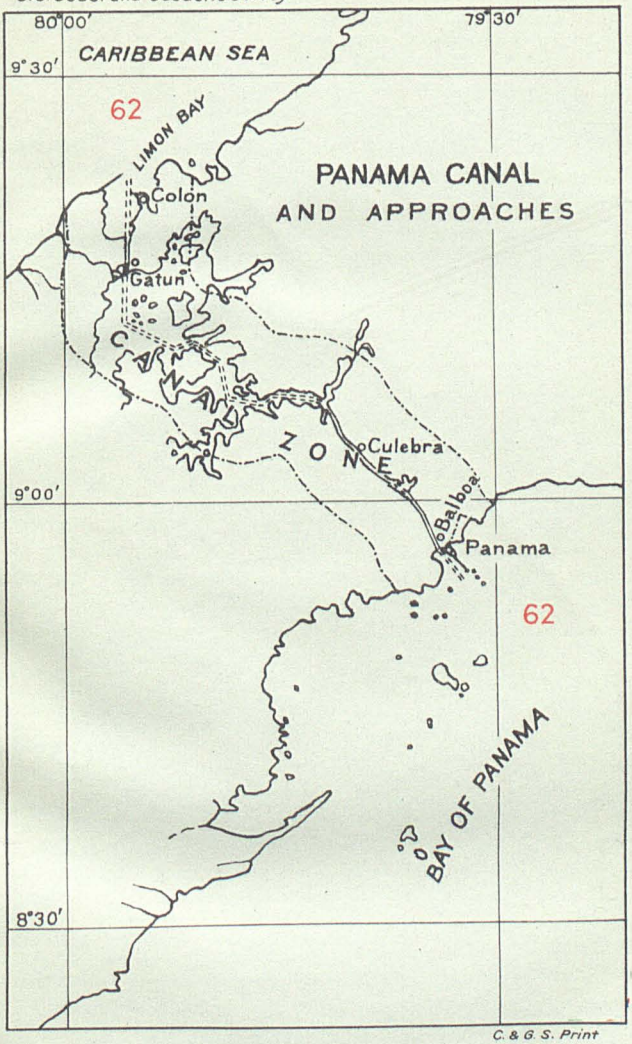
61. VIRGIN ISLANDS.—The Virgin Islands were purchased from Denmark, and the United States took possession in 1917. The surveys that have been made are by the British and Danish Governments. It is certain that the coral formation in the waters touching these islands requires extensive wire-drag surveys before accurate charts can be issued. Topographic surveys of these islands were requested by the Navy Department. The triangulation was extended eastward from Porto Rico for the control of the topography. St. Thomas and St. John have been completed, and St. Croix was completed last fiscal year. On completion of the wire-drag survey of Vieques Sound hydrographic work will be taken up there. All harbors will be thoroughly sounded out, and the shallow coastal waters will be dragged.

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. (See Fig. 17, opposite.)

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 survey 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 and 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 the 100-fathom curve, which is beyond the limit of soundings taken by merchant vessels. 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 unsurveyed. 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 reconnaissance and does not extend out far enough to be of practical value to navigators. Elsewhere no surveys have ever been undertaken until recently. 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 the immense expenditures for improvements, there is not a single one of these harbors the approaches to which have been adequately surveyed. The approaches to the Columbia River 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 depth 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

U.S. Coast and Geodetic Survey



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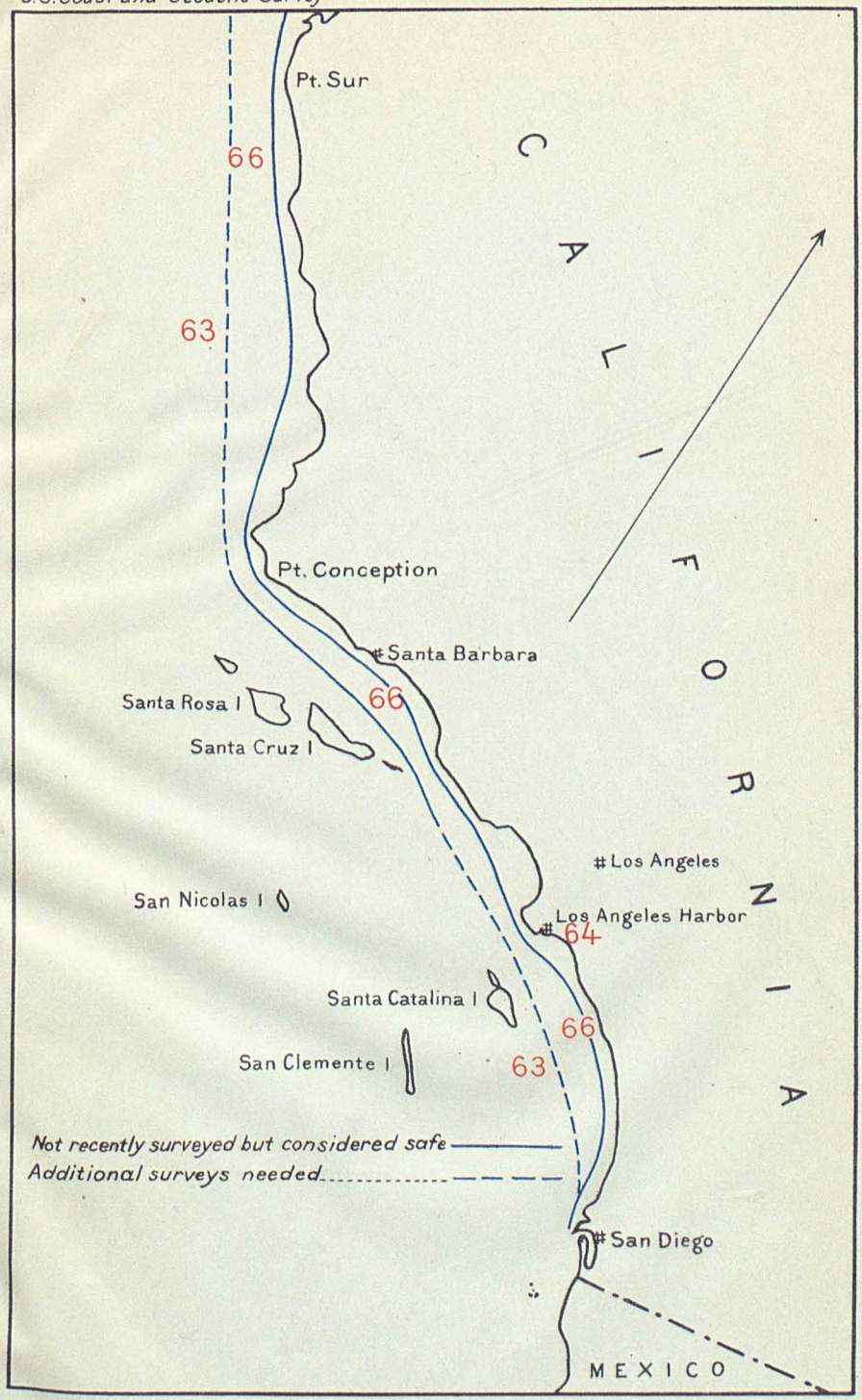
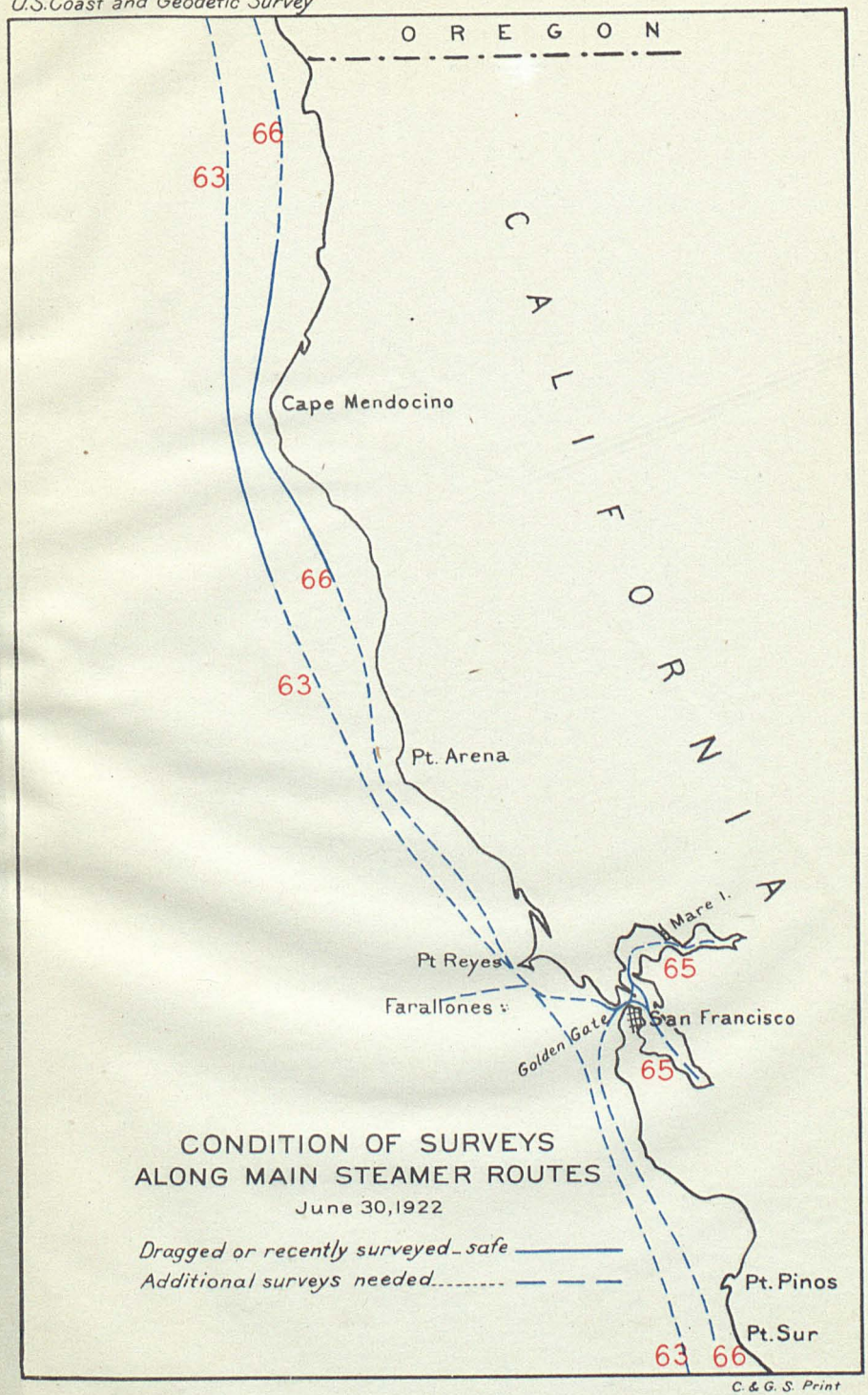
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES

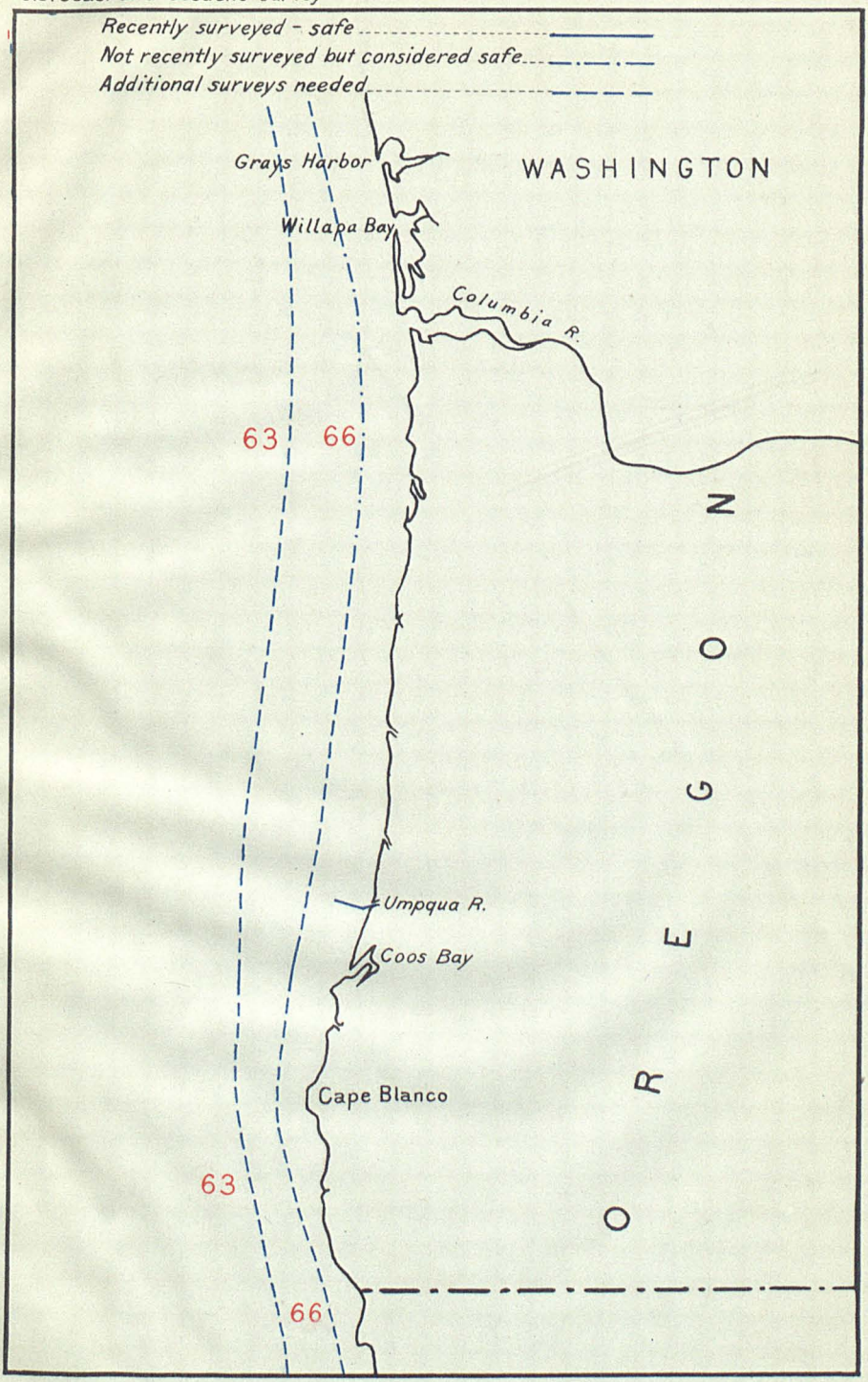
June 30, 1922


Pt. Sur
66
63
C A L I F O R N I A
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



CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922

Dragged or recently surveyed_safe ———
Additional surveys needed..... — — —


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

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 Fig. 18, opposite p. 76.)

64. Los Angeles Harbor.—A revision survey of Los Angeles Harbor and approach was completed during the first half of the fiscal year.

65. San Francisco Bay.—San Francisco Bay is of varied character of bottom and needed surveys vary to correspond. The immediate approaches are complete except in the vicinity of 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. 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 resurvey of the bar outside the Golden Gate has been completed. A resurvey of San Pablo Bay has been made during the fiscal year.

66. Alongshore 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. The surveys should be extended seaward to include the usual track of coastwise vessels, which lies an 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 600 fathoms.

Additional detailed surveys should be made in the vicinity of Point Arena and from there to the completed work south of Cape Mendocino. Detailed surveys are badly needed in the vicinity of Cape Blanco, and this work should be extended to Cape Flattery, joining the northern limits of the work completed in the vicinity of Cape Mendocino.

The offshore surveys which have been in progress for the past two years in the vicinity of Cape Mendocino have been completed. This work extends from close inshore to the 1,000-fathom curve.

The necessity for such surveys is shown by the location of the hitherto uncharted submarine valley north of Cape Mendocino, which was a factor in causing the wreck of the steamer *Bear*.

At the end of the fiscal year a vessel was engaged in making a survey of the water area in the vicinity of Cape Blanco, Oreg. This work is to extend both north and south of Cape Blanco from close inshore to the 1,000-fathom curve. 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 depth 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. 18, opposite p. 76.)

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 should be dragged wherever there is the slightest doubt as to the presence of dangers to navigation. (See Fig. 21, opposite.)

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 the 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 parties have been actively engaged in dragging the main steamer routes, and this work is now about 75 per cent complete.

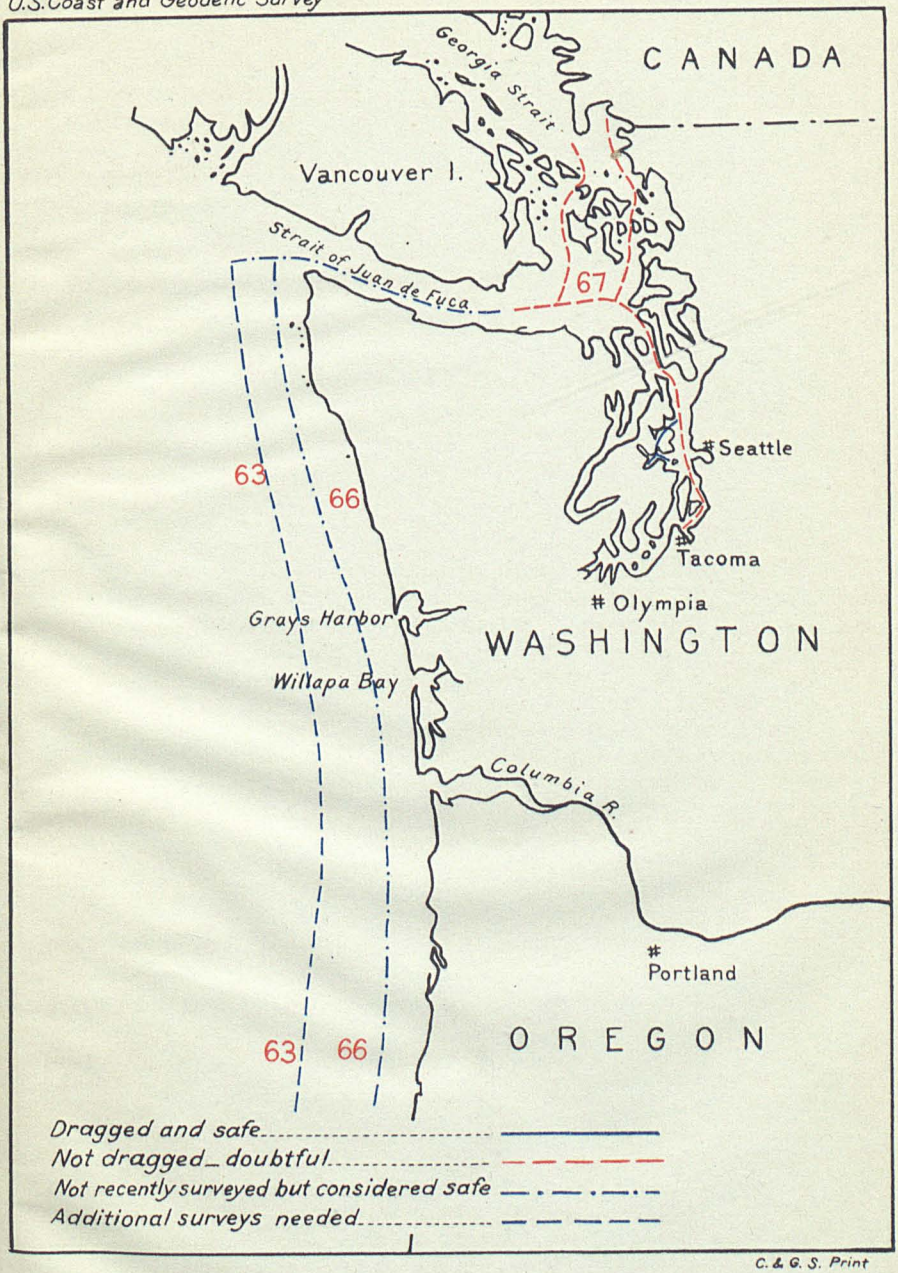
At the end of the fiscal year a party was engaged in wire-drag operations in Lynn Canal, which work is to be extended as far as possible during the season through Cross Sound and Icy Straits to Cape Spencer.

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 the chart on which the shore line is sketched—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. Work on the outer coast is now in progress northward from Dixon Entrance. Surveys were also in progress in Clarence Strait and Ernest Sound. (See Fig. 22, opposite.)

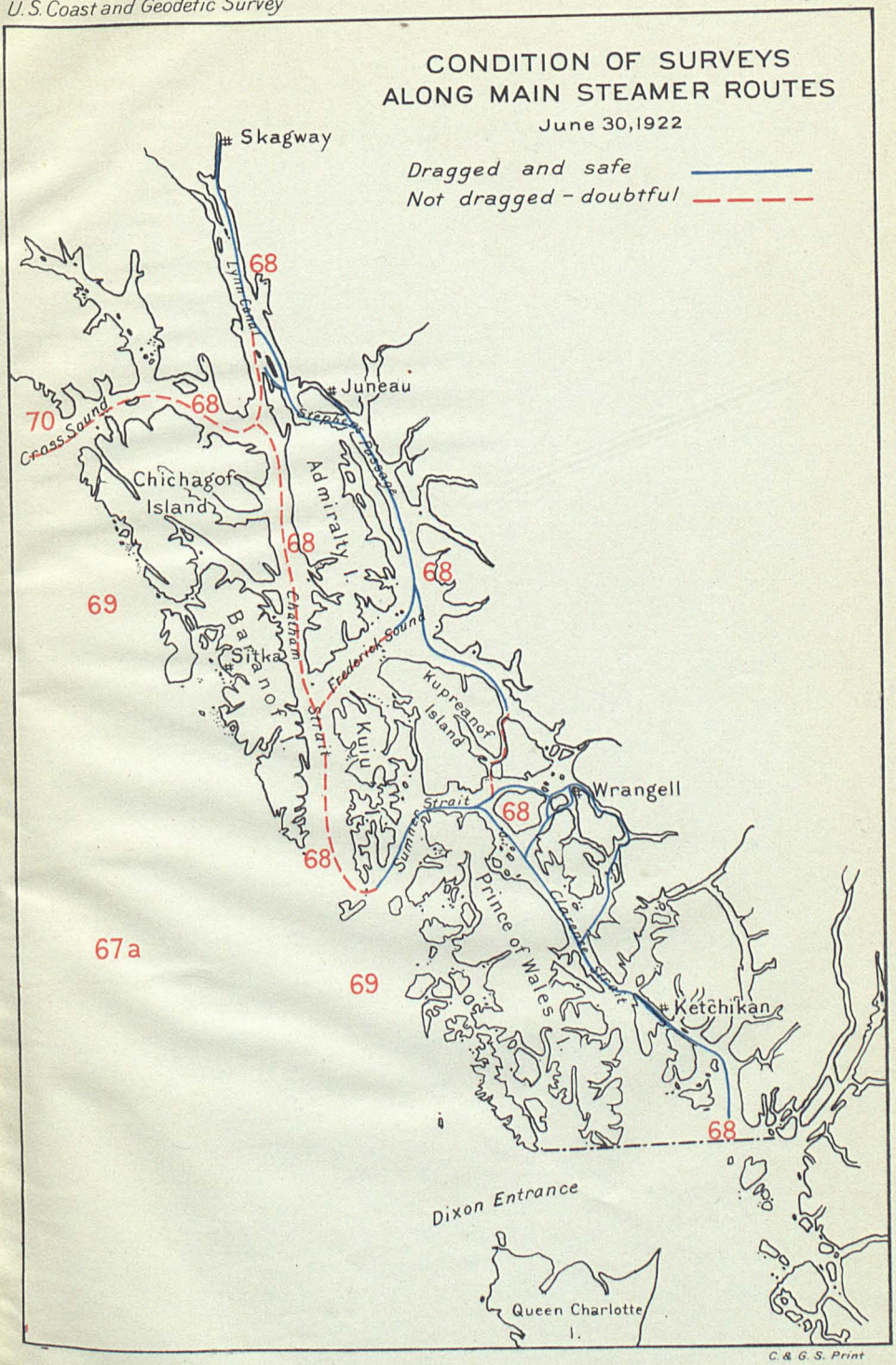
70. CROSS SOUND TO PRINCE WILLIAM SOUND.—From Cross Sound, the northernmost channel from the inside waters to the sea, to Prince William Sound the coast has few features of present or prospective importance. There is, however, urgent need for surveys to insure the safety of vessels approaching and passing this coast. In this region the charts are very defective in the manner of showing soundings and prominent coastal mountain peaks and headlands that would enable the navigator to obtain his position on approaching from seaward.

Additional surveys are needed in Yakutat Bay. A survey of Icy Bay was in progress during this fiscal year. As oil has been reported in this vicinity, Icy Bay may be of commercial importance.

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


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

C. & G. S. Print


CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30, 1922
Dragged and safe
Not dragged - doubtful
Skagway
Juneau
Lynn Canal
Stephens Passage
Cross Sound
Chichagof Island
Admiralty I.
Baranof
Sitka
Chatham Strait
Frederick Sound
Kupreanof Island
Kuiu
Sumner Strait
Wrangell
Prince of Wales
Clarence Strait
Ketchikan
Dixon Entrance
Queen Charlotte I.
68
70
69
67a

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. Kodiak Island, with a number of canneries and with some cattle grazing, is largely unsurveyed. From Kodiak Island westward to Unimak Pass surveys are now in progress; only a comparatively small part has been surveyed at present. 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 Island 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. Surveys were in progress from Shelikof Strait westward to Metrofania Island during the season of 1920. The operations were hampered by a shortage of fuel oil, and with the expectation of a continuance of this shortage and the high price of the oil during the season of 1921 it was decided to postpone surveys in this section until another year. (See Fig. 23, opposite p. 80.)

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. 23, opposite p. 80.)

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 river, 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. 23, opposite.)

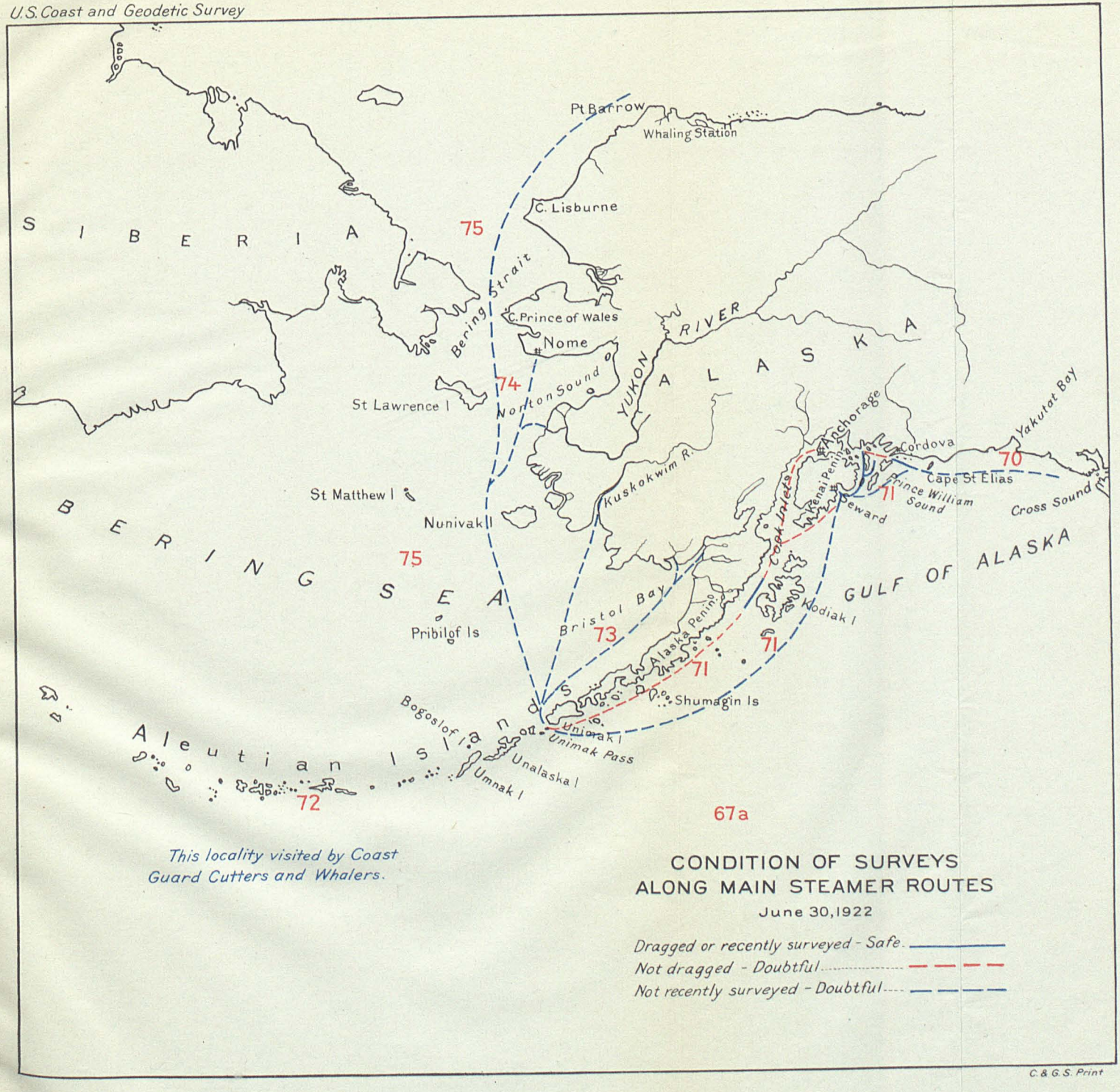
74. NORTON SOUND.—The importance of Norton Sound is due to the gold mining on its northern shores and as being the outlet of the Yukon Delta on the southern shore. In all of Norton Sound additional surveys are needed. It is curious that in this sound, which according to all available information is of 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. 23, opposite.)

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. 23, opposite.)

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 Lania and the vicinity of the two westernmost islands, Jauai and Niihau, are practically unsurveyed. The various channels between the islands from Taui to Oahu are fairly well surveyed. The others are practically without surveys. (See Fig. 24, opposite.)

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 and 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. 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. 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 Natan Islands, and Bashi Channel; the entire west coast of the island of Palawan; the south coast of Mindanao, from Pola Point to Malita, in Davao Gulf; the Sulu Archipelago and the Sulu Sea from the Tubbataha Reefs south to the limit of our possessions off the coast of Borneo. (See Fig. 25, opposite p. 82.)



This locality visited by Coast Guard Cutters and Whalers.

CONDITION OF SURVEYS ALONG MAIN STEAMER ROUTES

June 30, 1922

Dragged or recently surveyed - Safe. ———

Not dragged - Doubtful — — — —

Not recently surveyed - Doubtful — — — —

U.S. Coast and Geodetic Survey

HAWAIIAN ISLANDS

CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES

June 30, 1922

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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 harbors 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. 25, opposite p. 82.)

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. 25, opposite p. 82.)

81. WEST AND EAST COAST OF PALAWAN.—The coast line of the island of Palawan is very irregular, indented with deep bays, forming some of the finest harbors in the archipelago. The whole region about the island and extending southward to Balabac 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. This work was in progress at the end of the fiscal year. These localities must be swept with the wire drag. (See Fig. 25, opposite p. 82.)

82. WEST COAST OF MINDANAO.—This island is of little commercial importance due to the absence of harbors and having a rugged mountainous country adjacent to the coast which is not adapted to the growth of any of the staple products. The usual steamer tracks do not approach the shore within 4 or 5 miles, a sufficient distance to avoid all dangers. For these reasons the surveys now in progress have been postponed for more important localities.

83. SOUTH COAST OF MINDANAO.—This stretch of about 150 miles, from Pola Point to Malita in Davao Gulf, is similar in many respects to the west coast. In general, it is bold and steep, with numerous outlying reefs, which, however, do not extend a great distance from shore. The triangulation for furnishing the controlling positions for the hydrography and topography presents a difficult problem, the shore line being invisible from the peaks and ridges but a short distance back.

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. Surveys in this area are now in

progress. It required a survey of the most careful and intricate character, and much of the locality must be swept with the wire drag after the present hydrographic survey is made. 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. 25, opposite.)

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. A large part of the region to the south of the Tubbataha Reefs remains unsurveyed except for a reconnaissance with approximate locations by navigational methods. A survey of this area is now in progress. 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. 25, opposite.)

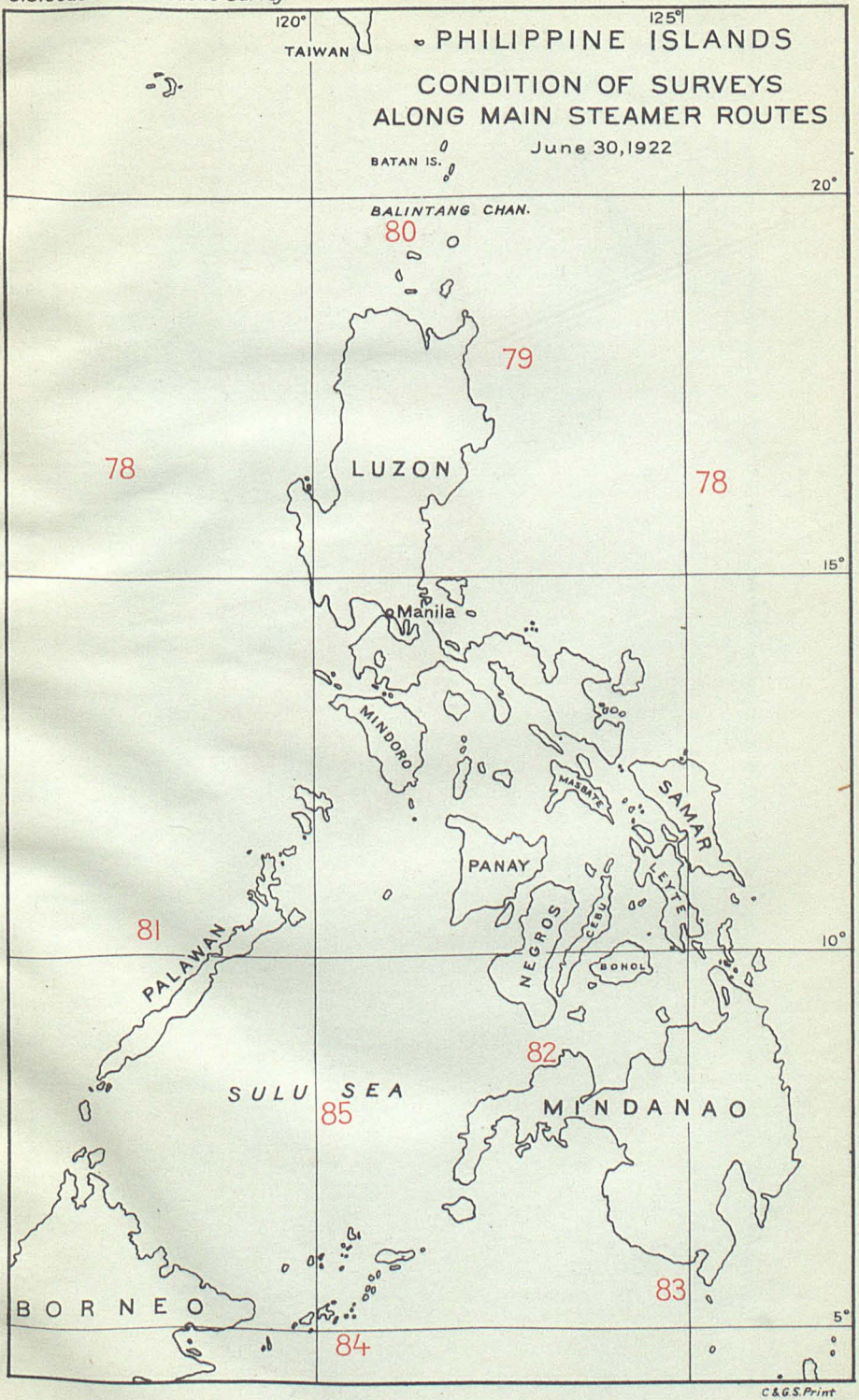
GEODETIC WORK.

An important operation of the U. S. Coast and Geodetic Survey is the extension of precise triangulation, traverse, and leveling over the area of the United States and Alaska. A definite plan is being followed by the bureau which has been approved by the board of surveys and maps. This plan provides that control surveys shall be carried on to such an extent that no place in the United States will be farther than 50 miles from a horizontal control station nor more than 15 miles from a bench mark whose elevation above sea level is known.

The field work in triangulation, traverse, and leveling done in the United States during the past year was designed to carry control into large regions that have not yet been reached with this class of work in accordance with the general plan outlined above.

It has been the experience of many nations of the world that one of the best investments that can be made for their welfare is the surveying and mapping of their areas to show the configuration of the ground and the accurate geographic positions and elevations of the topographic features. Accurate maps must be made wherever engineering and other industrial activities are carried on.

The question has often been asked, Why should not the corporations or individuals needing the map make it? This at first glance would seem to be a logical solution of the problem, but it must be remembered that any business organization adds to its capital account the cost of the surveys and maps that it may make, and indirectly the public must pay high interest on any such expenditures for at least many years and perhaps indefinitely. The same area may be surveyed and mapped by half a dozen or more organizations, each one working independently of the other and no one furnishing the data to the others. Such surveying and mapping are of but little value to the country, and the people, as a whole, will really pay for this work many times over in the form of advanced


PHILIPPINE ISLANDS
CONDITION OF SURVEYS
ALONG MAIN STEAMER ROUTES
June 30,1922
120°
125°
20°
15°
10°
5°
TAIWAN
BATAN IS.
BALINTANG CHAN.
80
79
78
78
LUZON
Manila
MINDORO
MASBATE
SAMAR
PANAY
LEYTE
NEGROS
CEBU
BOHOL
81
PALAWAN
82
SULU SEA
85
MINDANAO
83
BORNEO
84

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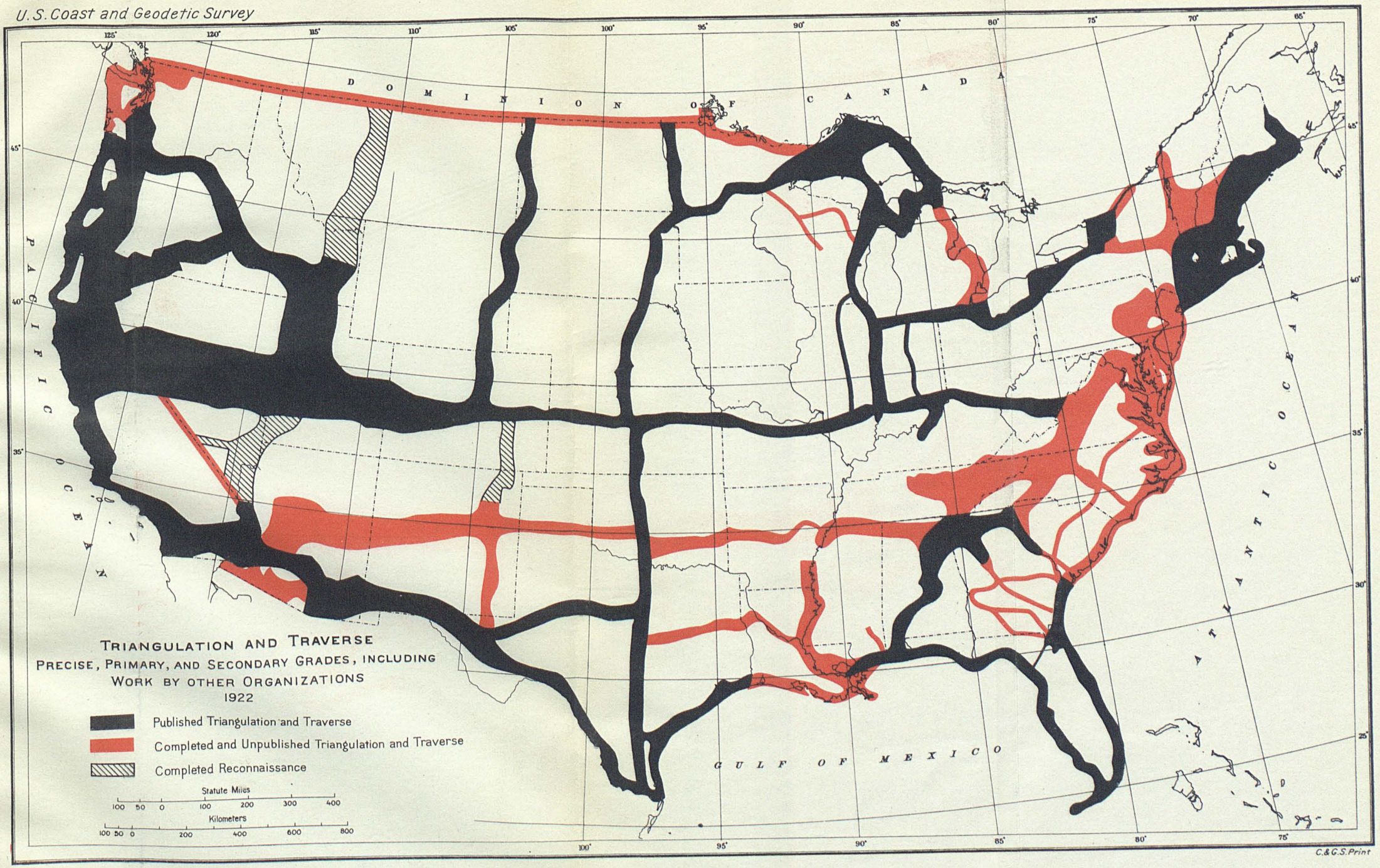

DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
TRIANGULATION AND TRAVERSE
PRECISE, PRIMARY, AND SECONDARY GRADES, INCLUDING
WORK BY OTHER ORGANIZATIONS
1922
Published Triangulation and Traverse
Completed and Unpublished Triangulation and Traverse
Completed Reconnaissance
Statute Miles
100 50 0 100 200 300 400
Kilometers
100 50 0 200 400 600 800

costs of the articles manufactured or the services rendered by the various corporations. Is it not better for the Government alone, or in cooperation with the States and industrial corporations, to make the survey of any particular area and to issue the results in the form of maps and reports? Then, not only the corporations doing business in the area will have the benefits of the maps, but also other organizations which may wish to do business in the particular area in the future. In addition the State will have the maps for the extension of highways, city development, soil surveys, etc., and our military forces will have the necessary maps should it become necessary to carry on military operations in the area. A careful consideration of these advantages proves most conclusively that great economy will result if the Government performs the work.

The U. S. Coast and Geodetic Survey has for a number of years advocated the rapid extension of the horizontal and vertical control systems of the country in order to furnish to Government organizations and to organizations and individuals outside of the Government the necessary control data for their detailed operations. The calls on this bureau are so great that I must again urge increased appropriations for carrying on more rapidly this geodetic control work of the country. As an indication of the condition of the control surveys in our country, I wish to call attention to the situation as it exists in some of our States. Iowa has not a single precise or primary horizontal control station within its area. Montana has only a few stations along its eastern border. North and South Dakota have horizontal control stations along only their eastern and western borders. Nebraska has only a single arc of triangulation running across it. Missouri has only one arc of triangulation within its area. There are many other States which, though somewhat better off than those mentioned, are seriously unprepared as regards geodetic control for detailed surveying and mapping. Although the United States is badly in need of much more geodetic control than exists to-day, yet very notable progress has been made in the extension of this control during the past 10 years.

The U. S. Coast and Geodetic Survey has recently issued a report entitled "Geodetic operations in the United States from January 1, 1912, to December 31, 1921," which was presented to the conference of the section of geodesy of the International Geodetic and Geophysical Union, held in Rome, Italy, in May, 1922. This report shows that much more work was done during the 10 years covered than during any other 10 years in the history of the survey. It will be interesting to indicate the advance made during those years.

The total length of the arcs of precise triangulation and precise traverse executed during the 10-year period is 7,719 miles. The amount of this class of work done by all organizations in the United States prior to January 1, 1912, was 11,000 miles. An increase of 70 per cent was, therefore, made during the 10 years. During the same period 15,475 miles of precise leveling were run in the United States by the U. S. Coast and Geodetic Survey and 500 miles by the Buffalo, Rochester & Pittsburgh Railroad. The total amount of precise leveling prior to January 1, 1912, was 30,000 miles. The increase during the 10-year period over what existed previously is therefore 53 per cent. During the 10-year period the determination of the intensity of gravity was made at 162 stations in the United

States. Previous to that period there had been established 124 stations. The increase in the number of stations was, therefore, 31 per cent.

The activities at the office of the U. S. Coast and Geodetic Survey during the 10-year period are indicated by the great number of geographic positions of triangulation stations and of elevations for precise leveling bench marks which were computed and adjusted; also by the large number of publications which give the results of the triangulation, traverse, and leveling, and the results of the research work done to throw light on the many problems involved in geodetic work.

A number of improvements in the geodetic instruments used in the field were made during the 10-year period. The most important of these are the electric signal lamps used in triangulation, the invar precise level which is practically free from the bad effects of changes in temperature, the invar rod for precise leveling which eliminates the detrimental effects resulting from the use of the wooden rod, the invar pendulums which make it possible to establish gravity stations at places where there are no constant-temperature rooms, and the apparatus for recording radio time signals in connection with the determination of differences of longitude. This last-named instrument was designed and constructed by the Bureau of Standards at the request of the U. S. Coast and Geodetic Survey. Funds belonging to the survey were transferred to the Bureau of Standards for paying certain portions of the expense of constructing and testing the instrument.

Although observations have been continued throughout and since the war at the international latitude stations located at Ukiah, Calif.; Mizusawa, Japan; and Carloforte, Italy, the work has been accomplished with considerable trouble, and at times it seemed as if the observations would have to be discontinued, at least at the Ukiah station. The results of 20 or more years of variation of latitude work by the International Geodetic Association and, since the beginning of the war, by the Reduced (Neutral) Geodetic Association, have proved of great value to astronomers, geodesists, and geophysicists. It is very strongly hoped that there will be no break in the observations at these stations, and it is believed that valuable results will be obtained if other stations are located in other countries of the world. The status of the variation of latitude work was given very careful consideration at meetings of the joint committee on this subject appointed by the International Astronomical Union and by the geodetic section of the International Geodetic and Geophysical Union at Rome last May. The countries of the world were urged to support the variation of latitude work which might fall within their areas, and the delegates from the United States, Japan, and Italy agreed that they would make such efforts as were practicable to secure funds from their respective Governments for making the observations and for the upkeep of the stations located in their countries. It is believed that the Congress of the United States should grant authority to the U. S. Coast and Geodetic Survey to continue other stations in the United States as may be needed. The cost would be very little, outside of the pay of an officer who would be assigned to make the observations.

Gravity observations have been made at a number of places in the United States for the purpose of testing the theory that the earth's crust is in isostatic equilibrium; that is, that at a certain depth, found by experiments to be approximately 60 miles below sea level, each large block of the earth's crust of a given unit area will exert the same pressure as a block of the same cross section or unit area anywhere else in the world. The work in this country has been supplemented by gravity investigations made in India by the Trigonometrical Survey of that country and in Canada by the Dominion Astronomic Observatory. The results so far have proved that the earth's crust, under continental areas, is in isostatic equilibrium, and now it is proposed that further tests be made in such areas as the West Indies, the vicinity of the Panama Canal, Alaska, Hawaiian Islands, and other possessions of the United States. The estimates for the fiscal year 1924, if approved by Congress, will enable this bureau to extend its gravity surveys over such additional areas as may be needed by our investigations in geophysical subjects. It is especially desirable to have a gravimetric survey made of the Panama Canal Zone and the coasts adjacent thereto and of the islands near the Bartlett deep or trough which runs to the southward of Cuba and eastward to Porto Rico. It is believed that along the edges of this trough many of the strong earthquakes have occurred which in the past have caused so much damage to shipping in some of the harbors of the West Indies. Gravimetric work has a great practical value and importance as well as scientific interest.

There is an excellent grade of triangulation, with well-marked stations, along the whole course of the Mississippi River done by the Mississippi River Commission, but the results of this triangulation are not available for the public because the geographic positions of the stations have not been computed and adjusted to the North American or final datum. Inquiry made of the officials of that commission by this bureau has brought out the fact that no money has been appropriated to the commission for making the computations and printing the results. The commission realizes the importance of this triangulation to the surveyors and engineers of the States bordering on the river and suggested that efforts be made by the U. S. Coast and Geodetic Survey to secure appropriations for making the computations, etc. An item is contained in the estimates for the fiscal year 1924 for the U. S. Coast and Geodetic Survey to start this computation. It is certain that the cost of the small amount of work necessary to make the final geographic positions available will be very small in comparison with the value of the results.

Some years ago the Hawaiian government extended triangulation over a number of the islands of the group, but the final computation and adjustment of the observations have never been made. It is impracticable for the Hawaiian government to make these computations, for it would require the employment of specialists who would be difficult to obtain for the short time that the work would last. The results of this triangulation are valuable in coordinating the charts made along the coasts of the islands by the U. S. Coast and Geodetic Survey, and it would seem fitting that the United States Government should pay for the cost of making the computation and adjustment and that the work should be done at the office of the U. S.

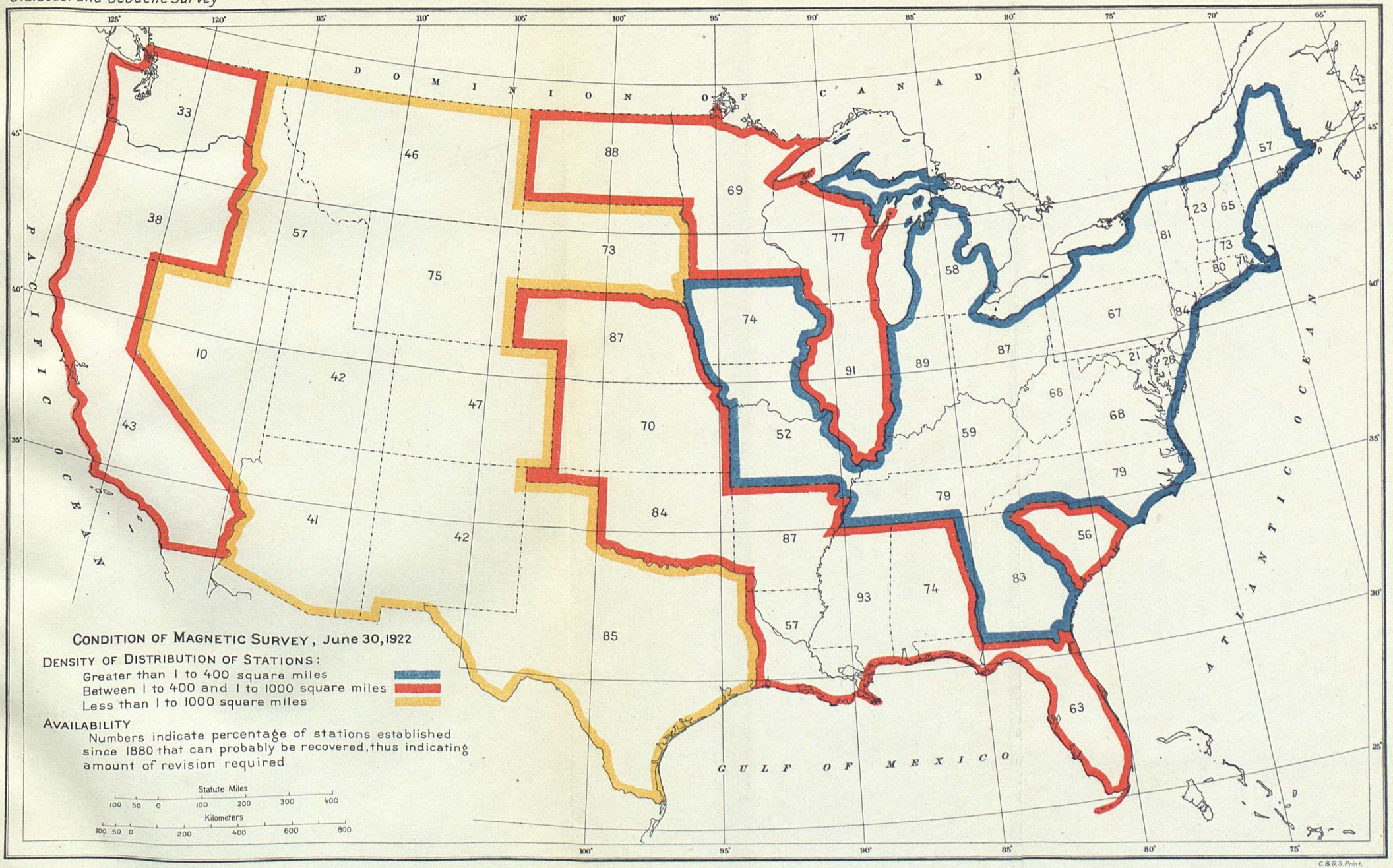
Coast and Geodetic Survey. An item has been included in the estimates for beginning these computations.

The U. S. General Land Office is cooperating with the U. S. Coast and Geodetic Survey by sending one of its engineers with each of two of our triangulation parties. One of these parties is working in Idaho and Montana and the other in New Mexico and Colorado. As a result of this cooperation a number of land corners of the public-land surveys will be tied into the triangulation of the country and their latitude and longitude will be determined. It is unfortunate that most of the public-land surveys of this country had to precede the establishment of the horizontal control system, but much can be done to remedy the resulting condition by having the land corners connected with triangulation wherever either class of work is done in the future.

PRESENT CONDITION OF THE MAGNETIC SURVEY.

The magnetic survey of the United States has been completed to the point where it is possible to analyze the situation for the entire country. The following magntic survey includes observations at new stations; recovery and replacement of old stations, including station and reference marks; observations at repeat stations; observations to determine the extent and intensity of local disturbances. These subjects will be taken up by States. The map brings out the general conditions of magnetic surveys with reference to density and probable recovery of stations for each State. The table shows the number of stations that have been occupied since 1880 and for reference the number of counties and the county seats now occupied are given. This is done because the original plan for the magnetic survey of the United States called for observations at every county seat. The number of repeat stations in each State is also given. This work is planned so that 35 to 40 of these repeat stations are occupied each year, but all of the stations will be occupied as nearly as possible at five-year intervals. This permits the preparation of accurate isogonic maps to show the secular change of the magnetic declination. Local disturbances will be described with reference to each State. The meaning of the terms used in describing local disturbances should be clearly understood. "Slight" means that the earth's magnetic field is nearly uniformly distributed, and that the declination varies nearly uniformly throughout the State and the isogonic lines, therefore, are regular. "Moderate" means that for at least a part of the State the local magnetic field is distorted because of local magnetic material, values of the magnetic declination varying by a degree or more from the values which would exist if regular distribution were found and the isogonic lines are irregular. In the State the disturbances may be slight over most of the area and considerable in local localities. "Strong" means that local magnetic disturbance is found over the entire State, or the considerable departures from normal values are found at a number of places throughout the State. In such regions the isogonic lines are highly irregular and are difficult to trace.

MAINE.—Some local surveys are made by magnetic methods and old lines are being constantly retraced. A few new stations are


DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
CONDITION OF MAGNETIC SURVEY, June 30, 1922
DENSITY OF DISTRIBUTION OF STATIONS:
Greater than 1 to 400 square miles
Between 1 to 400 and 1 to 1000 square miles
Less than 1 to 1000 square miles
AVAILABILITY
Numbers indicate percentage of stations established since 1880 that can probably be recovered, thus indicating amount of revision required
Statute Miles
Kilometers

C.&G.S. Print.

required, and some of the existing stations should be examined and replaced if necessary.

NEW HAMPSHIRE.—The general need is for the replacement of old stations. The isogonic lines are somewhat irregular, and additional stations are therefore desirable.

VERMONT.—Old stations should be revisited, inspected, and replaced if necessary. Local reports indicate the need for this work.

MASSACHUSETTS, RHODE ISLAND, AND CONNECTICUT.—No surveys by magnetic methods are now being made, but old lines are frequently retraced. Old stations should be inspected to see that they are available for the use of surveyors. There are a few places in Massachusetts where areas of local disturbances should be examined more fully.

NEW YORK.—Land surveys by magnetic methods are made in some parts of this State, and old lines are frequently rerun. The stations have been well marked, but a limited amount of inspection is necessary to insure their availability. The northern and western parts of the State show considerable local disturbance, and more work along this line is necessary.

PENNSYLVANIA.—Additional stations are needed to increase the density to that of surrounding States. Recovery and re-marking if necessary of old stations should be taken up. There is a possibility in this State of finding valuable deposits of magnetic iron ore by magnetic methods.

NEW JERSEY.—Revision of existing stations is needed. The magnetic fault extending into this State indicates the same possibilities as for Pennsylvania.

MARYLAND.—A very complete magnetic survey of Maryland has been made, but considerable time has elapsed. Many of the old stations were not well marked or can not be recovered, and for that reason the index number for Maryland is lower than for any other eastern State. There is a very considerable amount of local disturbance in various parts of Maryland, and further observations are needed on this account.

DELAWARE.—The chief need is recovery and re-marking of old stations as indicated by the low index number of 28.

VIRGINIA.—Surveys are frequently made by magnetic methods. The density of stations is good, but many of the stations should be revised and replaced if necessary. There are some areas of local disturbances which should be further examined.

WEST VIRGINIA.—Magnetic surveying methods are used to some extent in this State. Revision of stations is the chief need.

NORTH CAROLINA.—Magnetic methods of making land surveys are in constant use. Old stations should be revisited in order to learn whether the high index number of 79 is correct. Areas of local disturbance which need further examination are found throughout the State. This examination is especially important because of the widespread use of the magnetic needle.

SOUTH CAROLINA.—Magnetic methods are much used. It is therefore important that the number of stations be increased and that old stations be revisited and re-marked.

GEORGIA.—Magnetic surveys are constantly being made in this State. The very present need is examination of old stations and replacement where necessary.

FLORIDA.—The surveys by magnetic methods are considered very satisfactory in this State. A systematic revision of the stations, including the placing of meridian marks at the magnetic stations where desired, was started last winter and is about half finished. This work will be resumed next winter and existing needs will then be met.

ALABAMA.—Land surveys by magnetic methods are frequently made. The chief need is for a revision of old stations. There is some local disturbance which should be investigated. The possibility of finding iron ore by magnetic methods is now being investigated.

MISSISSIPPI.—Magnetic methods are frequently used in land surveys. The unusually high index number indicates that stations were exceptionally well marked, but many have probably been destroyed, and accordingly revision is necessary.

TENNESSEE.—Surveys by magnetic methods are frequently made. There is considerable magnetic disturbance in the central part of the State that needs further investigation. Inspection of old stations is needed.

KENTUCKY.—A considerable amount of revision and the replacement of old stations is needed as surveys by magnetic methods are frequently made. The isogonic lines are very irregular in this State and more observations are needed.

OHIO.—The stations were exceptionally well marked, but revision is needed. There is considerable local disturbance which needs further investigation. Surveys by magnetic methods consist chiefly in the rerunning of old lines.

INDIANA.—Stations were well marked, but revision is needed. There are areas of local disturbances which should be further examined.

ILLINOIS.—Stations were well marked, but revision is needed.

MICHIGAN.—Frequently new surveys are made by magnetic methods, but magnetic methods are chiefly used for rerunning old lines. Replacement of old stations is needed. There is very little local disturbance in the southern part of the State, but there is considerable in the northern part which should be further examined. It is apparently very difficult in this State to distinguish iron ore from other useless magnetic rock, and accordingly magnetic methods are of little use in searching for ore deposits.

WISCONSIN.—The chief needs are revisional work and additional observations on account of the very widespread local disturbances. In some parts of this State the conditions are unfavorable for use of the magnetic needle in surveying.

MINNESOTA.—The need in this State is for the revision of old stations and further determination of the declination on account of the great amount of local attraction.

IOWA.—Old stations should be revised and further determinations made of the widespread local disturbances. The conditions in the State handicap the local surveyor who desires to use magnetic methods.

MISSOURI.—Additional stations and the replacement of old ones are needed. In some parts of the State there is considerable local disturbance and in others magnetic surveying methods can probably be used successfully.

ARKANSAS.—Revision of stations is the chief need. The State is fairly free from local disturbances except a few localities, which need further investigation.

LOUISIANA.—Land surveys are frequently made by magnetic methods. The chief need is for the revision of old stations.

TEXAS.—While many more observations have been made in Texas than in any other State, the density is not great. The chief need is the establishment of magnetic stations at 19 county seats and also the revision of old stations. Conditions are favorable to the use of the magnetic needle in making surveys.

OKLAHOMA.—The chief need is the revision of the old stations. Conditions are favorable to the use of the magnetic needle.

KANSAS.—Revision work is needed, also further investigations of disturbed areas at different places in the State.

NEBRASKA.—Revision of stations and further investigation of areas of local disturbance are needed.

SOUTH DAKOTA.—Observations at several county seats, the reoccupation of old stations, also other additional stations are needed.

NORTH DAKOTA.—Revision of old stations is the chief need.

MONTANA.—While the density is very much lower than in most of the other States, it is not practicable at the present time to bring the density of the mountain States up to that of the more thickly settled regions. Stations are needed at 13 county seats, and also the revision of existing stations. Conditions are not unfavorable for magnetic surveying methods.

WYOMING.—The chief need is the revision of existing stations.

IDAHO.—Revision of existing stations is the chief need.

COLORADO.—Additional stations are needed, but the chief need is the replacement of existing stations. There is a wide area of local disturbance in this State which should be further investigated.

UTAH.—Additional stations are needed, but revision of existing stations is the great need. There are nine county seats which are without magnetic stations.

NEVADA.—The condition of the magnetic survey in this State is most unsatisfactory, even when the lack of density of population is considered. More stations are needed, especially those at six county seats, but the great need is the replacement of most of the old stations.

NEW MEXICO.—The chief need in this State is inspection and replacement of stations where observations have been made.

ARIZONA.—Revision of stations is the chief need.

CALIFORNIA.—The density of stations is good, but the replacement of stations is the chief need. Many stations were marked by methods satisfactory in the undeveloped regions, but such marks have disappeared as the State has developed. There are a number of regions in California where there is more or less local disturbance, and these need further investigation.

OREGON.—There is need of revision of old stations and for establishing new ones to get sufficient information for tracing the isogonic lines. There is a great deal of local disturbance in small amounts which greatly distort the isogonic lines.

WASHINGTON.—The needs are revision and replacement of stations. There is some local disturbance in the southern part of the State, but apparently the amount is small.

REMARKS.—For those stations where no remark is made concerning the use of magnetic methods full information on the subject is not available. In general, it may be said that where land is cheap the expense of an accurate survey does not seem to be warranted but elsewhere more precise methods are used. However, in practically all of the States land surveys have been made by magnetic methods some time in the past and magnetic information is needed for retracing old lines. This matter of actual use of magnetic survey methods, while not strictly a part of the statement of present conditions, the needed survey is so closely connected that it can not be ignored.

State.	Station since 1880.	Number of counties.	County seats not occupied.	Necessary repeat stations.	Local disturbance.
Alabama	81	65	0	4	Moderate.
Arizona	44	14	2	3	Slight.
Arkansas	85	75	3	3	Moderate.
California	152	58	5	10	Do.
Colorado	100	63	2	6	Strong.
Connecticut	25	8	0	1	Moderate.
Delaware	25	3	1	0	Slight.
Florida	98	61	2	6	Do.
Georgia	167	160	7	7	Moderate.
Idaho	58	44	7	6	Slight.
Illinois	117	102	2	4	Moderate.
Indiana	103	92	0	4	Strong.
Iowa	146	99	0	6	Do.
Kansas	107	104	1	6	Do.
Kentucky	158	120	3	3	Do.
Louisiana	82	64	2	3	Slight.
Maine	62	16	0	3	Do.
Maryland	123	24	0	2	Do.
Massachusetts	41	14	1	2	Moderate.
Michigan	153	83	4	4	Strong, slight.
Minnesota	135	86	6	4	Strong.
Mississippi	90	82	4	4	Slight.
Missouri	194	115	0	5	Strong.
Montana	72	53	13	7	Slight.
Nebraska	111	93	2	5	Moderate.
Nevada	62	17	6	4	Slight.
New Hampshire	35	10	0	1	Moderate.
New Jersey	70	21	1	1	Slight.
New Mexico	60	29	1	3	Do.
New York	116	62	2	5	Strong, moderate.
North Carolina	124	100	3	5	Strong.
North Dakota	75	53	9	4	Moderate.
Ohio	110	88	2	4	Do.
Oklahoma	96	77	2	6	Slight.
Oregon	71	36	3	3	Moderate.
Pennsylvania	111	67	1	4	Slight.
Rhode Island	7	5	0	1	Do.
South Carolina	59	46	1	4	Moderate.
South Dakota	71	68	7	4	Slight.
Tennessee	113	95	1	5	Strong.
Texas	269	254	19	13	Slight.
Utah	40	29	9	2	Do.
Vermont	29	13	0	3	Moderate.
Virginia	141	100	4	4	Do.
Washington	98	39	2	3	Do.
West Virginia	85	55	2	2	Do.
Wisconsin	122	71	1	6	Strong.
Wyoming	106	21	0	4	Slight.

PORTO RICO.—The chief need is revision of stations and the occupation of one or more repeat stations.

ALASKA.—A considerable amount of magnetic work has been done along the main lines of travel, but little of it is recent. The occupation of stations along the outer coast from Nome to Demarcation Point emphasizes the fact that we have little magnetic information for the interior of Alaska. Observations are needed along the line of the Government railroad. There is especial need for observations

along the Aleutian Islands owing to the fact that the great circle course of the Pacific coast of the United States to the Orient passes close to these islands; also to the islands in the Bering Sea. The small value of the horizontal force and lack of knowledge of the values of the declination and possible fluctuations makes navigation precarious. It will take several years of continuous work in Alaska to obtain needed information.

HAWAII.—Occupation of repeat stations and revision of stations is needed.

GUAM.—Magnetic surveys have been made by this bureau, but advantage should be taken of a stop by transport at Guam to occupy one or more repeat stations.

PHILIPPINE ISLANDS.—Occupation of repeat stations and revision of stations is urgently needed, and this work should be taken up without delay. It is only because we know from observations at Manila that the secular change is slight at the present time that this lack of magnetic resurvey has not resulted in placing erroneous values of the declination on the charts of the Philippine Islands.

OBSERVATORIES.—Each of the observatories is now furnishing a complete and continuous record of the values of the magnetic elements. As these instruments record only the variations, determinations of the absolute values are made frequently. The result of this work is that at five widely scattered places within the jurisdiction of the United States—namely, Vieques, P. R.; Cheltenham, Md.; Tucson, Ariz.; Sitka, Alaska; and near Honolulu, Hawaii—continuous values of the magnetic elements are available. As a result it is possible to reduce the values obtained in the field surveys to the standard value. Need for this is indicated by the statement that without such correction the change in declination from year to year could not be furnished. The observatory records show magnetic storms for periods when the actual values differ more or less from the normal values. The observatories near the seacoast have an important function in that they indicate the rates of change from year to year over adjoining sea areas. This makes it unnecessary to remeasure the declination at frequent intervals.

Even with the old type seismograph in use at all except one station a great amount of useful information in regard to earthquakes has been obtained. The observatories are in a position to do a much higher grade of seismological work if made of primary importance as a function of the work. The five observatories named do not provide all of the needed information. There is urgent need for an additional observatory in the Canal Zone.

SEA OBSERVATIONS.—This bureau has not made magnetic observations at sea for a number of years, as it has been felt that the observations of the *Carnegie*, combined with shore observations along the coast, give all necessary results. There is urgent need, however, for observations in the shallow waters along the Atlantic coast. The *Carnegie* recently found a difference of 1° from the charted value in the entrance of the Chesapeake Bay. This occurrence in a region of dense navigation might readily be duplicated elsewhere. The difficulty is that the *Carnegie* has demonstrated the vast superiority of the nonmagnetic vessel for such work. It appears that a nonmagnetic launch or else a scow which can be held in a given direction is urgently needed. It should be understood that in most cases

present values for most of the bays and inlets are deduced from shore observations, and accordingly the charts do not show areas of local disturbances.

PACIFIC COAST.—There is a great need for magnetic observations from southern California to Point Barrow, especially from San Diego to Unimak Pass. Insufficient observations have been made along the coast in the path usually followed by vessels between San Diego and Puget Sound. Except for recent work by the *Lydonia* off the California and Oregon coasts, comparatively few observations have been made in recent years in the waters of Puget Sound and tributaries and other inside waters in the State of Washington. There remains to be done a large amount of work in southeastern Alaska, though useful results have been obtained by the *Surveyor* and *Wenonah* in the general vicinity of Ketchikan and to the westward. The *Explorer* has done a very considerable amount of magnetic work in the general vicinity of Juneau and Skagway.

The investigations by the *Explorer* in 1920–1922 indicate that it is possible to make a magnetic survey of a region of very marked local disturbance which includes a water area. Magnetic observations are needed along the coast of the Gulf of Alaska. Even though present navigation is slight, more observations should be made in Bering Sea. This is a region of much fog and of strong currents, and navigation is still further handicapped by lack of complete magnetic information.

TIDE AND CURRENT WORK.

It is the aim of the bureau to keep in the lead among other maritime nations in the economy of securing tidal and current results, as well as in the accuracy of the data furnished engineers, mariners, and scientists. This has led the members of the tides and currents division of this survey to be on the alert in the development of instruments along modern lines—to secure accurate results at a minimum of cost.

The tide-predicting machine, designed and constructed at this office, which was put in operation in 1910 and used continuously since that time in the prediction of tidal and current data for the annual tide and current tables, is an example of this policy. Descriptions of this wonderful machine have appeared in many of the scientific journals of the world and, therefore, none will be made in this report, except for the statement that it will do the work of a larger number of mathematicians working continuously and even then turn out results equally accurate.

Along these lines the survey has recently designed and established at its principal tidal stations staffs and backing pieces of standard design, which not only will permit the securing of a more accurate zero of staff over a long period, but also tend strongly toward economy in the manufacture of parts which are standard.

With a view to economy as well as accuracy in the securing of tidal data by the different field parties for the production of charts, the bureau has during the past year developed and built a compact field automatic tide gauge which will require a minimum of time for installation and maintenance and at the same time take the place on the hydrographic surveys of expensive and often unreliable tide

observers. The development of such instruments has permitted the survey to keep abreast of other nations along tidal lines, so that the tide tables issued by the United States have been brought to a standard ranking well with those of other nations.

Although the harmonic analysis which is made use of in the prediction of tides has not yet reached a state of perfection, further study of the method may be made from the observations at the representative tidal stations maintained for other purposes by the bureau at the larger ports along the coasts.

The survey has been less fortunate in the study of currents, a subject very vital to the safety of shipping. This matter has not been neglected because of lack of interest nor lack of knowledge of the great importance of such work, but because of the fact that the securing of information on currents is far more expensive than that of the securing of tidal data, and the meager appropriations of past years have not been sufficiently large to obtain even preliminary observations. With the present appropriation continued from year to year, so that a systematic program of current observations may be carried out for a number of years, we may expect to build up current tables ranking with those of other nations and furnishing to mariners information on currents for all our coasts and harbors of vital importance to the safety of shipping and to engineers in the development of our harbors and the protection of our coasts against erosion.

A beginning is being made in New York Harbor through a recent appropriation by a systematic and thorough current and tidal survey of that harbor. Such surveys should be made of all the harbors of the United States, taking them up each year in the order of their commercial and military importance. These surveys will furnish necessary data to engineers charged with the development of the harbors both for commercial and military and naval purposes and to the mariner in furnishing him more accurate predictions for the berthing of large vessels where strong currents make it hazardous and at times impossible to berth large vessels except very near to the times of slack water.

While little progress has been made in the study of tidal currents, even less has been made in the matter of wind-driven currents along the open coasts, and these, too, are of even greater importan e to the mariner, looking to the safety of his vessel in thick weather when he is unable to fix his position by either terrestrial or celestial objects, with his vessel beset by unknown currents. The survey has made use of every available means of securing observations for the study of coastal currents. The cooperation of the Lighthouse Service and mariners has been obtained in the securing of observations on these currents. What is now needed are short series of observations made by a survey vessel at designated vital points between light vessels which will link together the observations made at these light vessels. A beginning was made during the past winter between Alaskan seasons by the steamer *Surveyor*. This should be continued from year to year until the whole coast line has been covered. The methods used by the survey in the observation and reduction of currents are such that the wind currents and the tidal are deduced from the same set of observations.

Under physical oceanography, comprising miscellaneous oceanographic observations and computations for the purpose of furnishing information relative to densities, temperatures, ocean currents, and related matters to navigators, engineers, and scientists, very little has been done and much is required to bring our state of knowledge and amount of information to that of other even less important maritime nations. At our door is the Gulf Stream, a study of which is one of the most important items in oceanography, which should be continued by the survey. Considerable work of a reconnaissance nature was done a number of years ago by the Coast and Geodetic Survey in this important field, but lack of funds has not permitted further work. At present the survey is making use of every available means for the securing of densities and temperatures. These are now being secured at 13 of the principal tidal stations maintained by the survey.

Tidal bench marks are necessary to all engineers engaged in marine work in the vicinity of our coastal and harbor waters and, since the survey is the only organization of the Government service which has a strictly tidal division, it is evident that these bench marks must be furnished by this bureau. The most economical way of establishing these bench marks is in connection with the hydrographic surveys made by this bureau for the charting of the coasts, connected into long series by simultaneous observations at the principal stations maintained by the survey, and it is this system that the bureau is following.

At a number of points along the coasts the Coast and Geodetic Survey has for many years been establishing by means of tidal observations made at its principal stations bench marks defined by a mean sea level datum. These are furnished to engineers throughout the country and other Government bureaus. Many of these bench marks are at old stations, discontinued after a sufficient number of years of observations to define an accurate mean sea level, and the series of tidal observations which they protect and perpetuate are in danger of being lost. The preservation of these bench marks is giving the survey great concern, for these stations should be visited, old bench marks recovered where possible, and the new standard disk bench marks installed. This is at present being done at the stations now maintained by the survey, but lack of personnel and funds are preventing the revisiting of old stations of many years standing. This important work, however, should not be delayed longer, for these bench marks protect in many cases long series of tidal observations costing thousands of dollars and the duplication of which would not only require many thousands more but many years.

To the present time new bench marks have been established and old ones releveled only in connection with other survey work, and while this makes for economy and will be continued, there is still great need for a special tidal bench mark party for reestablishing of bench marks at stations which have been discontinued. At any one station this work will be necessary only every 10 years.

CHAPTER III.

PROGRAM FOR CURRENT FISCAL YEAR IN THE FIELD.

HYDROGRAPHIC AND TOPOGRAPHIC WORK.

ATLANTIC COAST.—*Offshore hydrography.*—The steamer *Bache* will continue southward the offshore work already accomplished in the vicinity of the entrance to Chesapeake Bay. This work will extend from close inshore to the 100-fathom curve.

The steamer *Lydonia* when relieved from work on the Pacific coast will continue southward the offshore work already accomplished in the vicinity of St. Augustine, Fla. This work will extend from the 5-fathom curve to the 100-fathom curve.

The steamer *Hydrographer* will complete the inshore work in the vicinity of the Chandeleur Islands, and upon completing this will take up work in the Florida Keys, extending the work already accomplished to Sombrero Key toward Miami, Fla., or do work in the vicinity of Sabine Pass, Tex., developing the shoal area out to the 20-fathom curve.

Wire-drag work.—Wire-drag work will be resumed next spring on the New England coast by one party if the appropriation for the fiscal year 1924 is sufficient to continue this work into the first half of that year. Otherwise this work must be deferred until the appropriations make it possible to work through an entire summer.

Inshore hydrography and topography.—If funds are available the latter part of the fiscal year, inshore hydrography from Bull Bay to Winyah Bay will be completed, and this class of work will be continued from Savannah southward. Work will include besides inshore hydrography a topographic revision of the shore line and will be accomplished by parties working from the launches *Mikawe* and *Elsie*.

PORTO RICO AND VIRGIN ISLANDS.—*Wire drag and hydrography.*—The steamer *Ranger*, with wire-drag launches, will continue dragging the navigable waters between Porto Rico and Virgin Islands and on completion of that work will extend the drag survey to the waters surrounding the Virgin Islands. The party will also resurvey all of the harbors of the Virgin Islands.

PACIFIC COAST.—*Offshore hydrography.*—The steamer *Lydonia* will continue the offshore hydrography in the vicinity of Cape Blanco, Oreg., until relieved by another vessel, which will carry that work to completion there. A vessel will take up offshore soundings in the vicinity of San Diego and Los Angeles Harbor this fall, extending the work from the completed work close inshore to the 100-fathom curve. This work will be extended northward and will be prosecuted continuously, appropriations permitting, during succeeding winters, vessels alternating between these waters and the northern Pacific waters, so as to take the best advantage of favorable working weather.

Inshore hydrography.—The steamer *Natoma* will upon completing the survey of San Francisco Bay take up hydrographic and topographic revision work in Puget Sound if funds are available to maintain that vessel throughout the year.

SOUTHEASTERN ALASKA.—*Offshore hydrography.*—The steamer *Surveyor* will continue on the offshore hydrography and the combined operations, triangulations, topography, and hydrography upon which she was engaged during this fiscal year. It is contemplated that this work be continued without interruption to Cross Sound, as much work as possible being done each year.

Wire drag.—The steamer *Explorer* will continue wire-drag operations and such hydrographic and topographic work as may be needed to supplement the work already accomplished along the main inside ship channels from Lynn Canal through Cross Sound and Icy Strait to Cape Spencer. Upon the completion of this work the main ship channels of Southeastern Alaska will have been completely covered by the wire drag. The next work for this party will be the dragging of the more important side passages and those arms and bays to which vessels go regularly.

Inshore hydrography.—The steamer *Wenonah* will execute such hydrography and topography as may be necessary to supplement the work already accomplished in Clarence Straits, Ernest Sound, and Zimovia Straits, so all data may be available which are necessary for the construction of a large-scale chart of this locality. Upon the completion of this work during the fall of 1922 the *Wenonah* will be discontinued as a surveying vessel.

Precise triangulation.—During the last two fiscal years precise triangulation has been executed by ship parties for the first time. This work has been done in connection with the wire-drag work, hydrography, and topography assigned to the vessels. At the end of the present fiscal year, with the exception of a small gap in Dry Straits, an arc of precise triangulation will have been completed extending from Dixon Entrance along the inside passage to Skagway, Alaska. This arc will eventually be connected at Dixon Entrance with a similar arc of precise triangulation now being executed by the Canadian survey, upon the completion of which it will be possible to compute all points in southeast Alaska on North American datum.

WESTERN ALASKA.—*Triangulation, hydrography, and topography.*—One of the new vessels will be employed during the latter part of the fiscal year 1923 in extending the triangulation, hydrography, and topography executed in Shelikof Straits by the party on the steamer *Surveyor* in 1919 westward toward Chignik Bay. The steamer *Yukon* will also be used by this party. If funds are available, one of the new vessels will take up hydrographic work in Prince William Sound next spring and extend the work westward to Resurrection Bay. One of these vessels will also, if practicable, make a complete survey of Kachemak Bay and a resurvey of a part of Cook Inlet, in which there have been extensive changes in depth since the last survey.

PHILIPPINE ISLANDS.—*Triangulation and hydrography.*—Three vessels, the *Pathfinder*, *Fathomer*, and *Marinduque*, will operate during the fiscal year in continuation of the projects on which they are

now engaged. This will include general survey operations on the west coast of Palawan Island and work in the southern part of the Archipelago.

GEODETIC WORK.

TRIANGULATION AND SIGNAL BUILDING IN NEW MEXICO AND COLORADO.—This is the continuation and completion of the arc of triangulation along the one hundred and fourth meridian from the vicinity of Pecos, Tex., northward to the junction with the thirty-ninth parallel triangulation just east of Colorado Springs. This line crosses the unadjusted arc of triangulation extending from Oklahoma to Pheonix, Ariz., and will permit of the proper adjustment of both these major arcs.

TRIANGULATION IN IDAHO AND MONTANA.—This begins an arc of triangulation along the one hundred and eleventh meridian from Pocatello to the Canadian boundary. It is hoped to reach the boundary with this triangulation by the end of the fiscal year 1923.

TRIANGULATION IN WASHINGTON.—Starting from the Utah-Washington arc of triangulation in the vicinity of Umatilla, Wash., a party in the spring of 1923 will begin triangulation northward toward the Canadian boundary. This, together with the triangulation along the one hundred and eleventh meridian, is part of the scheme of triangulation in the Northwestern States which is a necessary adjunct to the proposed triangulation to be executed in conjunction with Canada along the forty-ninth parallel.

TRIANGULATION IN ALASKA.—It is hoped to continue the operations along the proposed line of triangulation from Cook Inlet toward Fairbanks, Alaska. The country to be traversed is very difficult and expensive for precise triangulation, but such control is so badly needed in the interior districts that the expense is fully warranted.

LEVELING IN ALASKA.—A good beginning was made during the latter months of the fiscal year 1922 on a line of precise levels along the railroad from Cook Inlet toward Fairbanks. These levels will be continued by one party during all the months of the fiscal year 1923 when it is possible to perform such operations. The line of levels will extend to Fairbanks, then down the mail route to Valdez.

PRECISE LEVELING, ILLINOIS AND WISCONSIN.—This leveling has been requested by the U. S. Geological Survey and will extend from Duluth to Green Bay, Wis., over the route of the precise traverse line executed last year. There will also be a line of levels from Vandalia to Cairo, in southern Illinois. It is expected that both these projects will be finished during the first half of the fiscal year.

LEVELING, LAKE CHAMPLAIN TO PORTLAND, ME.—This line was begun in the fiscal year 1922, and it is expected that it will be finished to a junction with the tidewater bench marks in Portland by the end of field work this autumn.

LEVELING IN CONNECTICUT.—A party will be organized in September, 1922, to run a line of precise levels from New York to the vicinity of Providence. This is part of the proposed trunk line of precise levels to extend along the coast from Portland to New York, and it is being undertaken out of turn at the urgent request of the

officials of the highway department of the State of Connecticut who have in contemplation an elaborate system of levels on which their highway system of surveys will be based.

MEASURING STANDARD BASE IN CALIFORNIA.—During the winter months a very precise determination will be made of the distance between two mountains in southern California which will be used as a test line for standardizing an apparatus for measuring the velocity of light. This apparatus after being so standardized can then be used, it is hoped, in measuring bases of secondary accuracy. In regions where base sites are difficult to obtain, as in southeastern Alaska, this may result in great savings on triangulation operations. The base measuring and triangulation used in determining the distance between two mountains will be of such character as to give an absolute error for the required distance of not more than one part in 500,000.

WIRELESS LONGITUDE.—A party is now in the field, using an apparatus which records radio time signals for longitude determinations. The apparatus gave satisfactory results in Wisconsin and is now being used in Colorado and New Mexico. It is hoped that the apparatus as at present constituted will record radio time signals on the western coast and in southeastern Alaska, in which case it will be used in the latter country next spring at Laplace stations along the arc of precise triangulation. Such stations are needed before the triangulation can be adjusted.

GRAVITY OBSERVATIONS.—A gravity party, using trucks as a means of transportation and a radio recording apparatus for receiving time signals, will be kept in operation during the summer and autumn months of 1922 and, if funds permit, will take the field again in the spring of 1923. The remainder of the appropriation for State surveys will be spent on the purchase and repair of instruments, etc. The appropriation for the surveys of the earthquake regions for the current year will be used exclusively on triangulation. A party is now in the field reobserving at old stations of the thirty-ninth parallel triangulation, on the Nevada-California boundary. This triangulation will be extended over previously observed schemes to the westward toward the San Andreas fault of 1906. About two-thirds of the appropriation will be spent during the first half of the fiscal year, and the remainder will be spent on similar triangulation during the spring of 1923.

MAGNETIC WORK.

Two magnetic observers will be continuously at work in establishing new stations, occupying repeat stations, and revising and replacing old stations. One party will continue the systematic replacement of old stations and the establishment of meridian lines where desired at all of the county seats in Florida during the winter. Especial attention will be given to the north-central group of States and the middle western group, also the west coast and New England, in order that accurate record can be kept of the secular change at the present time.

If practical, some work will be done in Maryland. One observer will spend a part of the year in investigating areas of local disturbances, both to determine the economic value of magnetic meth-

ods in searching for iron ore under certain conditions, and to study the more general problem of widespread local disturbances which affect the operations of the land surveyor using magnetic instruments. These problems will be given further study, the need for which is evidenced in the statement that approximately one-third of the area of the United States is affected by local disturbance.

The five observatories will continue the magnetic and seismological work as usual, buildings and equipment will be maintained, and improvements made as found necessary. Attention will be given to the replacement and improvement of instrumental outfits for field and observatory use.

TIDAL AND CURRENT WORK.

During the following fiscal year it is proposed to continue, between Alaskan seasons, the short series of current observations in the long stretches between light vessels begun last year by the *Surveyor* off the coasts of Washington and Oregon. In order to utilize fully the series of systematic current observations made on the different light vessels on the Pacific coast during the past few years in the building up of satisfactory and useful current tables for the use of the coastwise mariner, these short series are necessary along the comparatively long sailing lines between these light vessels for the purpose of linking together the current conditions along the whole coast. This addition to the regular program of tidal and current work will necessitate a curtailment of other very important normal activities, but vital information obtainable should not be longer kept from the mariner on this coast, where the current conditions are most complicated and strandings of frequent occurrence.

Early in the fiscal year, in cooperation with the Army engineers, it is proposed to carry out an extensive and final current and tidal survey of the harbor of New York, for which an appropriation was made by the last Congress.

Principal tidal stations representative of tidal conditions along the different stretches of coast will be continued at the following places:

Portland, Me.
Boston, Mass.
Delaware Breakwater, Del.
Philadelphia, Pa.
Baltimore, Md.
Charleston, S. C.
Fernandina, Fla.
Key West, Fla.
Cedar Keys, Fla.
Galveston, Tex.
San Diego, Calif.
San Francisco, Calif.
Seattle, Wash.
Ketchikan, Alaska.

The tidal station at Anacortes, established for the purpose of defining a mean sea level datum for connecting the Canadian and American precise leveling, will be continued during this fiscal year; also the tidal station established at Anchorage, Alaska, during the fiscal year for the purpose of defining a mean sea level datum for controlling the precise leveling in this section of Alaska.

In order to carry out the field work on currents at intermediate stations on the Pacific coast as previously outlined, it has been found necessary to curtail somewhat the current observations on the light vessels on both coasts. On the Atlantic coast observations will be continued only on Nantucket Shoals and Diamond Shoals for the

full year and at Fire Island, Ambrose Channel, Scotland, and Cornfield Point Light Vessels for the period of the current and tidal survey of New York Harbor. On the Pacific coast current observations will be discontinued temporarily at all light vessels except Blunts Reef. Observations on all the vessels on the Pacific coast, however, will be resumed when the survey vessel begins observations at intermediate points along the coasts.

It is part of the program of the tidal and current work for this fiscal year to continue the installation of standard staffs and backing pieces to replace the old type staffs at all the principal stations maintained by the survey. In order to maintain a fixed zero of staff, a most essential matter in securing a long series of tidal observations, tide staffs of standard design with special backing piece, cap, and stop were designed in this division in 1920, and installations of these are being made as the different stations are visited, until all the principal stations are so equipped.

It is planned to have a party visit the locations of as many tidal stations and discontinued tidal stations during the fiscal year as the modest appropriation will permit for the purpose of leveling to old nonregulation bench marks as they may be recovered and installing sufficient standard disk bench marks to comply with the present policy of the bureau of maintaining five bench marks at all stations having a year of observations and one additional for each additional year of observations to a maximum of 10 disks. This work is absolutely necessary in order to perpetuate long series of observations which are now protected by a few nonregulation bench marks, many of which have been destroyed and others in danger of being lost.

Datum planes for the use of the engineer and mariner based on tidal definition are the only ones which lend themselves to coordination of surveys widely distributed and subsequently brought together. The survey has for many years by means of its principal and subsidiary tidal stations established bench marks and is furnishing to engineers in all parts of the country descriptions and elevations of such bench marks based on mean sea level. Since an accurate determination of mean sea level can be obtained only from a comparatively long series of observations, the value of such bench marks and the importance of their preservation is apparent.

It is a part of the program of field work to reestablish the tidal station at Atlantic City, N. J., which was discontinued during extensive repairs to the pier on which the station was located. The importance of this station lies in its being the only station at present maintained by this survey on the open ocean.

It is proposed to maintain a tidal station at Washington, D. C., for the purpose of testing, under the immediate supervision of this office, new instruments and appliances for the observation of tides. The hiring of an observer for this station during this year is not contemplated, but to use the station under the supervision of this office only at such times as tests of instruments are in progress.

Part IV.—DETAILED STATEMENT OF FIELD WORK.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, ATLANTIC COAST.

MASSACHUSETTS.

[Lieut. Commander W. C. HODGKINS, July 1, 1921, to March 21, 1922; Clerk HORACE F. RUSSELL, March 22, 1922, to April 30, 1922; Lieut. Commander D. B. WAINWRIGHT, May 1, 1922, to June 30, 1922.]

The work of the field station has been continued throughout the year and included the distribution and sale to the public of charts and nautical publications, gathering and supplying information in regard to surveys, aids and dangers to navigation, changes in shore line and depths, channels in harbors, improvements, tides and currents, and all matters affecting the charts, coast pilots, and tide tables.

Information and charts were supplied in response to numerous requests from the Army, Navy, Coast Guard, and other branches of the public service, and charts and publications were also furnished sales agents of the survey to enable them to comply with emergency calls or meet unusual demands.

The duties of the station include the supervision of the tide station at South Boston.

NEW YORK.

[Lieut. Commander ISAAC WINSTON, July 1 to October 31, 1921, and April 10 to June 30, 1922; Lieut. Commander D. B. WAINWRIGHT, November 1, 1921, to April 9, 1922.]

During the fiscal year the work of the New York field station has been continued as heretofore. The duties assigned to the station include the sale and distribution of Coast and Geodetic Survey charts and nautical publications; furnishing information and publications to Government officials, and sale of charts and publications to the public; also the inspection of agencies for the sale of charts in New York City and vicinity; the collection of information in regard to dangers of navigation, changes in buoys and lights; new structures on the coast; improvements in channels and harbors; observations of tides and currents, and all other matters affecting the charts, coast pilots, and tide tables.

Tidal data were furnished for publication in 12 principal daily papers published in New York City and also for use in almanacs, calendars, and other publications.

Shipments of freight by steamer from New York to vessels and parties of the survey were supervised by the field station.

Tidal and other information was furnished in a number of admiralty cases and the inspector appeared as a witness in the United States district court several times.

Cordial relations were maintained with the branch hydrographic office of the Navy Department, the Maritime Exchange, City Dock Department, and other Federal and municipal bureaus.

During the continuance of the Motor Boat Show in New York from February 17 to 25, a clerk was detailed from the field station to render all possible assistance to the officer in charge of the bureau exhibit, and the inspector was present on several evenings.

Consultations were held with the officers of the U. S. Engineers in regard to a tidal and current survey of New York Harbor.

PENNSYLVANIA AND DELAWARE.

[PAUL SCHUREMAN.]

In compliance with instructions dated May 2, 1922, and after conference with the department of docks and ferries, and the settlement of preliminary details, a tide station was established on Pier No. 9, north, Philadelphia, search was

made for old bench marks, new standard disk bench marks were set, and levels were run between the tide staff and bench marks. The work in Philadelphia was completed May 22.

On May 25 a new standard portable tide staff was installed at Lewes, Del., levels were run, the tide station inspected, and the observer instructed in his duties. The work at Lewes was completed May 28, and the observer returned to the office at Washington.

DELAWARE AND MARYLAND.

[L. A. COLE.]

In July the tide station on the iron pier at Breakwater Harbor, Lewes, Del., was inspected and the observer was instructed in the method of making temperature and density observations and the care of the tide gauge. The tide staff was connected by spirit leveling with 12 recovered bench marks and 5 newly established bench marks.

During the same month a visit was made to the tide station at the proving ground at Aberdeen, Md. The gauge was found to be in bad condition and the substitution of another gauge was recommended. Two bench marks were connected by spirit leveling with the tide staff.

VIRGINIA.

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

SUMMARY OF RESULTS.—Triangulation: 3 stations in main scheme occupied for horizonta measures. Topography: 16 miles of shore line surveyed. Hydrography: 1,550 miles of area covered; 2,926.8 miles run while sounding; 45,655 soundings made.

The resurvey of the approaches to Chesapeake Bay, under instructions dated February 8, 1921, was in progress on July 1, 1921, and continued until October 5, 1921. On this latter date the command of the *Bache* was transferred to Eoline R. Hand.

The field work executed in this period consisted of launch hydrography, ship hydrography, topographic traverse for location of signals, and intersection triangulation to locate signals.

The hydrography, consisting of launch inshore hydrography, ship inshore hydrography, and ship offshore hydrography, was extended from the limits mentioned in the annual report of June 30, 1921, to the latitude of Hog Island Lighthouse. This area extends from latitude 38° 08′ to latitude 37° 20′ and from longitude 74° 30′ to the shore line about 75° 45′. All hydrography has been completed and all shoals in this area have been developed, giving a finished survey of this area.

The launch hydrography was extended from shore to about the 3-fathom curve and from the vicinity of Cape Charles Lighthouse to Hog Island Lighthouse. A close development was made on the approach to Ship Shoal Inlet and Great Machipango Inlet.

The ship hydrography extended from the 3-fathom curve to the 100-fathom curve. In general, the lines were spaced one-quarter mile apart to the 10-fathom curve, a half mile from the 10-fathom curve to the limits of the inshore sheets, 1 mile apart from the outer limit of the inshore sheet to the 25-fathom curve, and 4 miles from the 25-fathom curve to the 100-fathom curve. The area covered by the ship hydrography is exceedingly irregular, and a great deal of development was necessary, especially along the line of the survey buoys about 12 miles offshore.

The development of the 48-foot spot, as called for in paragraph 7 of instructions of February 8 was completed. No shoaler water was found at this time than was found in 1919. In developing this area a slightly different procedure was followed from that outlined in the instructions. The shoal was found by sounding and a buoy dropped about the middle of it. The position of this buoy was determined by precise dead-reckoning methods. Lines were run from this buoy as an origin. Positions on the lines were determined by a method similar to that outlined in Tables 33 and 34 of Bowditch's "American Practical Navigator." An observer was stationed in the crow's nest of the ship and observed the sextant angle between the buoy to the horizon. A table was compiled using the height of the crow's nest from the water's edge to correspond with Table No. 34 mentioned previously. A launch was made fast to the buoy

and an observer stationed in the launch to observe the sextant angle between the fore truck of the ship and the water line. A table was compiled using the distance of 70 feet to correspond with Table No. 33, mentioned above. These angles were observed simultaneously at a signal from the ship. A mean of the distances, as found by these two methods, was taken as the distance between the ship and the buoy at the time of observation. The direction of the buoy from the ship at the time of the sextant observation was observed by standard compass. Using this method it was possible to control very accurately the position of the sounding lines with reference to the buoy and by plotting the soundings as the work continued and drawing in a depth curve very satisfactory development was made.

A similar procedure to this was used in developing another shoal to the northward and considerably outside the limit of visibility of either shore signals or buoys.

In order to complete the hydrography to the latitude of Hog Island Lighthouse, a tall hydographic signal was necessary at the southern end of Parramore Island. This signal was built by a detached party living ashore. This signal was about 110 feet high and was completed during the first two weeks in September.

A traverse was run with plane table to locate the tall hydrographic signal built at the southern end of Parramore Island. This traverse was started from Hog Island Lighthouse. As there were no fixed positions available for tying this traverse in at the northern end, the traverse was run with more than the usual care and the position of the signal was checked by sextant cuts from offshore. This plane table work was done by an officer of the vessel.

The signals between Ship Shoal Inlet and Hog Island, three in number, were located by triangulation cuts from Cape Charles Lighthouse, Mockhorn Island, and Hog Island Lighthouse.

The launch hydrographic party, topographic traverse party, signal building party, and triangulation party were subsisted ashore during the entire time they were engaged in these operations.

The automatic tide gauge was continued at Assateague Harbor. In addition to the Assateague Harbor tide station, the tide staff on Fisherman's Island was continued.

The same type of survey buoy as was described in special report of August 13, 1921, was used this season. Some difficulty was experienced in maintaining the buoys during the storms. Several went adrift and were lost. It is thought that the anchor pendant had parted, probably through twisting, as one buoy picked up toward the end of the season showed that this had happened. In all, nine survey buoys were built during the season, and at the date of transfer of command five were still in position.

In accordance with paragraph 9 of instructions of February 8, considerable work was done in testing the radio compass bearings from Hog Island, Virginia Beach, and Poyners Hill. At points where the position of the ship was known by three-point fixes, bearings were obtained at frequent intervals, while on the dead-reckoning lines offshore bearings were obtained at each anchorage. The errors of these bearings were tabulated and were forwarded each week to the district communication superintendent at the naval operating base, Norfolk. In the latter part of August, after a thorough inspection of the radio compass stations by the naval authorities, it was decided to rebuild all of them and no further work along this line was done. The results obtained previous to that time had been very unsatisfactory, the errors being widely distributed for no apparent reason. Plotting these errors was tried both according to distances and according to azimuths, but the resulting curves were so irregular that they could not be standardized with sufficient accuracy for the rigid requirements of the work. From the results obtained, however, the radio compass stations mentioned herein appear to be sufficiently accurate for a navigator's purpose and he could enter the Chesapeake Capes with a combination of radio direction positions and soundings without fear.

Great Machiponga Inlet makes an excellent harbor, especially in westerly weather. Unfortunately, it is bar bound and the bar breaks heavily in easterly weather. The bar has a least depth of 16 feet according to our survey and is amply buoyed.

The best approach to Sand Shoal Inlet seems to be from the southward in place of the northeast channel in use at present. Before the southeast channel can be used, however, it should be buoyed.

The projections used on this work were: Two on a scale of 1:40,000 and one on a scale of 1:120,000.

VIRGINIA AND MISSISSIPPI.

[Lieut. E. R. HAND, Commanding Steamer *Bache*.]

SUMMARY OF RESULTS.—Hydrography: 40.4 square miles of area covered, 122.4 miles run while sounding 300 positions determined (double angles), 1,659 soundings made, 1 tidal station established, 3 current stations occupied, 2 hydrographic sheets finished, scales 1:40,000, 1:120,000.

From October 5 to 27 the *Bache* continued the unfinished hydrographic work off Chesapeake Bay entrance that had been begun by another commanding officer. From October 28 to November 29 the vessel was undergoing repairs and refitting at Norfolk, Va. On November 30 the *Bache* sailed for Gulfport, Miss., arriving December 11. From that time until the end of December preparations were made for the season's work. Signals were built and hydrographic work begun.

NORTH CAROLINA.

[Lieut. (Junior Grade) H. W. HEMPLE.]

SUMMARY OF RESULTS.—Triangulation: 2 square miles of area covered; 1 station in supplemental scheme occupied for horizontal measures; 1 geographic position determined. Leveling: 4 permanent bench marks established; 1¼ miles of levels run. Topography: 1.5 square miles of area surveyed; 5.57 miles of detailed shore line surveyed; 0.28 mile of shore line of creeks surveyed; 5.25 miles of roads surveyed; 1 topographic sheet finished, scale 1:5,000. Hydrography: 70 square miles of area covered; 13.60 miles run while sounding, 280 positions determined (double angles); 1,475 soundings made; 1 tidal station establised; 1 current station occupied; 1 hydrographic sheet finished, scale 1:5,000.

Between August 18 and September 8, 1921, a detailed hydrographic survey was made on the offshore side of Cape Hatteras, N. C., from the beach out to the 3-fathom curve and from three-quarters of a mile south of Cape Hatteras Lighthouse to three-quarters of a mile north of the light.

One new triangulation station Shore was established to replace Beach which had been occupied in 1909. The position of Shore was computed from angular measurements on known points.

Starting from station Shore a traverse was run on a sheet, scale 1:5,000, and 5 signals were located. Work was done on this sheet when hydrographic work was impracticable on account of unfavorable weather.

As the hydrography was to be done in considerable detail it was thought best to run the lines out by means of ranges established on shore.

While the soundings were being taken, a tide staff erected in 10 feet of water, just beyond the inner bar about 100 yards beyond high water mark, was read every 15 minutes. Four bench marks were established and connected with the tide staff by leveling.

Observations of currents were made at frequent intervals.

The bottom of the area covered is in general hard sand, except just inside the inshore ends of the lines, where the bottom comes up very quickly, and in some cases forms a bar about 100 feet wide, which bares at low water.

SOUTH CAROLINA.

[Lieut. Commander R. F. LUCE, in Charge of Launch *Mikawe*.]

SUMMARY OF RESULTS.—Triangulation: 76.9 square miles of area covered; 16 signals erected; 14 stations occupied for horizontal measures. Topography: 18.5 square miles of area surveyed; 56.1 miles of shore line surveyed; 22.4 miles of shore line of creeks, sloughs, and shoals, etc., surveyed. Hydrography: 90.3 square miles of area covered; 700.8 miles run while sounding; 3,520 positions determined (double angles); 17,637 soundings made; 4 tide stations established; 6 bench marks established.

During the period from July 1 to October 8, 1921, the party on the launch *Mikawe* was engaged in surveys on the coast of South Carolina as follows: Offshore work from Frampton's Inlet to Winyah Bay; location by triangulation of Navy radio compass station at Folly Island, Lighthouse Inlet; additional surveys in entrance to St. Helena Sound and in Charleston Harbor.

During this period the parties on the launches *Mikawe* and *Elsie III* were working in cooperation with each other and the work was divided between them.

Only such triangulation was done as was necessary to furnish control for the topography and hydrography.

The naval radio compass station at Folly Island was located by triangulation and a distant object was located for the calibration of the compass station.

In order to provide control in the vicinity of Stono Inlet and to locate stations along the coast between North Edisto River and Stono Inlet, the quadrilateral Charleston Lighthouse, Bass, Key, and Ville was observed in accordance with the requirements for tertiary triangulation. This gave a correct location for stations Kiawah and Ponds.

The topography done during this period included the mapping of the shore line and contiguous territory to about a mile in from the shore, including creeks, inlets, sloughs, low-water line where possible, and shoals offshore along the coast as follows: Connecting with work done during the previous season, along the coast from Kiawah Inlet to the Quarantine Station; Charleston Harbor, including both jetties; the shores of Stono Inlet and River to the junction of the Stono and Kiawah Rivers; the shores of Folly River to the new highway bridge over the river; the shores of Lighthouse Inlet; and one day's work at Hobcan Point, Charleston Harbor.

The hydrography included the area along the coast from Kiawah Inlet, connecting with work done during the previous fiscal year to the north jetty at Charleston Harbor, extending from the shore line out to a junction with the work by the steamer *Isis*, about 4 miles offshore, except for a small area left unfinished; inside work in the Stono, Folly, and Kiawah Rivers and Stono and Lighthouse Inlets; a large piece of close development work in the entrance to St. Helena Sound; completing the work in the North Edisto River, some of which had been done in the previous fiscal year; and some work just inside the entrance.

In general, the coast hydrography was extended into all inlets of any importance to a distance of at least a mile or to a point where the depths were unchangeable. Developments were carefully made where the presence of shoals was indicated, and whenever shoals bare at low water were found a special effort was made to locate the low water on them.

An automatic tide gauge was established at Lighthouse Inlet and staff gauges at Peters Point, Edisto Sound, and Folly Island in order to obtain tidal corrections for the reduction of soundings. At each station the bench marks were recovered and new ones established where necessary and were connected with the tide staff by leveling.

At Stono Inlet extensive changes were found to have taken place in the shore line and soundings, so that the inlet had little resemblance to the representation of it shown on the chart.

[Lieut. F. S. BORDEN.]

SUMMARY OF RESULTS.—Topography: 21 square miles of area surveyed; 110 miles of general coast line surveyed; 28 miles of railroads, creeks, and sloughs surveyed. Hydrography: 110.6 square miles of area surveyed; 792.4 miles of soundings run; 3,287 positions determined (double angles); 26 515 soundings made; 1 tide station established; 3 permanent bench marks established; 2 current stations occupied; 3 hydrographic sheets completed.

On July 1 work was in progress by the party on the launch *Elsie* in making combined surveys along the outer coast from Charleston entrance to the northward for the purpose of obtaining the necessary data for publishing new charts of this area. The field work included the mapping of the entire shore line from Charleston to the east entrance point of Bull Bay, and the hydrography from the shore out to a junction with the offshore hydrography executed by the steamer *Bache* in 1917. The topographic and hydrographic work were carried up each inlet, creek, and slough until a junction was made with the older surveys. All shoals were carefully examined to obtain the least depth over them, and all inlets were developed to ascertain the depth over the bars. The work accomplished on this project is mapped on two topographic and two hydrographic sheets. Detailed descriptions of all changes found, methods employed, etc., were given on separate reports covering these sheets.

During the month of July, while working in the vicinity of Charleston, current observations were made by the party in the main entrance channel to the harbor in accordance with special instructions for this work. Approximately 60 hours of observations were obtained at a station near the outer end of the jetties. A detailed report covering this work was submitted.

On October 8 the launch *Mikawe* was also turned over to this party in accordance with instructions from the director dated October 4. Work was continued by the party on the *Mikawe* in completing the survey from Charleston

to the southward and in revision work in Charleston Harbor. The party on the launch *Elsie*, after completing the outside survey to the northern limit, was combined with the party on the *Mikawe* to complete work in Charleston Harbor.

Revision work in Charleston Harbor consisted in (1) determining the changes which had taken place by making a careful inspection of the area and by consultation with officials in Charleston; (2) revising the shore line where changes were found to have taken place; (3) locating new prominent objects by triangulation; (4) running sufficient sounding lines to determine the amount of sounding required to bring the chart up to date; (5) making special investigations called for in the instructions for this work. A considerable number of changes were found in the shore line and it was found necessary to remap the greater portion of the area. These changes were described in detail in the report accompanying the topographic sheet.

All field work was completed on November 5, and, in accordance with instructions, the launches *Mikawe* and *Elsie* were hauled out and stored, the crews discharged, officers detached, and the launches turned over to a ship keeper.

Special instructions were issued to the chief of party on August 4 to supplement the main scheme of triangulation extending from Charleston to Cape Romain with enough additional work to place a station in the vicinity of each of the stations lost, provided that this work did not interfere with hydrographic work.

As the weather was exceptionally favorable for hydrographic work subsequent to the receipt of the instructions it was not possible to replace all of the lost stations with new ones. However, enough new stations were established and permanently marked so that it is now possible to obtain a strong base distant not more than 5 miles from any point in the area. All new stations were located with the same accuracy that the original stations had. Station Middle, which was reported lost in 1919, was recovered as described. With this station and the new ones established there are now 10 of the 16 stations in the main scheme permanently marked and easily recoverable.

It was found possible in connection with the topographic work in the vicinity of Bull Bay to revise the topography of the inside route, wherever discrepancies were found between the actual and the charted shore line. The majority of the discrepancies occur at the junction of the dredged cuts and the streams which they connect. In reality the inside passage in this particular locality is more essential and of more importance to the public than the outside coast. All changes and corrections to the chart as regards the inside route were fully described in the reports accompanying the sheets.

For the reduction of soundings on the coast work, tide staffs were established at Dewees Inlet and in Bull Harbor. Both stations were close to the outside coast and the tides at the staffs and on the outside are practically simultaneous. The reference plane for the staff at Dewees was obtained by simultaneous observations with a gauge at Fort Sumter. This reference plane was also checked to the nearest tenth of a foot by a mean of 76 low waters. The reference plane for the Bull Harbor staff was obtained by simultaneous observations with the Dewees Inlet staff.

For the reduction of soundings in Charleston Harbor the record of the automatic gauge at the customhouse wharf was used.

Three permanent standard disk bench marks were established at each of the new tidal stations.

MISSISSIPPI AND LOUISIANA.

[Lieut. F. B. T. SIEMS, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Triangulation: 2 stations in main scheme occupied for horizontal measures; 2 geographic positions determined. Magnetic observations: Ship swung at 1 station at sea. Hydrography: 879$\frac{8}{10}$ miles run while sounding; 2,576 positions determined (double angles); 7,017 soundings made; 369 specimens of bottom preserved; 12 current stations occupied; scales of hydrographic sheets 1:40,000 and 1:80,000.

At the beginning of the fiscal year the steamer *Hydrographer* was engaged in hydrographic work off Southwest Pass, Mississippi Delta. Owing to trouble with the engine it was necessary to take the vessel to New Orleans on August 8 for installation of the new condenser pump and for general repairs. After

the completion of these repairs the vessel returned to Burrwood, La., on September 28 and resumed work off Southwest Pass. On December 6 the command of the vessel was transferred to Charles Shaw.

The hydrography accomplished off Southwest Pass extends from latitude 89° 17′ and from the 3-fathom curve to the 100-fathom curve, the western limit of the work being latitude 29° 00′.

The 3-fathom curve off East Bay was found to have moved inshore appreciably since the original survey, while to the westward of Southwest Pass the inshore waters have shoaled considerably. Along a line extending south between South Pass and Southwest Pass the slope of the bottom from 20 to 100 fathoms is quite regular. There is a gradual widening of the distance between the 20, 60, and 70 fathom curve upon approaching the line south-southwest from Southwest Pass. Out from the 70-fathom curve south-southwest of Southwest Pass there is an abrupt slope which apparently marks the limit of the continental shelf. A bank of 32 fathoms, consisting of small loose coral rock, was found near the toe of the bar between the 60 and 70 fathom curves.

LOUISIANA.

[Lieut. CHARLES SHAW, Commanding Steamer *Hydrographer*.]

SUMMARY OF RESULTS.—Triangulation: 2 observing tripods built, heights 52 and 44 feet; 2 observing scaffolds built, heights 60 and 55 feet. Hydrography: 10 square miles of area covered; 39.2 miles run while sounding; 135 positions determined (double angles); 282 soundings made; 9 specimens of bottom preserved; scales of hydrographic sheets 1:40,000 and 1:80,000.

During the month of December, 1921, the officer temporarily in command of the steamer *Hydrographer* continued the work of filling in splits in the hydrography off the South Pass of the Mississippi River, whenever the weather was such as to permit sounding.

During the intervals the party was employed in constructing signals for the extension of the triangulation from Breton Sound to the Mississippi Passes. A 60-foot scaffold was built at the head of the passes and a 55-foot observing scaffold and a 44-foot observing tripod at the mouth of Main Pass.

[Lieut. F. S. BORDEN, Commanding Steamer *Hydrographer*.]

During the spring of 1922 a scheme of triangulation was extended along the coast of Louisiana with a view to tying in rigidly all survey work in the Mississippi on the North American datum. The results of the triangulation as determined prior to the adjustment of the net place positions on the outer end of the delta 0.1 second to the northward and 0.6 second to the westward of their positions as computed approximately on the North American datum. The scheme started from the base Biloxi Lighthouse-Ship Island Lighthouse and was extended in 1921 by the party on the *Hydrographer* to the base triangulation Sable-Batledore-Breton. The portion covered by this abstract was done in the spring of 1922 and extends from the above-mentioned triangle to the base South Pass Lighthouse-Southwest Pass Lighthouse, at the outer end of the delta.

A base line 3.7 miles in length was measured on the east bank of the Mississippi River just northwest of Quarantine, La. The base was measured on two days, one complete measurement being made on each day.

The triangulation covered by this report comprises 27 main and base expansion triangles and 36 intersection station triangles.

The line Southwest Pass Lighthouse-South Pass Lighthouse which has been used as a base for practically all of the surveys of the delta in recent years is one of the main scheme lines in the new triangulation.

An azimuth was measured at Southwest Pass Lighthouse and referred to the main scheme.

Three lighthouses were used in the main scheme of triangulation. Other signals were of the tripod and scaffold type, averaging 45 and 55 feet in height for the tripod and scaffold, respectively. Reference marks were placed at all of the stations except the lighthouses.

While the triangulation was in progress on the delta, aerial photographs were taken in connection with mapping work. In several of the photographs taken at a height of 8,000 feet the triangulation stations in correct relation to the shore line can be clearly seen as well at the paths radiating from the signals to the reference marks.

MISSISSIPPI AND LOUISIANA.

[Lieut. EOLINE R. HAND, Commanding Steamer *Bache.*]

SUMMARY OF RESULTS.—Triangulation, tertiary: 160 square miles of area covered; 3 stations in main scheme occupied for horizontal measures. Topography: 15.2 square miles of area surveyed; 99.3 miles of detailed shore line surveyed; 4 topographic sheets finished, scale 1:20,000. Hydrography: 2,022.6 square miles of area covered; 1,404.5 miles run sounding; 1,708 positions determined (double angles); 12,011 soundings made; 1 tide station established; 80 current stations occupied; 1 hydrographic sheet finished, scale of hydrographic sheets 1:40,000 and 1:80,000.

On January 1, 1922, the *Bache* was engaged in hydrographic surveys in the Gulf of Mexico in the vicinity of the Chandeleur Islands under instructions of November 8, 1921. Work was continued under those instructions through the winter season and until May 17, when the vessel returned to Gulfport preparatory to going north. In addition to the work accomplished in the locality mentioned, a beginning was made on the hydrography about Breton Island, and a few lines were run off South Pass Light, using the submarine sentry, in an ineffectual search for reported shoals in that locality.

Some topography was done in the Chandeleur Islands but not of the groups inside. The mapping of Breton Island was done while the boat sounded in the vicinity, and at the same time a small amount of triangulation was done for the use of the steamer *Hydrographer.*

The precise dead-reckoning operations were carried out so as to properly cover the area out to the work done by the previous party that had sounded down from the north, or to the 100-fathom curve beyond the limits of that finished part. As the east and west lines approached the area off the river mouths it became difficult to estimate and allow for the current changes.

Buoys of a simple design were utilized outside the limit of visibility for shore signals.

While the *Bache* was undergoing repairs at Norfolk in June a 90-foot signal was erected on the coast about 5 miles below Virginia Beach, and a preliminary location of it was made by topographic methods. An automatic tide gauge was established at Fishermans Island, Cape Charles.

HYDROGRAPHIC AND TOPOGRAPHIC WORK, PACIFIC COAST.

CALIFORNIA.

[Lieut. Commander FREMONT MORSE.]

The regular work of the San Francisco field station was continued as usual. This consists in the maintenance of a sales agency, the supervision of the Presidio tidal station, the forwarding of supplies intended for the parties of the survey in the Philippine Islands, and furnishing transportation to field officers arriving at San Francisco, furnishing information in regard to surveys to Government officers and others, and tidal data for publication in the newspapers; and collecting and supplying to the office at Washington information affecting the charts, coast pilots, and tide tables.

In August the office of the inspector was moved from rooms 308–310, on the third floor of the customhouse, to rooms 508 and 509 on the fifth floor.

In May and June inspection was made of the chart agencies of the survey at San Francisco, San Diego, San Pedro, and Long Beach, Calif.

[Commander E. H. PAGENHART, Commanding Steamer *Lydonia.*]

SUMMARY OF RESULTS.—Triangulation: 25 square miles of area covered; 1 signal pole erected; 4 stations in main scheme occupied for horizontal measures; 3 geographic positions determined. Leveling: 5 permanent bench marks established; 2 miles of levels run. Topography: 19 miles of detailed shore line surveyed; 2 topographic sheets finished, scale 1:20,000. Hydrography: 2,538 square miles of area covered; 2,585 miles run while sounding; 4,316 positions determined (double angles); 9,554 soundings made; 2 tide stations established; 5 hydrographic sheets finished, scales 1:20,000, 1:40,000, and 1:120,000.

During the period from July 1 to November 4, 1921, the *Lydonia* was engaged in offshore hydrography in the vicinity of Cape Mendocino, Calif., which had been begun on April 5, 1921.

On July 1 work was in progress in the vicinity of Cape Mendocino, and it was continued until November 4, when the vessel returned to San Francisco for the completion of records for the transfer of the command.

The instructions for this work called for additional soundings where the soundings in the older surveys were widely spaced, for a junction with surveys executed in recent years, and for the extension of the offshore work of the 1,000-fathom curve; the original instructions specifying one-fourth-mile lines to 100 fathoms were modified so as to permit of sounding lines one-fourth mile apart to 50 fathoms and one-half mile apart to 100 fathoms where there were no indications to dangers. The supplemental instructions provided for work on the reported Tibbetts Bank which is situated well offshore.

In so far as the weather conditions permitted the work was carried from the south to the north, leaving completed work to the southward. Inshore work was done with tubes, trolley, and up-and-down casts with the ship stationary. Two sounding machines were used for this work.

On offshore work the Sigsbee sounding machine with a 35 lb. lead was used. The fixes were obtained from mountain peaks, by dead reckoning or by sights. Many radio bearings were taken but they were not used to locate the position of the ship. Currents were observed at several places inside the 100-fathom curve.

The surveys have been completed from the latitude of Ussal Creek northward to Rockey Point with the exceptions of several spots where additional investigation was desirable.

The result of the investigation in regard to Tibbetts Bank indicates that if the bank exists near its reported position it is of limited extent and will require close development to find it.

[Lieut. Commander R. F. LUCE, Commanding Steamer *Lydonia* November 25 to December 31.]

SUMMARY OF RESULTS.—Hydrography: 8.5 square miles of area covered; 51.3 miles run while sounding; 124 positions determined (double angles); 221 soundings made; 1 tidal station established.

The transfer of command of the steamer *Lydonia* from E. H. Pagenhart to R. F. Luce was effected November 25, 1921, the ship remaining at Oakland and afterwards at San Francisco for coal, supplies, and fumigation.

On December 4 the *Lydonia* arrived at Eureka, Calif., and from that time was engaged in offshore hydrography in the area off Trinidad Head, coast of northern California.

Sounding lines were run normal to the coast line, one-fourth mile apart in depths less than 50 fathoms, one-half mile apart from 50 to 100 fathoms, 2 miles apart from 100 to 300 fathoms, and 4 miles apart from 300 to 1,000 fathoms. Inside the 100-fathom curve this system of lines was supplemented by a system of cross lines run at right angles to the other lines and spaced about 1 mile apart.

While the work was in progress a self-registering tide gauge established near the Coast Guard station in Lower Humboldt Bay was continued in operation to obtain data for the reduction of soundings.

The weather during December was unfavorable for rapid progress.

[Lieut. Commander F. G. ENGLE, Commanding Motor Vessel *Natoma*.]

SUMMARY OF RESULTS.—Topography: 3.9 square miles of area survey; 39.8 miles of general coast line surveyed; 100.3 miles of shore line of creeks surveyed; 1 mile of roads surveyed; 5 topographic sheets finished, scale 1:10,000. Hydrography: 37.8 square miles of area sounded; 478.6 miles run while sounding; 3,243 positions determined (double angles); 15,422 soundings made; 5 tidal stations established; 1 hydrographic sheet finished; scales of hydrographic sheets 1:10,000 and 1:20,000.

At the beginning of the fiscal year the *Natoma* was at San Francisco undergoing repairs.

On July 20, in accordance with instructions dated July 9, a party left the ship for San Pedro to make a resurvey of the outer harbor. On August 9 the chief of party returned with party from San Pedro and preparations were begun for work in Tomales Bay and San Pablo Bay.

On August 18 two officers and three men were detailed to make a survey of Tomales Bay in accordance with instructions dated July 28.

On August 23 field work in San Pablo Bay was begun by the ship.

On September 26 the subparty from Tomales Bay returned to the ship and took up office work on records and sheets of this survey. An officer left ship on October 3, for the week, to obtain and check up in the field data for the chart of San Francisco streets and buildings.

On October 7 an automatic tide gauge was erected at Refugio Landing.

On October 19 a topographic party, consisting of an officer and two men, left ship on revision work from Point San Pedro northward. On October 27 a topographic party left ship on revision work from Point San Pablo eastward. Both shore parties were kept at work continuously up to November 29.

On October 27 launch hydrography on the west side of the bay was started. This party was kept in continuous operation until November 29, using the ship anchored on working grounds as a base. In addition to the automatic gauge, staff readings were taken either at McNears Landing or Petaluma Creek by observer from the ship using the motor dinghy to go to and fro.

In accordance with orders dated October 22, 1921, command of the *Natoma* was transferred to O. W. Swainson, hydrographic and geodetic engineer, on November 29, 1921. Unfinished topographic and hydrographic sheets of San Pablo Bay and ships copies of triangulation data were turned over to him. The original records and computations of triangulation were transmitted to the Washington office.

[Lieut. O. W. SWAINSON, Commanding U. S. Motor Vessel *Natoma*.]

SUMMARY OF RESULTS.—Topography: 112 square miles of area survey; 28.2 miles of general coast line surveyed; 23 miles of shore line of creeks surveyed; 108.5 miles of roads surveyed; 11 topographic sheets finished, scale 1:10,000. Hydrography: 91.8 miles of area sounded; 15,966 miles run while sounding; 9,455 positions determined (double angles); 64,933 soundings made; 7 tidal stations established; 12 hydrographic sheets finished, scales 1:10,000 and 1:20,000.

The command of the *Natoma* was transferred to O. W. Swainson November 29, 1921, relieving F. G. Engle.

On December 5 the vessel proceeded to San Pablo Bay and resumed the surveys in that vicinity under orders dated June 1, 1921. Work was continued in this locality May 25, 1922, when the vessel was taken to San Francisco for repairs.

Prior to November 28 the party on the *Natoma* had completed the triangulation and built the hydrographic signals in San Pablo Bay. The topography of the shore line on the west and south sides of the bay had been begun. Several days of launch hydrography between the Sisters and Petaluma Creek had been done. An automatic tide gauge was in operation at Refugio Landing and plain staffs had been erected at McNears Landing and Black Point. The staff at Black Point had been tied in with the automatic gauge by 52 hours of continuous readings.

Two topographic parties were put on shore—one on the west side and one on the south side of the bay. The ship began the ship hydrography at the western end of the bay and worked eastward, reading tides at McNears Landing.

The work was planned so as to keep all the parties as near together as possible.

Every effort was made to finish the work in the bay during the calm season, leaving the creeks and Napa River for the windy season.

The topographic and hydrographic sheets were laid out with the necessary amount of overlap. The existing chart was incomplete in the vicinity of Sonoma Creek. Additional stations had to be established and another topographic sheet made to cover this area.

The triangulation was done in accordance with the instructions for tertiary work. The signals were built and the observing done as the control was required. Many prominent natural and artificial objects were cut in.

The Petaluma scheme was joined to the old line Swift-Petaluma Creek. The Napa River work was continued from the triangulation on the river begun by F. G. Engle.

All of the topography was done on a scale of 1:10,000.

One party was in the field continuously and about two-thirds of the time there were two. Each party consisted of 1 officer and 3 or 4 men.

Considerable changes were found in the chart due to the reclaiming of the land by levees. With the exception of the south shore, complete new sheets had to be made.

The revision work of the south shore was done directly on bromide copies of the original topographic sheets. This was found to be unsatisfactory as the original survey was so old that many changed features were shown on the charts that did not show on the original sheets. The bromides were also much distorted.

Blue prints of the industrial plants on the south shore of the bay were obtained and were forwarded with the topographic sheets of the locality.

A complete hydrographic survey was made, the inshore work and creeks on a scale of 1:10,000, and the bay proper on 1:20,000. The complete survey was necessitated by the uncertainty and irregularity of the change in the bottom.

The lines were spaced 100 to 200 meters apart and crossed by lines one-quarter to one-half mile apart. All soundings over 4 feet were taken with the hand lead. Those under that were usually taken with a pole marked in half feet.

A lead line with a bronze metal core was used for both the ship and launch work. This was found to be far better than the sash-cord lines, and required no correction on account of shrinking or stretching.

The ship did the work into the 5-foot curve, the inner portions of this at high tide.

An automatic tide gauge was kept in operation at Refugio Landing. Plain staffs were established at McNears Landing, Black Point, Lakeville, Petaluma Creek Quarry drawbridge, Sonoma Creek, Crockett, Mare Island, railroad drawbridge across Napa River and Napa. All were connected to Refugio by simultaneous readings for periods of 52 to 60 hours. Wherever possible the staffs were tied in to old bench marks. The datum plane established checked the old marks at Crockett by one-tenth of a foot, at McNears Landing by three-tenths of a foot, and at Mare Island by three-tenths of a foot.

CALIFORNIA AND OREGON.

[Lieut. Commander R. F. LUCE, Commanding Steamer *Lydonia*.]

SUMMARY OF RESULTS.—Triangulation: 7 signal poles erected; 13 stations occupied for horizontal measures. Hydrography: 772 square miles of area covered; 818 miles run while sounding; 1,972 positions determined (double angles); 4,286 soundings made; 1 tide station established. Leveling: 3 miles of levels run; 5 bench marks established.

The hydrographic work on the coast of California done by the steamer *Lydonia* during the period from January 1 to June 30, 1922, includes the area extending along the coast from Trinidad Head to Redding Rock, and from a junction inshore with work previously done (about the 17-fathom curve) out to the 1,000-fathom curve.

The spacing of sounding lines as called for in the instructions was closely followed.

Inside approximately the 70-fathom curve, soundings were by means of a trolley apparatus, using a special stranded wire from the vessel under way and proceeding at a speed of from 3 to 4½ knots, depending upon the depth, and soundings were taken as rapidly and as often as possible, which gave a spacing of soundings of about 200 meters.

Outside the 70-fathom curve, vertical soundings were taken with the vessel stopped for each sounding, the spacing of soundings being from 250 to 350 meters out to the 100-fathom curve, outside of which soundings were spaced about one-half the distance between lines.

In the area covered by this report the bottom was exceptionally even, and in general the depths obtained increased gradually and evenly out from the inner to the outer limit of the work.

In connection with the work on the California coast an automatic tide gauge, previously established at the Coast Guard station in Lower Humboldt Bay, was continued in operation for the purpose of obtaining reducers for the soundings taken, and the results obtained were excellent.

On May 24 the steamer *Lydonia* arrived at Marshfield, Oreg., to take up combined operations on the Oregon coast in accordance with instructions of March 11, 1922, calling for the topography of the shore line of Coos Bay and from Coos Bay to Cape Sebastian, the hydrography of the coast, from as close inshore as safety would permit, out to the 1,000-fathom curve, and such secondary triangulation as might be necessary for the control of the other work.

During the period covered by this report considerable triangulation and hydrography was accomplished, but no topography, as the complement of officers permitted only one shore party to be in the field at a time, and that party was necessarily engaged in triangulation for the control of the other work.

The character of the country in this vicinity, made up as it is of flat-topped rolling hills, generally heavily wooded, coupled with the large amount of hazy and foggy weather experienced, has made this triangulation very difficult. Considerable time was required on reconnaissance, a large amount of clearing

was necessary, and heliotropes had to be used at each station for the observing, though the lines were not long, in general.

As hydrography, however, could not be permitted to wait for the execution of triangulation, the *Lydonia* commenced sounding work the 1st of June, using the only three triangulation stations which were available along the coast, Cape Arago Light, Coquille River Light, and Clump (the latter located by this vessel in May from stations Cape Arago Light and Empire 3).

From locations obtained from these three stations, while sounding work was in progress, frequent sextant cuts were taken from the vessel on all prominent objects along the coast, and in this manner sufficient points were determined along the coast, so that no difficulty was experienced in utilizing all possible weather for hydrography by the *Lydonia*, with the result that a very considerable amount of hydrography was accomplished during June. Points located temporarily in this manner, by sextant cuts, are being located now by triangulation and topography.

The hydrography done to date covers the area extending along the coast from a point about 3 miles north of the entrance to Coos Bay to about 2 miles north of Five Mile Point, and extending from the 1,000-fathom curve in to as close inshore as safety would permit, which, in general, was about the 17-fathom curve.

The spacing of lines and soundings and the methods used were in strict accordance with instructions, and were the same as those adopted for work on the California coast, which is given in detail in another part of this report.

In connection with the work, for the reduction of soundings taken, an automatic gauge was established at Empire, on Coos Bay, and will be kept in continuous operation as long as work is in progress. This station was established in accordance with the instructions, and the general instructions for field work were closely followed.

WASHINGTON AND CALIFORNIA.

[Lieut. F. L. PEACOCK.]

SUMMARY OF RESULTS.—Topography: 16 square miles of area surveyed; 21.7 miles of general coast surveyed; 5 miles of shore line of creeks surveyed. Hydrography: 42 square miles of area sounded; 541.9 miles run while sounding; 3,957 positions determined (double angles); 17,329 soundings made; 2 tide stations established; 1 hydrographic sheet finished, scale 1:20,000.

A resurvey of Willapa Bay and Bar, Wash., authorized by instructions dated January 5, 1922, was begun January 19, 1922, and completed June 13, 1922.

Numerous intersection stations and aids to navigation were located by triangulation or by plane table during the progress of the work. The interesting feature of the topography is the marked change in the shore line in the vicinities of Cape Shoal water, Ellen Sands, and Ledbetter Point. The shore line at the latter place was revised at a late period of the work for the reason that it was undergoing considerable changes during the month of February. A retreat of about 40 miles at the northwest extremity was observed during that month. Comparison of surveys indicates a retreat of 200 meters since September, 1921. The hydrographic work was carefully done, and only a few doubtful soundings had to be rejected.

An automatic tide station was in constant operation at Pacific County Wharf, Toke Point, from February 2 to June 15. A plain staff gauge was operated at Bay Center for 21 days between April 20 and May 15, during the hours from 8 a. m. to 5 p. m. From May 16 to 18 a 48-hour consecutive series was observed on the Bay Center staff for the purpose of establishing the tidal constants of that place as compared with the Standard Station at Toke Point.

Three bench marks established at Toke Point in 1911 were recovered, five additional ones were established and connected with one another and with the tide staff by leveling.

The old bench mark at Bay Center was found to have been destroyed. Three new ones were established near the inner end of Bay Center Wharf and were connected to the Bay Center 1922 staff by spirit leveling by two observers.

No current observations were taken, but information was gathered in regard to the times of flood and ebb and of slack water.

Notes in regard to newly discovered dangers, changes in aids to navigation, and other matters affecting the charts and sailing directions were collected for the use of the coast pilot division and division of tides and currents.

OREGON AND WASHINGTON.

[Lieut. Commander T. J. MAHER, Commanding Steamer *Surveyor*.]

SUMMARY OF RESULTS.—Physical hydrography: 7 sea stations occupied for observations of currents.

Instructions issued to the commanding officer of the *Surveyor* in November, 1921, called for observations of surface and subsurface currents, water densities and temperatures, measurement of velocity and direction of the wind, notations regarding the condition of the sea and direction of the swell, and samples of water at the surface, at half depth, and at bottom. The ship was to be anchored at the stations mentioned below:

Station A, Straits of Juan de Fuca, south of Point Sheringham, near the 100-fathom curve; Station B, off Grays Harbor, Pacific Ocean, at or near the 100-fathom curve; Station C, off the mouth of the Columbia River, near the 100-fathom curve; Station D, at or near the edge of Hecete Bank; Station E, south of Cape Blanco; Stations D, C, B, A, to be reoccupied in the order given for lengths of time corresponding to those of the first set.

The instructions were carried out except the occupation of Station E and the reoccupation of Station B, which were omitted in accordance with telegraphic instructions.

On January 12 the ship left the yard of the Winslow Marine Railway & Ship Building Co., and proceeded to Seattle for supplies, fuel, etc.

On January 18 current work was started at Station A and completed on January 19.

On January 20 observations were started at Station B and completed on January 27.

On January 28 observations were started at Station C and completed on February 4.

Operations were stopped here as the wire-anchor cable had been lost. The ship proceeded to Astoria for equipment.

On February 18 the ship left Astoria, occupied Station D on February 19, and completed observations on February 26.

On February 27 the ship was at Station C again.

On March 2, owing to an accident to the anchoring equipment and loss of gear, the vessel again went to Astoria.

Operations were resumed on March 4, using a 1,200-pound mushroom and rope in anchoring. This was afterwards backed by a 750-pound kedge and additional weights, but these were not sufficient to keep the vessel from dragging and the vessel again proceeded to Astoria on March 10.

Observations were resumed at Station A on March 20 and were completed on March 21. The tide gauge was removed from Port Angeles, the bench marks connected by a line of levels with tide gauge, and the vessel proceeded to Port Townsend and thence to Seattle on March 22.

The work of observing currents proceeded rapidly and there were no interruptions due to the ship's leaving the station on account of bad weather. There were no violent storms, but moderate gales were of frequent occurrence.

Various tests were made during the work to determine the accuracy of the current meters used. In the Columbia River current observations were made with the Price and Ekman meters and the current pole. These were unaffected by rolling and pitching as the water was calm. Tests were also made of the hydrometers used in determining water densities.

Where the shore was visible the ship's position was determined by sextant angles to objects whose positions were known, otherwise astronomical fixes were obtained. Where only one object was visible, or when only one object could be recognized, true bearings to it were taken.

WASHINGTON.

[Commander R. B. DERICKSON.]

An officer of the survey has continued on duty as inspector in charge of the field station at Seattle, Wash., with general supervision over all hydrographic and topographic work performed in the district, besides the purchase of supplies, the distribution and sale of charts, coast pilots and tide tables, collecting and supplying nautical information, and attending to other details.

The field station is located in rooms 200 to 204, inclusive, in the Burke Building, Seattle. There is also maintained a storeroom in the Readman warehouse, and a room in the Federal Building, Seattle, where instruments and some equipment are stored. During the year inspections were made of the chart agencies of the survey in Seattle and visits were made to Bellingham, Everett, Anacortes, Tacoma, and Olympia, with a view to obtaining information as to the publication of tidal data in advertising matter issued by shipbuilders, towboat companies, and others concerned in maritime commerce.

Advance information was obtained and issued to steamers plying between Seattle and Alaskan ports, and others interested concerning changes affecting the navigation of Cook Inlet.

Various recommendations have been made with a view to obtaining better results in the purchase of materials in common use by the vessels of the survey at Seattle and in making repairs to the vessels.

GEODETIC WORK, TRIANGULATION, RECONNAISSANCE, AND SIGNAL BUILDING.

NEW MEXICO, OKLAHOMA, AND TEXAS.

[Lieut. (Junior Grade) EARL O. HEATON, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance: 3 triangulation stations selected. Triangulation, precise: 10,950 square miles of area covered; 4 observing tripods built of aggregate height of 120 feet; 13 stands built each about 4 feet in height; 50 stations in main scheme occupied for horizontal measures; 50 stations occupied for vertical measures; 95 geographical positions determined; 95 elevations determined trigonometrically. Leveling: 16 miles run. Base line, precise: 1 base measured, 8 miles in length. Azimuth: 12 stations occupied for determination of azimuth.

On July 1, 1921, work was in progress near the Texas-Oklahoma boundary on the arc of precise triangulation extending from El Reno, Okla., to Needles, Calif. On November 21, 1921, all work had been completed to a junction with the previous work on this arc near Albuquerque, N. Mex.

Due to the fact that a large number of high signals were required on this part of the arc, especially on the eastern end, the building party was unable to keep far enough in advance and it became necessary for the observing party to move to the western part of the scheme, where only stands were needed at most of the stations. This made it possible to complete the observations at the high mountain stations before the beginning of cold weather and snow.

Several heavy winds during the season caused considerable damage to the high signals. Two 95-foot signals were blown down. Observing was made possible during more moderate winds by stretching canvas on the windward side of the observing scaffold to protect the tripod. Other difficulties encountered were impassable roads, due to excessive rainfall, which made long detours necessary, and sand storms. Good progress was made, however, and excellent triangle closures were obtained.

One base line about 8 miles in length was measured during the early part of November, 1921, near Vega, Tex.

Four automobile trucks were used for the transportation of the observing party, light keepers, and equipment.

TEXAS AND NEW MEXICO.

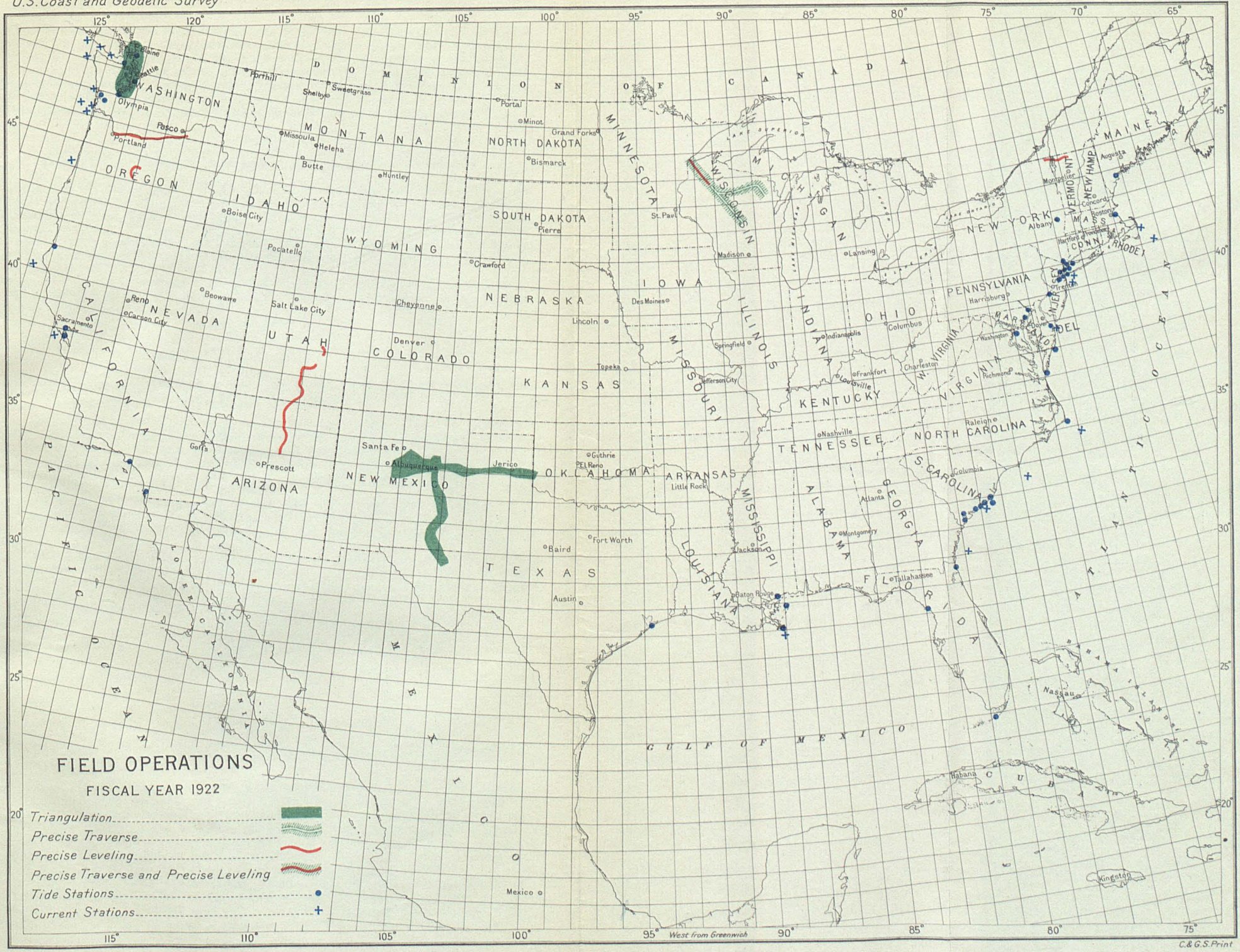
[Lieut. (Junior Grade) CASPER M. DURGIN, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Precise triangulation: 7,000 square miles of area covered; 41 stations in main scheme occupied for horizontal measures; 2 stations in supplemental schemes occupied for horizontal measures; 43 elevations determined trigonometrically. Azimuths: 4 stations occupied for determination of precise azimuth.

On March 14, 1922, work was started on an arc of precise triangulation along the one hundred and fourth meridian to extend from the Texas-California arc of precise triangulation near Pecos, Tex., to the transcontinental arc of precise triangulation, along the thirty-ninth parallel. About half of the arc had been completed by July 1, 1922.

The chief of party was assisted by Lieut. M. E. Levy, U. S. Coast and Geodetic Survey, from the middle of March to the end of April and by Ensign E. B. Roberts, U. S. Coast and Geodetic Survey, for the remainder of the time.

It was necessary to change the location of one reconnaissance station because of obstructed lines. Some delay was also caused by sand storms and heavy


FIELD OPERATIONS
FISCAL YEAR 1922
Triangulation
Precise Traverse
Precise Leveling
Precise Traverse and Precise Leveling
Tide Stations
Current 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
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
RHODE I.
NEW JERSEY
DEL.
MARYLAND
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
CUBA
West from Greenwich

winds, but the progress of the work has been very satisfactory. This rapid progress has been partly due to the fact that the light keepers and truck drivers and other hands attached to the party have given exceptionally good service.

Since early in June the party has been cooperating with the General Land Office in determining the geographic positions of as many land-section corners as possible within the area of the scheme or just outside of it.

The transportation of the party has been by automobile truck.

IDAHO.

[Lieut. (Junior Grade) W. M. SCAIFE, U. S. Coast and Geodetic Survey.]

About the middle of May, 1922, work was started near Pocatello, Idaho, on the arc of precise triangulation which will extend northward to the Canadian boundary. Several signals had been built and about five stations occupied for horizontal measures by the end of the fiscal year. Many of the stations in this arc are on high peaks, difficult of access, and where snow interferes seriously with the progress of the work except during two or three months in the middle of summer.

The chief of party was assisted by Lieut. (Junior Grade) W. H. Overshiner, U. S. Coast and Geodetic Survey; Earl C. States, extra observer; and Walter J. Bilby, signalman.

WISCONSIN.

[Lieut. Commander C. L. GARNER, Lieut. C. A. EGNER, and Lieut. (Junior Grade) CASPER M. DURGIN, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Traverse, precise: 370 miles of line completed; 275 principal stations occupied for horizontal measures; 290 geographic positions determined. Azimuth: 23 stations occupied for determination of azimuth.

On July 1, 1921, work was in progress near Mountain, Wis., on a line of precise traverse between Green Bay, Wis., and Duluth, Minn., under Lieut. Commander Clem L. Garner, U. S. Coast and Geodetic Survey, chief of party. On August 15 the party had reached Ladysmith, Wis., and it was then divided into two parts and transferred to Lieut. C. A. Egner, U. S. Coast and Geodetic Survey, and Lieut. (Junior Grade) Casper M. Durgin, U. S. Coast and Geodetic Survey. For the remainder of the line the former had charge of the reconnaissance, observing, and building, and the latter had charge of the tape measurements and leveling, but helped with the observing near the end of the season.

At Duluth the traverse was connected with the precise triangulation of the lake survey. Several bench marks of different types were set in West Duluth for the purpose of investigating the action of frost on concrete posts. After the work had been completed to Duluth a branch traverse line was run from Ladysmith southeastward to Wisconsin Rapids, Wis.

Automobile trucks, supplemented by hand velocipede cars, were used in transporting the parties and equipment. In most places the highways were so conveniently located in relation to the railroad track that it was seldom necessary to make use of the velocipede cars.

The season's work was completed about October 20, 1921.

MINNESOTA.

[J. S. BILBY, Signalman, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance for precise triangulation: Length of scheme, 230 miles; 1,400 square miles of area covered; 48 points selected for scheme; 2 sites for precise base lines selected.

As a part of the cooperative plan between the Geodetic Survey of Canada and the U. S. Coast and Geodetic Survey for extending precise triangulation along the international boundary, a reconnaissance for precise triangulation was made from the Lake of the Woods eastward along the international boundary between Canada and the United States to a connection with the precise triangulation of the Geodetic Survey of Canada, which had been extended a short distance along the boundary westward from Lake Superior.

Field work was begun at Baudette, Minn., July 26, 1921. Three stations of the precise triangulation at the Lake of the Woods were recovered and from there the reconnaissance was extended eastward along the boundary with one side of the scheme in Canada and the other side in the United States.

The country through which the western half of the scheme extends is heavily wooded and, therefore, would require tall signals and much cutting for triangulation. After the reconnaissance for triangulation had been completed as far as Rainy Lake, the party was visted by the assistant chief of the division of geodesy, and it was decided, after consultation, to recommend the alternative of precise traverse from Warroad, Minn., to Namaukan, Narrows, a distance of about 165 miles, of which 100 miles is along a railroad and the remainder on Rainy Lake and other lakes to the eastward. It was thought that the traverse over the lakes could be made readily while they were covered with ice. The reconnaissance was made for that part of the traverse which extends across the lakes.

From Loon Lake to the eastern end of the scheme only a preliminary reconnaissance for triangulation was made, as the ruggedness of the country and the difficulties of transportation are so great that a larger and better equipped party is necessary to make a thorough reconnaissance.

Transportation of the party was by automobile between the Lake of the Woods and International Falls, by motor launch between International Falls and Loon Lake, and by canoe between Loon Lake and the eastern end of the scheme.

On his way back to the Washington office the chief of party made an inspection trip by train along a proposed arc of precise traverse or triangulation between Tunnel City, Wis., and Spring Valley, Minn.

MONTANA.

[Lieut. Commander CLEM L. GARNER, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance for precise triangulation: Length of scheme, 140 miles; 3,500 square miles of area covered; 32 points selected for scheme; 1 base site selected.

This project is a part of a cooperative plan made by the Geodetic Survey of Canada and the U. S. Coast and Geodetic Survey to execute an arc of precise triangulation along the international boundary between Lake Superior and Puget Sound. The reconnaissance here mentioned extends along the boundary from the one hundred and ninth to the one hundred and eleventh meridian where it connects with the proposed arc of triangulation extending southward to Pocatello, Idaho. For most of this distance one side of the scheme is in Canada and the other side in the United States. Numerous connections were planned with the monuments along the boundary.

Work was started to the northward of Havre, Mont., on August 18, 1921, and was completed to a connection with the reconnaissance along the one hundred and eleventh meridian on September 25, 1921.

A base site was selected just north of Havre, Mont.

[Lieut. Commander CLEM L. GARNER, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance revision: 9 new stations selected; 1 base site selected.

The reconnaissance along the one hundred and eleventh meridian from the Canadian boundary to Pocatello, Idaho, was done in 1913. A revision of the Montana part of this reconnaissance was made between September 25 and October 15, 1921, in order to shorten the lengths of the lines and thus make the triangulation of more value for the control of local surveys. Most of the stations selected by the previous reconnaissance were retained but 9 new stations were selected, partly as intermediate stations in the scheme and partly in connection with a new base located near Bozeman, Mont.

TEXAS AND NEW MEXICO.

[DAN W. TAYLOR, Signalman, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, precise: 21 signals built, aggregate height 1,775 feet; 12 instrument stands built, each 4 feet high.

On July 1, 1921, signal building was in progress on the arc of precise triangulation extending from El Reno, Okla., to Needles, Calif. A number of tall signals, most of them 75 feet in height and having an additional superstructure of 20 feet, were required on this arc.

Trucks were used for the transportation of the party and equipment. Considerable difficulty was experienced on account of excessive rainfall, which made some of the roads impassable and long detours necessary.

The season's work was finished on the last of August at Albuquerque, N. Mex., where it joined the completed triangulation at the western end of the arc.

TEXAS, NEW MEXICO, AND COLORADO.

[DAN W. TAYLOR, Signalman, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, precise: 88 tripods built, aggregate height 850 feet; 17 scaffolds built, aggregate height 584 feet.

Signal building along the arc of precise triangulation which extends from Pecos, Tex., to Pueblo, Colo., was started on February 1, 1922, and was completed on June 30, 1922. Several tall signals were built along this arc, the tallest being 75 feet high and having a 20-foot superstructure. A ¾-ton truck was used for the transportation of the party, but much of the heavy building tackle was sent from station to station by freight as the truck was not heavy enough to carry everything needed by the party. These freight shipments were sometimes late in arriving and delayed the party at a few stations as they made it necessary for the chief of party, while awaiting the tackle, to go out of his way to other stations where only stands were required.

The party made rapid progress throughout the season, however, and the average cost per vertical foot for building the signals, including the salary of the chief of party, was only $3.30.

ILLINOIS, MISSOURI, AND KANSAS.

[J. S. BILBY, Signalman, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Recovery and remarking of precise triangulation stations: 75 stations visited; 63 stations recovered and re-marked.

On May 3, 1922, the recovery and re-marking of stations on the precise triangulation along the thirty-ninth parallel was begun in the vicinity of Junction City, Kans. By June 30, 1922, the work was completed from the vicinity of St. Louis, Mo., to Salina, Kans.

At each station the chief of party explained to the property owner, or other interested persons, the purpose of the station and the importance of preserving it for use as control for future surveys.

SOUTH CAROLINA.

[Lieut. F. S. BORDEN, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 60 square miles of area covered; 8 signal poles and 5 observing tripods erected; 14 stations in main scheme occupied for horizontal measures; 19 geographic positions determined.

This triangulation was done between July 1 and November 5, 1921, in connection with hydrographic work in the following localities: Broad River, Beaufort River, and Charleston Harbor and vicinity. The party worked from the launches *Mikawe* and *Elsie*.

LOUISIANA.

[Lieut. F. S. BORDEN, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, primary: 200 square miles of area covered; length of scheme 30 miles; 9 signals built, aggregate height about 500 feet; 14 stations in main scheme occupied for horizontal measures; 25 geographic positions determined. Base line, primary: 1 base measured 3.7 miles in length.

This triangulation extends from Mississippi Sound across the delta to the Southwest Pass of the Mississippi River. It was one of the combined operations carried on from the steamer *Hydrographer*.

Due to the flat topography and the presence of timber and other high vegetation, it was necessary to build high signals to make the stations intervisible.

The base was measured along the bank of the Mississippi River. The river was in flood stage during the time the measurements were made and the entire base site was covered with from 6 to 18 inches of water. Although this delayed the progress of the work, it did not seem to affect the accuracy.

CALIFORNIA.

[Lieut. Commander F. G. ENGLE, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 105 square miles of area covered; 25 signal poles erected; 8 stations in main scheme and 4 stations in supplemental scheme occupied for horizontal measures; 41 geographic positions determined.

On August 23, 1921, the revision of triangulation in San Pablo Bay and Napa River was begun by the party on the steamship *Natoma* in connection with hydrographic and topographic surveys in that locality. The positions of numerous intersection points were determined.

[Lieut. O. W. SWAINSON, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 60 square miles of area covered; 30 signal poles erected; 26 stations in main scheme occupied for horizontal measures; 3 stations occupied for vertical measures; 60 geographic positions determined. Leveling: 3 miles of leveling run; 22 permanent bench marks established.

The revision of triangulation in San Pablo Bay, Calif., was resumed during the latter part of February, 1922, by the party of the steamship *Natoma*, and continued to the northward into Petaluma Creek and Napa River. The positions of many intersection stations, such as windmills, gables of prominent barns, and transmission towers, were determined for use in the hydrographic and topographic surveys which were carried on at the same time. Several tidal bench marks were established.

CALIFORNIA, OREGON, NORTH CAROLINA, VIRGINIA, AND PORTO RICO.

In addition to the larger projects given above, several small pieces of triangulation were done in connection with hydrographic surveys along the coast, usually for the express purpose of controlling the hydrographic work. About 60 geographic positions, not mentioned in the preceding abstracts, were determined in this way.

WASHINGTON.

[Lieut. F. L. PEACOCK, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance, secondary: 11 points selected for scheme. Triangulation, secondary: 35 square miles of area covered; length of scheme, 10 miles; 10 signal poles erected; 11 stations in main scheme occupied for horizontal measures; 46 geographic positions determined; 7 old stations recovered. Leveling: 8 permanent bench marks established; 5.5 miles of levels run.

This triangulation was done in connection with a hydrographic survey of Willapa Bay, Wash. Work was begun on January 19, and the party was disbanded on June 16, 1922. The chief of party was assisted by Lieut. (Junior Grade) W. H. Overshiner, U. S. Coast and Geodetic Survey.

Much of the observing had to be done under unfavorable conditions because of an unusual amount of bad weather, but the average closing error of triangles was kept well within the allowable limit.

[Lieut. E. W. EICKELBERG, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance: 6 triangulation stations selected. Triangulation, precise: 540 square miles of area covered; length of scheme 75 miles; 46 signal poles erected; 32 stands built; 7 signals built of aggregate height of 165 feet; 38 stations in main scheme occupied for horizontal measures; 2 stations occupied for vertical measures; 65 geographic positions determined. Base lines, precise: 2 bases measured, 2.0 and 2.5 miles in length, respectively. Azimuth: 2 stations occupied for observation of azimuth.

On July 1, 1921, work was in progress on an arc of precise triangulation in Puget Sound from Tacoma, Wash., to the Canadian boundary. This arc is a part of the project for carrying the North American datum into western Canada and Alaska in cooperation with the Geodetic Survey of Canada.

All of the stations on this arc are either on islands or on the shore of Puget Sound. The party, therefore, used a launch during the entire season for moving from station to station and for transporting lumber for the signals. As the lines were short no light keepers were used, but lights were posted each night by the observing party. In his season's report the chief of party recommended clock-controlled electric signal lamps for work of this kind. The lamps could then be set in the desired position and the lights could be automatically turned on by the clock at a certain hour of the evening and turned off at some later hour.

Excellent weather conditions prevailed during the whole season and there were very few days when observing was prevented by rain, smoke, or haze. A connection was made to the triangulation of the Geodetic Survey of Canada and the season's work completed on November 10, 1921.

The chief of the party was assisted by Lieut. (Junior Grade) H. C. Warwick, U. S. Coast and Geodetic Survey.

LEVELING.

UTAH.

[Lieut. F. W. HOUGH, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 189 miles of levels run; 58 permanent bench marks established.

On July 1, 1921, work was in progress near the northern end of the line of precise levels extending from Green River, Utah, to Flagstaff, Ariz., which was being done at the request of the U. S. Geological Survey. The line completed by this party extends across desert country to Hall's crossing and along the bottom of Glenn Canyon to the "Crossing of the Fathers," where the party working from the southern end of the line was met and the work of the season completed.

This line of precise levels is probably the most difficult one in the history of the U. S. Coast and Geodetic Survey, especially the part through Glenn Canyon. The work in the canyon was begun about September 1 and was completed on November 11, during which time 84 miles of levels were run. For this part of the work two 18-foot rowboats, equipped with Evinrude motors, and an 18-foot canoe were used for transportation. The canoe proved much more efficient than the boats, which were too heavy to be handled in swift current.

As a matter of precaution two complete sets of instruments were carried, one set in each of the rowboats, and the original records were always carried in one boat and the abstracts in another. No serious accidents occurred on the trip, although they were avoided by narrow margins several times.

Many unusual conditions and difficult situations had to be met by unusual methods of leveling. It was necessary many times to take very long sights and often impossible to balance the backsights and foresights. Tapes had to be used instead of rods over some of the cliffs, and logs of driftwood were used as rod supports for turning points in quicksand.

The U. S. Geological Survey cooperated in this work by furnishing the rowboats and paying the party expenses. The U. S. Coast and Geodetic Survey furnished the two automobile trucks for the desert work and paid the salary of the chief of party.

ARIZONA AND UTAH.

[Lieut. F. E. JOEKEL, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 170 miles of levels run; 66 permanent bench marks established.

This line of levels is the southern end of the line extending from Green River, Utah, to Flagstaff, Ariz., which was done at the request of the U. S. Geological Survey. The party started at Flagstaff, Ariz., and worked along the Atchison, Topeka & Santa Fe Railroad as far as Lees Ferry. From Lees Ferry the line followed the bottom of Glenn Canyon. On November 11, 1921, the party working from the northern end of the line was met at the "Crossing of the Fathers," Utah, in Glenn Canyon, and the work of the season completed.

The line through the canyon was run in accordance with special instructions permitting long sights, inequality of sights, larger closing errors, double-rodded lines, the use of tapes for rods, and various other expedients made necessary by the character of the topography. At best the work was extremely difficult in the canyon. Transportation here was by means of a boat equipped with an Evinrude motor. Much of the way it was necessary for the party to get into the water and tow the boat. The party spent one night on a sand bar in the middle of the river without food or sleep. In spite of all difficulties, however, the work was carried through to completion with a very small closing error. The party was in the canyon from October 1 to November 11, 1921, during which time 40 miles of levels were completed.

The U. S. Geological Survey cooperated on the work through the canyon to the extent of furnishing the transportation and running expenses, except pay of officer and men.

OREGON AND WASHINGTON.

[Lieut. (Junior Grade) J. D. CRICHTON, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 250 miles of levels run; 134 permanent bench marks established.

Between July 8 and November 5, 1921, a line of precise levels was run from Portland, Oreg., to Wallula, Wash., along the south bank of the Columbia River, and another line was run from Bend to Princeville, Oreg. On both lines connections were made with all U. S. Geological Survey bench marks that could be recovered.

The level line along the Columbia River follows the Oregon-Washington Railroad & Navigation Co.'s lines. The river flows in a gorge for practically the entire distance, and the railroad, which follows the gorge, has many sharp curves. Although the Columbia River Highway is parallel with the railroad for most of the way, it is in many places several hundred feet almost vertically above the railroad. Two automobile trucks were used for the transportation. If possible, it was planned to finish each day's work at a place where the highway is accessible from the railroad.

Between Umatilla, Oreg., and Wallula, Wash., the roads are not sufficiently accessible to the railroad, and motor velocipede cars were therefore used instead of the trucks.

The new invar precise level gave very satisfactory service on this work. It tended to reduce the amount of rerunning necessary and to prevent an excessive divergence between the backward and forward runnings.

NEW YORK.

[Lieut. C. H. OBER, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 144 miles of levels run; 5 permanent and 81 secondary bench marks established. Leveling, check: 244 miles of single level lines run; 519 bench marks recovered.

Between July 1 and December 2, 1921, the following check levels were run in New York: Buffalo to North Tonawanda, Oswego to Moira, and Rouses Point to Troy. In addition, several tidal bench marks along the Hudson River were connected to the precise level net. On the line from Rouses Point to Troy 81 miles of precise levels were run.

The party used a ¾-ton truck for transportation. During the periods when the truck was undergoing repairs use was made of railroad trains and hired cars. The outfit and equipment were kept as small as possible.

For the greater part of the work only four men, in addition to the chief of party, were used. These men were the recorder, who also held the sunshade for the instrument; the truck driver, who also searched for old bench marks and set new ones; and two rodmen.

Special precautions were taken to guard against errors in reading the rod and recording, as the purpose of the check levels was to find small errors. There were no large blunders in the lines.

VERMONT.

[H. G. AVERS, Mathematician, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 27 miles of levels run; 11 permanent bench marks established.

On June 16 work was begun on a line of precise levels to extend from Rouses Point, N. Y., to Portland, Me. At the end of the fiscal year the line had been completed from Rouses Point to Sheldon Junction, Vt. Excessive rainfall and swollen streams, which overflowed the roads, interfered somewhat with the progress of the work, as automobiles were used for transporting the party.

WISCONSIN AND MINNESOTA.

[Lieut. (Junior Grade) HERMAN ODESSEY, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 81 miles of levels run; 61 permanent bench marks established.

On May 20, 1922, a line of precise levels was started at Duluth, Minn., to follow the traverse line of 1921 to Green Bay, Wis. The work was in progress at the end of the fiscal year.

The traverse stations established the year before were used as bench marks, thus effecting a considerable saving of time. Two automobile trucks were used for the transportation of the party.

TEXAS.

[DAN W. TAYLOR, Signalman, U. S. Coast and Geodetic Survey.]

Between November 26 and December 14, 1921, an inspection was made of the lines of precise levels from Pecos to El Paso and from Sierra Blanca to Marfa for the purpose of revising the descriptions and stamping the adjusted elevations on the metal bench marks. On January 9 1922, the work was resumed at Marfa and completed to San Antonio, including a spur line to Eagle Pass, by January 20. In all about 350 bench marks were stamped with the adjusted elevations. A hand velocipede car was used on the work.

GEORGIA.

[E. C. STATES, Extra Observer, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Inspection of precise leveling and precise traverse marks: 750 miles covered; 802 traverse stations recovered; 660 bench marks recovered and stamped.

Between January 9 and April 15, 1922, an inspection was made of the following precise level and precise traverse lines in Georgia: Macon to Savannah, Savannah to Everett City, Brunswick to Macon, Macon to Columbus, Columbus to Albany, and Albany to Valdosta. Except for the short distance between Macon and Jeffersonville, most of the marks were found in good condition. The adjusted elevations of all bench marks recovered were stamped on the metal disks. A hand velocipede car was used on the work.

KENTUCKY.

[H. G. AVERS, Mathematician, U. S. Coast and Geodetic Survey.]

Between September 8 and 19, 1921, a single line of wye levels was run over the precise level line which extends from West Point to Oakland, Ky., for the purpose of discovering a blunder of 1 meter in the original levels. Trains were used exclusively for transportation and the entire party walked during the actual leveling. The instrumental equipment consisted of an engineer's wye level and two extension rods graduated to feet.

WISCONSIN.

[Lieut. Commander CLEM L. GARNER, U. S. Coast and Geodetic Survey.]

From May 20 to June 6 instruction was given the precise leveling party operating at Superior, Wis., in methods of observing and other details of the work.

GRAVITY AND ASTRONOMY.

ALABAMA, LOUISIANA, MISSISSIPPI, AND TEXAS.

[Lieut. GEORGE D. COWIE, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Gravity: 10 gravity stations occupied; time determined astronomically at 7 stations. Latitude: 9 precise latitude stations established. Triangulation: 9 geographic positions (of latitude stations) determined; 2 observing tripods and scaffolds built, total height 55 feet.

In the latter part of August, 1921, arrangements were made for the determination of the intensity of gravity at 10 stations near the Mississippi Delta between Fort Morgan, Ala., and Sabine Pass, Tex., and for the determination of astronomic latitude at all but one of these stations. The chief of party was assisted by Ensign E. B. Roberts on this work.

After the chief of party had consulted with Government officials at New Orleans the party proceeded to Fort Morgan, Ala., and began gravity observations about September 5.

This is the first season in which invar pendulums have been used for gravity determinations. In order to test their accuracy and reliability, the bronze pendulums were also swung at several of the stations. The invar pendu-

lums were tested for magnetization before and after use at each station by means of a special compass declinometer, and if the magnetization exceeded a certain small amount they were demagnetized with a solenoid. By using these precautions satisfactory results were obtained in places where the bronze pendulums could not be used because of large ranges of temperature.

Time was determined at the first 7 stations by transit observations on 5 or 6 stars on each night during which the gravity work was in progress. At the last 3 stations Naval Observatory time signals were used. On one night at each of 9 of the stations observations were made on 16 pairs of stars for the determination of latitude. Local triangulation was done at each latitude station to connect it with the existing triangulation.

The gravity stations were at Fort Morgan, Ala.; Chandeleur Island, Port Eads, Burrwood, Fort St. Philip, Pointe à la Hache, Timbalier Island, and Morgan City, La.; and Beaumont and Sabine, Tex. Latitude was observed at all of these stations except Fort Morgan.

Throughout the season a portable frame tent was used as an observatory for the astronomical observations and at several of the stations it was also used for the gravity room. Two collapsible aluminum tripods were used in place of piers on which to mount the astronomical transit and the gravity receiver, and thus made possible a considerable saving in time.

Assistance was rendered during the season by the U. S. Engineers and the Lighthouse Service. Many of the stations were at lighthouses or other locations difficult to reach and could not have been occupied without the cooperation of these two organizations.

WISCONSIN.

[Lieut. GEORGE D. COWIE, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Latitude and longitude: 2 precise latitude stations established; 1 difference of longitude (radio) determined. Gravity: 1 gravity station occupied.

About the middle of April, 1922, a radio-recording apparatus for receiving wireless time signals was secured from the Bureau of Standards and by the end of the month the preliminary test of the apparatus had been completed at the U. S. Coast and Geodetic Survey observatory at the Washington office.

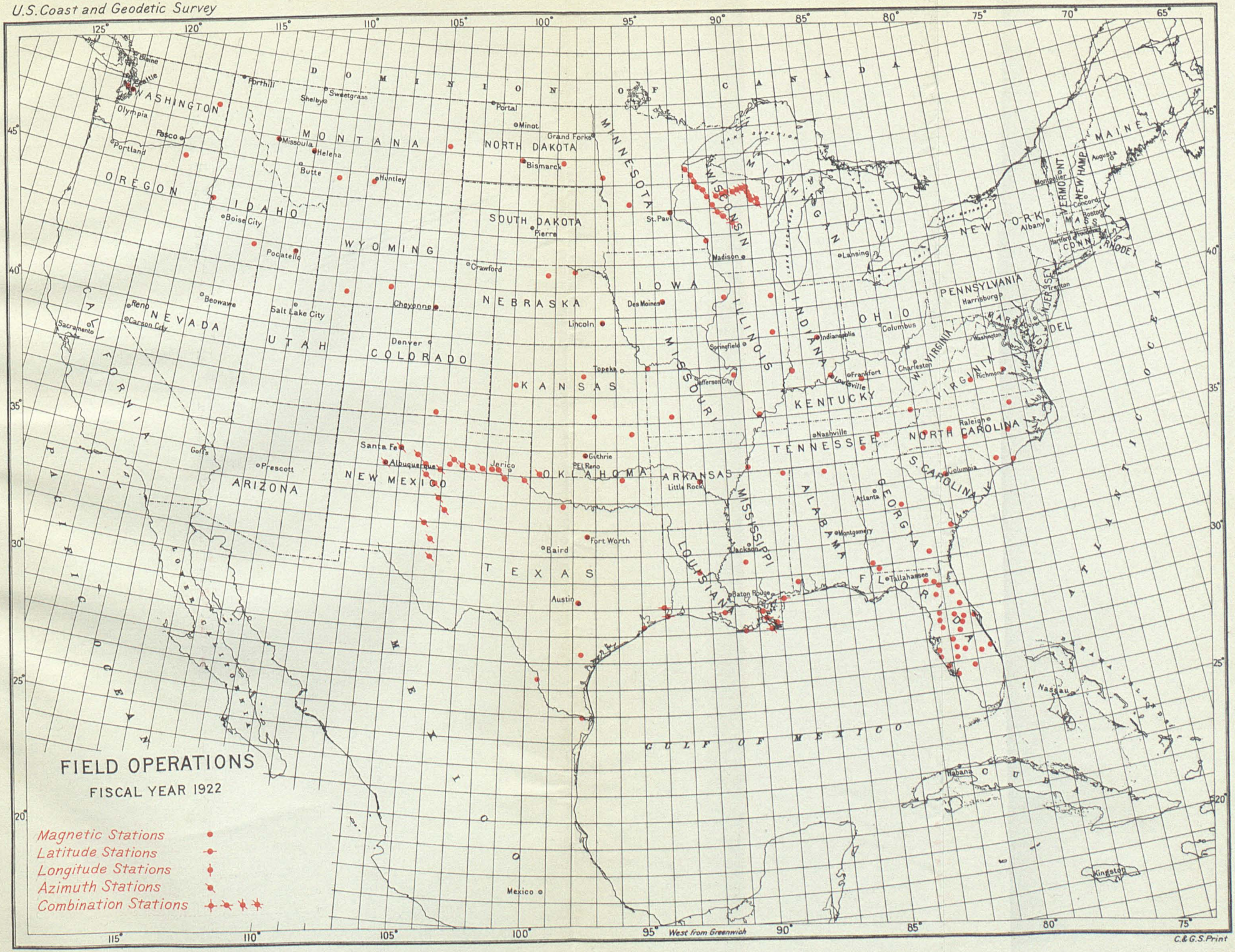
The equipment was then moved to the U. S. Naval Observatory in Washington and between May 1 and May 27, 10 good determinations of the wireless lag of the apparatus were made. This lag represents the interval of time between the tick of the master clock in the Naval Observatory and its record on the chronograph used in the field, after the impulse has passed through the telegraph relays at the Naval Observatory, the land telegraph line to Annapolis, the gang relays there, the Annapolis antennæ, and back through the antennæ, relays, and pen magnets to the pen record on the chronograph sheet. A correction for this lag must be applied to all longitude determinations by radio. The chief of party was assisted in these preliminary tests by Lieut. (Junior Grade) Fred E. Joekel.

The party next proceeded to Marshfield, Wis., and, after taking two trucks and other equipment from storage, moved to Wisconsin Rapids, Wis., where the first wireless longitude determination was made. The results obtained were very satisfactory.

The intensity of gravity was also determined at this station with the new invar pendulums. A duplicate determination was made with the bronze pendulums for the purpose of checking the accuracy and reliability of the invar pendulums. The time signals received by radio in connection with the longitude work were used also to obtain the rates of the gravity chronometers. The gravity observations were made by Edward P. Morton, extra observer, who is assistant to the chief of party on this work.

Latitude observations were made at this station and also at Owen, Wis., an intermediate point between Wisconsin Rapids and the next longitude station. At the end of June the party had reached Ladysmith, Wis., and had the apparatus set up and in good working order for determinations of longitude, latitude, and gravity.

Two ¾-ton trucks were used to transport the party and outfit. About 1½ days were required to set up the apparatus at each station where longitude, latitude, and gravity were all to be determined. At the station where only latitude was observed the apparatus was set up in a very short time by using a collapsible aluminum tripod in place of a pier on which to mount the instrument.


FIELD OPERATIONS
FISCAL YEAR 1922
Magnetic Stations
Latitude Stations
Longitude Stations
Azimuth Stations
Combination Stations
DOMINION OF CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
RHODE I.
NEW JERSEY
DEL.
MD.
W. VIRGINIA
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
S. CAROLINA
GEORGIA
ALABAMA
FLORIDA
MISSISSIPPI
LOUISIANA
ARKANSAS
MISSOURI
KANSAS
OKLAHOMA
TEXAS
NEW MEXICO
COLORADO
UTAH
ARIZONA
NEVADA
CALIFORNIA
PACIFIC OCEAN
GULF OF MEXICO
ATLANTIC OCEAN
CUBA
MEXICO
Seattle
Olympia
Pasco
Portland
Forthill
Sweetgrass
Shelby
Portal
Minot
Grand Forks
Bismarck
Missoula
Helena
Butte
Huntley
Boise City
Pocatello
Pierre
St. Paul
Madison
Lansing
Crawford
Beowawe
Salt Lake City
Cheyenne
Des Moines
Lincoln
Reno
Carson City
Sacramento
Denver
Topeka
Springfield
Jefferson City
Indianapolis
Columbus
Harrisburg
Albany
Montpelier
Concord
Boston
Augusta
Hartford
Providence
Trenton
Dover
Washington
Richmond
Charleston
Frankfort
Louisville
Raleigh
Nashville
Columbia
Atlanta
Montgomery
Tallahassee
Jackson
Baton Rouge
Little Rock
Guthrie
El Reno
Fort Worth
Baird
Austin
Jerico
Santa Fe
Albuquerque
Goffs
Prescott
Mexico
Nassau
Habana
Kingston
West from Greenwich
C.&G.S. Print

KANSAS.

[Lieut. (Junior Grade) FRED E. JOEKEL, U. S. Coast and Geodetic Survey.]

Field work for the determination of gravity at several stations in Kansas, Oklahoma, and Texas was begun June 5, 1922, at Wilkins Well, near Junction City, Kans. Observations at this station were in progress at the close of the fiscal year.

Invar pendulums are being used for these gravity determinations and the chronometer corrections are being obtained from the Naval Observatory time signals transmitted by radio and recorded by means of the new radio-recording apparatus recently designed and constructed by the Bureau of Standards for the use of this survey.

MAGNETIC WORK.

MARYLAND (CHELTENHAM MAGNETIC OBSERVATORY).

[Magnetic Observer GEORGE HARTNELL.]

The work of the observatory was continued throughout the year without material interruption. The two magnetographs were kept in continuous operation, requiring very little adjustment; scale value determinations were made once a month, absolute observations once a week, and meteorological observations daily. The chronometer corrections were determined daily by means of radio time signals sent out from Arlington.

The seismograph has been in continuous operation except for a few hours at the time of the great snowstorm of January 29–30, when the seismograph house could not be reached because of snowdrifts. On January 30 the observer in charge was more than two hours in going from his home to the observatory on improvised snowshoes, a distance of less than a mile. Twenty-seven earthquakes were recorded.

Several sets of field instruments were standardized. An electric-lighting attachment for illuminating the scale of the magnet of field magnetometers was tested and found to be satisfactory.

The observer in charge made a study of and prepared papers on the following subjects: Horizontal Intensity Variometers (now in the hands of the printer), The Physics of the Earth Inductor, Elementary Magnets, and Suspended Type of Vertical Intensity Variometer.

FLORIDA AND GEORGIA.

[Magnetic Observer WALLACE M. HILL.]

STATIONS OCCUPIED.—Florida, Arcadia, Bartow, Bradentown, Brooksville, Dade City, De Land, Fort Myers, Port Pierce, Gainesville, Inverness, Kissimmee, Lake Butler, Lake City, Moore Haven, Okeechobee, Orlando, Palatka, Punta Gorda, Sanford, Sarasota, Sebring, Starke, Tavares, Titusville, Wauchula; Georgia, Milledgevile.

Between February 11 and June 30 the three magnetic elements were determined at each of the above places. Meridian lines were established at the stations marked. Old stations were reoccupied, or very nearly so, at the places marked. At Lake City and De Land new stations were also established.

This work was undertaken primarily at the request of the Florida Engineering Society and will, when completed, provide, at each county seat in the State, a meridian line or other true bearings by means of which county surveyors may test their compasses. The need of it was shown by the fact that of 19 places in the above list where stations had been established in earlier years 12 were no longer suited for magnetic observations.

ALABAMA, COLORADO, GEORGIA, ILLINOIS, INDIANA, KANSAS, LOUISIANA, MISSISSIPPI, MISSOURI, NEW MEXICO, OKLAHOMA, SOUTH CAROLINA, AND TEXAS.

[Magnetic Observer FRANKLIN P. ULRICH.]

STATIONS OCCUPIED.—Alabama, Mobile; Colorado, Trinidad; Georgia, Bainbridge, Donaldsonville, Savannah, and Waycross; Illinois, Cairo; Indiana, Indianapolis; Kansas, Scott City; Louisiana, Alexandria; Mississippi, Brookhaven; Missouri, Springfield; New Mexico, Tucumcari; Oklahoma, Vinita; South Carolina, Columbia; Texas, Amarillo, Austin, Beeville, Brownsville, Forth Worth, Galveston, Laredo, and Wichita Falls.

Between February 11 and April 18 determinations of the three magnetic elements were made at the stations named above, of which one, Donaldsonville, was

a new station. At 19 of the 22 repeat stations visited the original spot was occupied. At Galveston, Brownsville, and Cairo the old stations could not be reoccupied. At Galveston and Cairo the new stations were very close to the old ones and at Brownsville the new station was about 500 feet distant from the former one. At Bainbridge and Trinidad the old stations were occupied and also new stations were established. New marks were set at several stations.

Whenever practicable the county surveyor of each county was visited. They were found to be must interested in the work and willing to furnish any assistance in their power.

IDAHO, ILLINOIS, IOWA, MINNESOTA, MONTANA, NEBRASKA, NORTH DAKOTA, OREGON, WASHINGTON, WISCONSIN, AND WYOMING.

[Magnetic Observer WILLIAM WALTER MERRYMON.]

STATIONS OCCUPIED.—Idaho, Pocatello, Shoshone, and Weiser; Illinois, Joliet; Iowa, Davenport and Des Moines; Minnesota, Breckenridge, St. Paul, and Wilmar; Montana, Billings, Glendive, Helena, Livingston, and Missoula; Nebraska, Chadron, Lincoln, and Newport; North Dakota, Bismarck, and Jamestown; Oregon, Pendleton; Washington, Spokane; Wisconsin, La Crosse; Wyoming, Cheyenne, Rawlins, and Green River.

Between July 1 and September 30, 1921, observations of the three magnetic elements were made at the stations named above.

At all of these places the old stations were reoccupied except at Billings and Livingston, Mont., and Cheyenne, where stations were occupied as near as possible to the old stations, and at Joliet, Ill., where a new station was established.

Auxiliary observations for declination were made at Bismarck, N. Dak., at a point as near the 1907 station as could be determined.

ALABAMA, ARKANSAS, INDIANA, KANSAS, KENTUCKY, MISSISSIPPI, MISSOURI, NORTH CAROLINA, OKLAHOMA, TENNESSEE AND VIRGINIA.

[Mathematician W. N. MCFARLAND.]

STATIONS OCCUPIED.—Alabama, Huntsville; Arkansas, Little Rock; Indiana, Vincennes; Kansas, Salina and Winfield; Kentucky, Louisville and Winchester; Mississippi, Corinth; Missouri, Kansas City and University City; North Carolina, Goldsboro, Halifax, Morganton, Salisbury, Troy[1, 2], Whiteville[2], and Wilmington[1]; Oklahoma, Guthrie and McAlester; Tennessee, Athens, Knoxville, and Memphis; Virginia, Bristol, Lynchburg, and Richmond.

Between July 1 and October 22, observations were made for magnetic declination, dip, and intensity at the stations named. Where additional work was necessary the fact is indicated by the footnotes.

All of the stations were repeat stations, but it was necessary to redetermine the azimuth at 10 of them. Auxiliary stations were occupied where local disturbance was suspected.

TUCSON, ARIZ., MAGNETIC OBSERVATORY.

[Magnetic Observer WILLIAM H. CULLUM.]

The work of the observatory was continued without material interruption throughout the year. The magnetograph was kept in continuous operation, scale value determinations were made at least once a month, absolute observations once a week (except that for part of June the earth inductor was out of order and no dip observations were made), and meteorological observations daily. Difficulty was experienced in keeping the vertical intensity variometer in proper adjustment, but the other two variometers gave very little trouble.

The seismograph was in continuous operation and 32 earthquakes were recorded. The driving clocks gave much trouble and for part of the year only one component of the seismograph was running while the driving clock of the other was undergoing repairs.

The chronometers were kept rated by means of weekly comparison in Tucson with telegraphic time signals from Mare Island.

The buildings were painted and repairs were made as needed. The seismograph house was improved by the addition of a window, which facilitates the care and adjustment of the instrument.

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[1] New stations established. [2] Meridian lines established.

ALASKA—HYDROGRAPHIC AND TOPOGRAPHIC WORK.

[Lieut. Commander T. J. MAHER, Commanding Steamer *Surveyor*.]

SUMMARY OF RESULTS.—Triangulation: 720 square miles of area covered; 48 observing tripods and scaffolds built; 21 stations in main scheme occupied for horizontal measures; 18 stations in supplemental scheme occupied for horizontal measures; 3 stations occupied for vertical measures; 96 geographic positions determined; 24 elevations determined trigonometrically. Magnetic work: 5 new primary stations on land occupied. Topography: 72.3 square miles of area surveyed; 68 miles of detailed shore line surveyed; 5 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 2,764 square miles of area covered; 5,598 miles run while sounding; 21,647 positions determined (double angles); 44,378 soundings made; 4 tidal stations established; 1 hydrographic sheet finished, scales of hydrographic sheets 1:10,000 and 1:20,000. Physical hydrography: 5 current stations occupied; 5 deep-sea current stations occupied; 1,370 deep-sea current observations made; 8,200 deep sea subsurface current observations made; 717 observations of density of water made; 358 observations of surface temperature of water made; 1,074 observations of subsurface temperature of water made; 210 observations of temperature of air made; 1 tidal station established; 359 specimens of water preserved.

The operation of the vessel during this year may be divided into four periods: The first from July 1, 1921, until November 6, 1921, covering its work in southeast Alaska; the second from November 6, 1921, until January 16, 1922, a period of repairs and outfitting for current work; the third from January 17, 1922, to March 22, 1922, covering the operations of the party while engaged on current work off the Washington and Oregon coasts; the fourth from March 23 to June 30, 1922, covering repairs, outfitting, and work in southeastern Alaskan waters.

Instructions dated February 21, 1921, covered the first work, which consisted of the usual combined operations in the area between Dixon entrance and the southern ends of Chatham and Sumner Straits, southeastern Alaska. Triangulation was carried from Cape Bartolome, Baker Island, to the northern end of Iphigenia Bay. The main scheme consisted of large figures with seven stations on mountain tops. Small schemes were carried along the outer coasts of Baker and Noyes Islands, through San Nicholas Channel, amongst the Anguilla Islands, across the Gulf of Esquibel to control the topographic and hydrographic surveys in those sections.

The topographic surveys of Baker, Noyes, San Pedro, and Noname Islands were completed and gaps in surveys in the vicinity of Point Garcia, Gulf of Esquibel, were filled in.

The hydrographic survey of the Gulf of Esquibel, of San Nicholas Channel, and the inshore hydrography along the west coast of Baker Island were finished. The hydrographic survey of the outer coasts of Noyes Island was partly completed.

Ship hydrography was carried from the vicinity of Forrester Island north to approximately the latitude of Timbered Isle and westward beyond the 1,000-fathom curve.

Declinometer observations were made at triangulation stations for the purpose of determining the magnetic variations, and the ship was swung for the same purpose. The ship's compasses are compensated within the errors of observation, and any local attraction would have become evident while sounding.

An automatic tide gauge was maintained in operation at Steamboat Bay, Noyes Island. It was centrally and favorably located with regards to all hydrographic work.

The drift of the ship when hove to at night was observed for the purpose of deriving information regarding currents, but the data obtained only gave information regarding the drift of the vessel under different weather conditions.

From November 6 until December 13 the vessel was at Seattle, Wash. On December 13, 1921, the vessel proceeded to Eagle Harbor, Wash., for repairs. On January 12, 1922, the work was completed and the ship returned to Seattle. Supplies and provisions were taken aboard.

On January 17, 1922, the ship got under way, stopping at Port Townsend, Wash., for fumigation. On January 18 current work was started. The vessel was engaged on this class of work until March 22, 1922, occupying the following stations: Station A, Straits of Fuca, south of Point Sheringham, January 18–19, 1922; Station B, 34.7 miles, 287° true from Westport Light, Grays Harbor, Wash., January 20–27, 1922; Station C, 26.8 miles, 235° true from North Head Light, Columbia River, Oreg., January 27–February 3, 1922; Station D, Heceta Bank, Oreg., February 19–26, 1922; Station A, Straits of Fuca, south of Point Sheringham, March 20–21, 1922.

On April 18 the ship left the yard of the Seattle Shipbuilding & Drydock Co., where repairs had been made. On April 19 the vessel was fumigated at Port Townsend, Wash., and at 9 p. m., April 22, tied up at the lighthouse dock at Ketchikan, Alaska. Repairs to the *Cosmos* were started on April 24. After spending a week at Ketchikan authority was requested to have the work done under contract. This was authorized. The contract time was 14 days.

On May 4 the party proceeded to the working grounds. Only one launch (the small steamer) was operating. The other gas launches (including the motor sailer) were not ready for field work.

It was not practicable to resume work where left off during October, 1921, as launches were necessary for that purpose. Triangulation was started in the vicinity of Warren and Coronation Islands, as the service of the entire party could be used on this class of work. The area was unsurveyed and care had to be exercised in navigating, causing delay, and considerable time was lost by the parties going in pulling boats to and from the ship. Some very fine weather for offshore hydrography could not be taken advantage of.

On May 22 the *Surveyor* returned to Ketchikan. On this date the *Cosmos* was received from the contractor. It was not desirable to leave in an unfinished condition the work which had been started, so this was completed. About June 10 launch work was resumed where left off during 1921.

At the end of June parties were in the field as specified below: One hydrographic party on the *Cosmos* working in the vicinity of Cape Addington; one hydrographic party, using steam launch *No. 47*, in the Anguilla Islands; one hydrographic party, using a gas launch, in the Anguilla Islands; one hydrographic party on the ship.

The following was accomplished during the season: Topographic survey of Warren Island completed; hydrographic survey of Warren Cove completed; triangulation along the outer coast of Coronation Island completed, but on account of defective reconnaissance the scheme was carried forward through a single triangle—it will be strengthened by another triangle, but very favorable weather conditions will be necessary before this can be done; triangulation from Fairway Island down Coronation Channel to Noyes Island completed; triangulation in the Anguilla group to locate signals for hydrographic work; hydrography in the Anguilla group well under way; hydrography along the outer coast of Noyes Island practically completed; ship hydrography in the vicinity of the Anguilla Islands in Coronation Channel and southwest from Coronation Island in progress. An automatic gauge was in operation in Steamboat Bay, Noyes Island. One tide staff was read in the Anguilla Islands.

Declinometer observations were made at the triangulation stations. Inspection of a chart agency was made at Craig, Alaska.

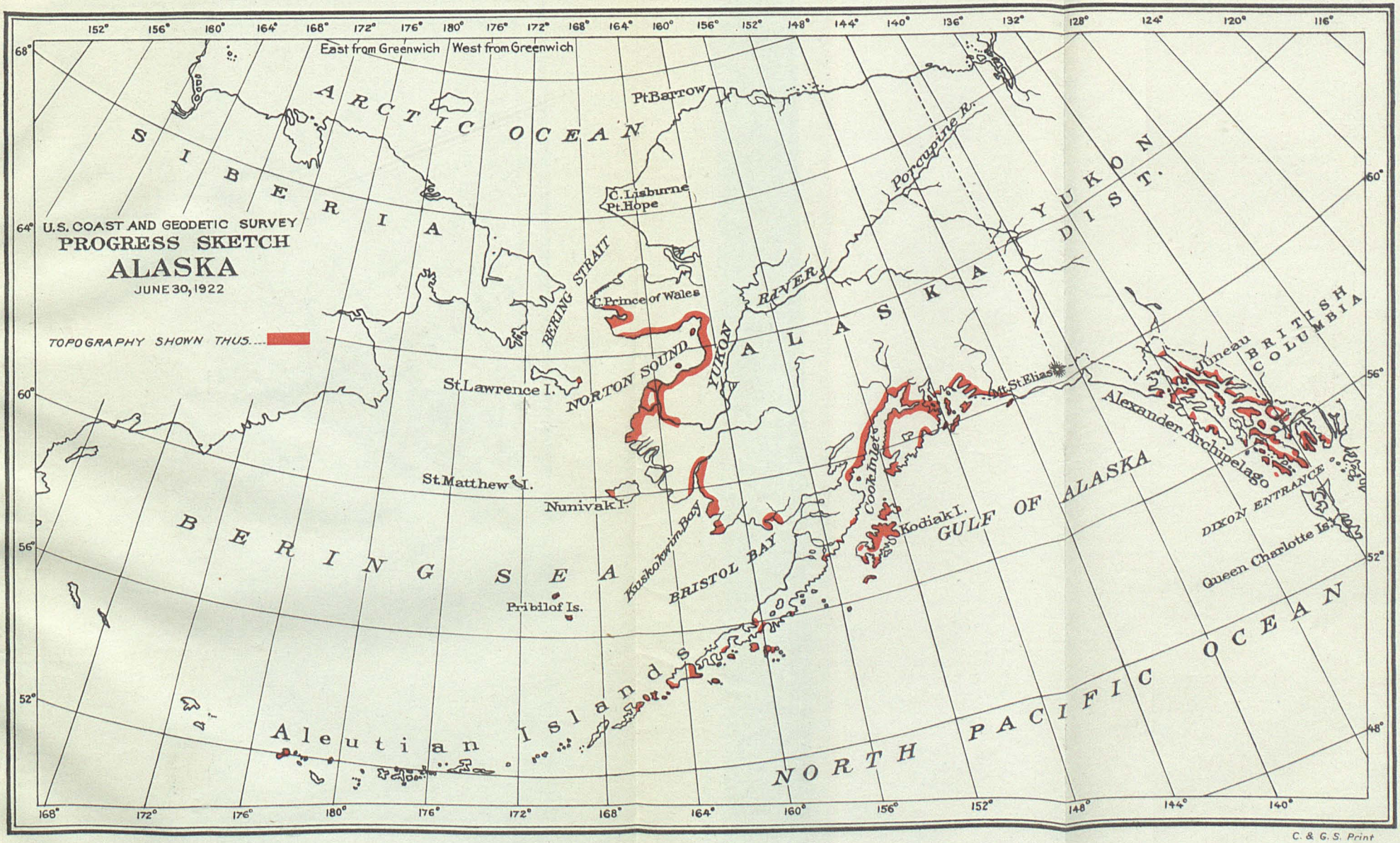
A few sounding lines were run over the area between Coronation and Hazy Islands. Depths varying from 35 to 50 fathoms were found, and distant from big Hazy Isle, less than one-quarter of a mile, a depth of 30 fathoms was obtained. Southwest from Warren Island two soundings less than one-half a mile apart differed by more than 100 fathoms.

[Commander N. H. Heck, Commanding Steamer *Explorer*.]

Summary of results.—*Magnetic work*: 62 land stations occupied for magnetic declination; 110 sea stations occupied for magnetic declination; 3 stations at which ship was completely swung. *Topography*: 112 square miles of area surveyed; 146 miles of general coast line surveyed; 2 miles of road surveyed; 2 topographic sheets finished, scales 1:10,000 and 1:20,000. *Hydrography*: 304 square miles of area dragged or sounded or both; 150 miles run while sounding; 4,215 miles run while drag was sweeping; 11,396 angles measured; 1,808 soundings made; 5 tidal stations established; 5 hydrographic sheets finished, scales 1:20,000 and 1:40,000.

At the beginning of the fiscal year the steamer *Explorer* was engaged in completing the surveys in the region of Juneau, after which work in Lynn Canal was taken up and made satisfactory progress. The use of the long sweep in covering large areas at a rapid rate of operating continuously for at least 16 hours had been developed. The *Explorer* had been used successfully in all classes of work, especially in the inshore sweep and drag work, and a new method had been devised for indicating when an obstruction was encountered by the sweep.

Topography.—The scheme of work extended from Grand Island to Horse Island, Stephens Passage, including form lines for this area, and also for a part of Douglas Island on which the shore line was finished; Gastineau Channel including the water fronts of Juneau, Douglas, Treadwell, and Thane; form lines for sheet of 1917 between North Island and Auke Bay; and Lynn Canal


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1922
TOPOGRAPHY 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
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

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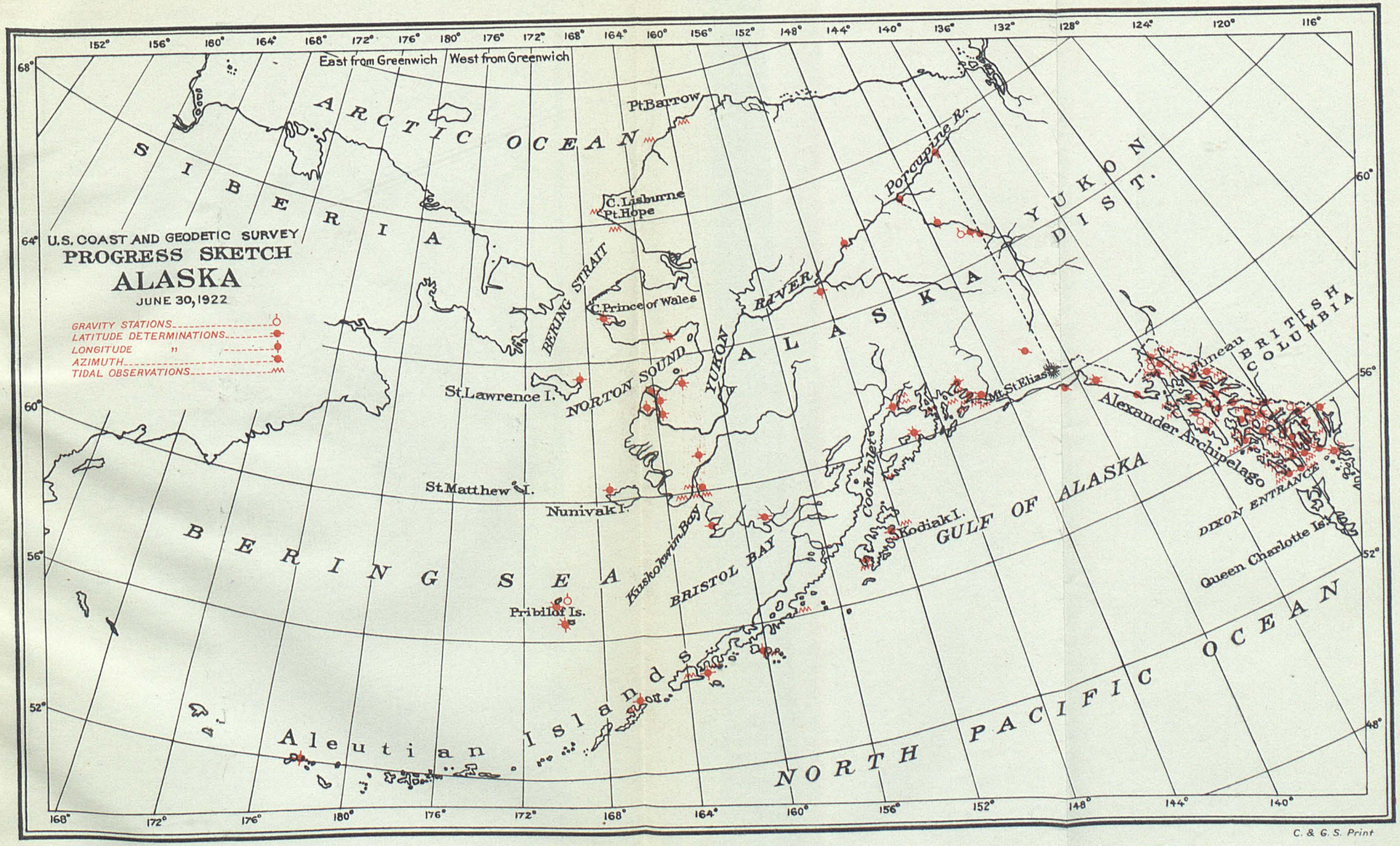
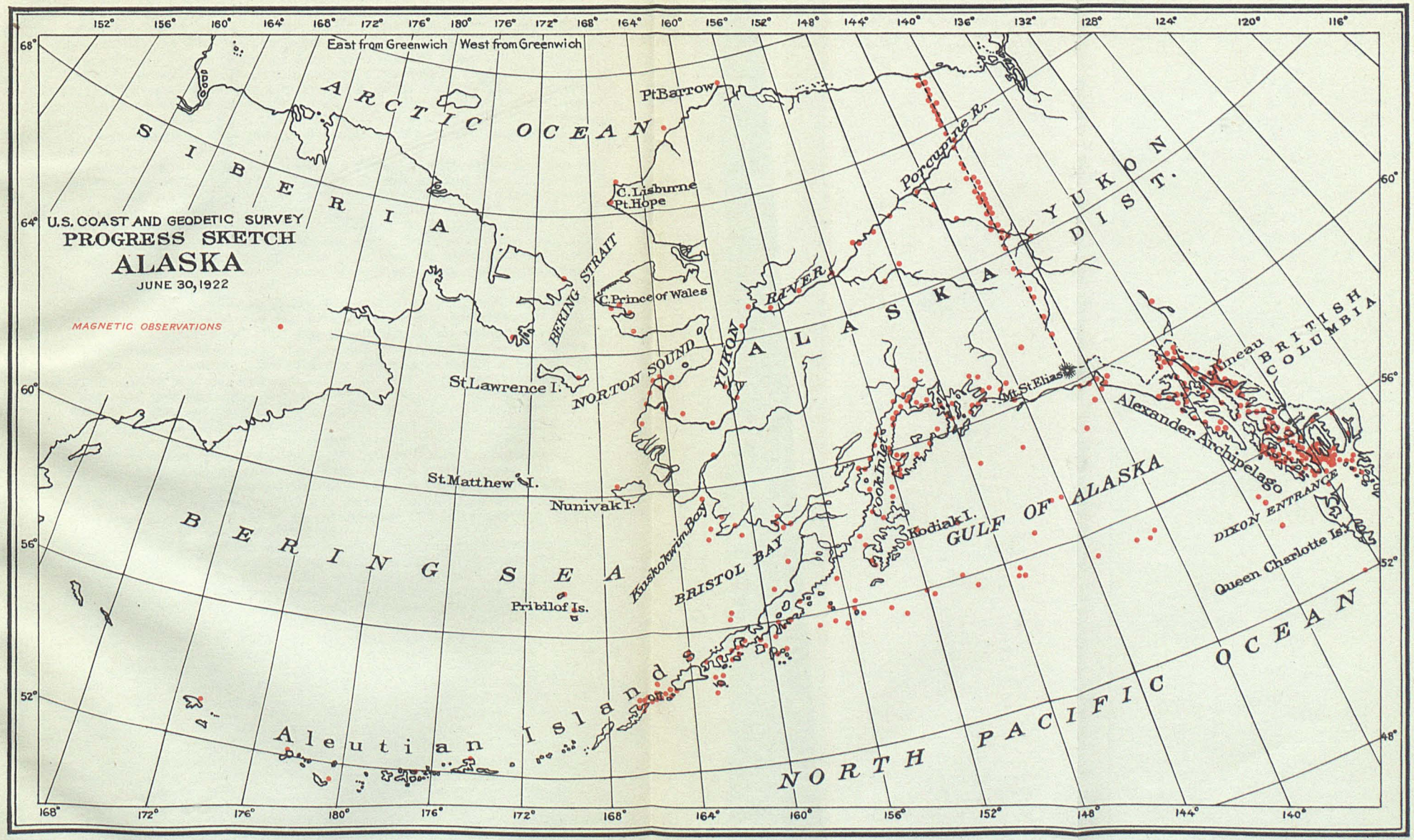

U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1922
GRAVITY STATIONS
LATITUDE DETERMINATIONS
LONGITUDE "
AZIMUTH
TIDAL OBSERVATIONS
East from Greenwich
West from Greenwich
ARCTIC OCEAN
SIBERIA
Pt. Barrow
C. Lisburne
Pt. Hope
BERING STRAIT
C. Prince of Wales
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
BERING SEA
Pribilof Is.
Kuskokwim Bay
BRISTOL BAY
YUKON RIVER
Porcupine R.
YUKON DIST.
ALASKA
Mt. St. Elias
Cook Inlet
Kodiak I.
GULF OF ALASKA
Alexander Archipelago
Juneau
BRITISH COLUMBIA
DIXON ENTRANCE
Queen Charlotte Is.
Aleutian Islands
St. Paul
NORTH PACIFIC OCEAN
C. & G. S. Print


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1922
MAGNETIC OBSERVATIONS
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
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
Cook Inlet
Kodiak I.
GULF OF ALASKA
DIXON ENTRANCE
Queen Charlotte Is.
BERING SEA
Pribilof Is.
Aleutian Islands
NORTH PACIFIC OCEAN

C. & G. S. Print

from North Island to Skagway. Portions of this scheme are widely scattered and much of it does not correspond to the other classes of work. In coordinating this work with the other operation difficulty was experienced throughout the season except for the area in Lynn Canal, and even here the drag work had to be slowed down so as not to get too far ahead.

Magnetic work.—After July 1, 1921, magnetic observations were made at numerous triangulation stations. Unfortunately, the necessary triangulation in the vicinity of Haines was not completed until late in September, when a magnetic survey of the area affected by local disturbances could not be accomplished. While the effect is slight in comparison with that at Port Snettisham, the area affected is considerable and apparently includes Portage Cove. Observations for declination were made at 25 well-distributed stations in Lynn Canal. Evidence of local attraction was obtained at only one station. Of the scheme of observations planned for Gastineau Channel only four stations could be completed.

Sweep and drag work.—During the past two seasons' work there has developed the following conception of the problems to be met in this class of surveying. All of the area on the coast of Alaska can be divided in three parts: First, deep, open area in which there is little likelihood of the existence of shoals; second, deep area inshore or in the vicinity of known shoals; third, alongshore area or shoal area where the known depth is generally less than the maximum depth verified by the drag. The provision of an effective means of covering each class of area with the greatest speed is the outstanding accomplishment of this season.

Taking all the various classes in order, the sweep as now perfected, with proper apparatus, is beyond question the best for covering open areas rapidly. It was proved during this season that the possibility of covering very large areas in short time is limited only by the possibility of determining the necessary control points on the shore. Without any attempt to make a record, an area of 45 square miles was covered on each of several days using the 15,000-foot sweep, but only the fact that the area of this class to be dragged this season was limited prevented the use of the 25,000-foot sweep from being operated day and night. It is sufficient to say that if this method had been available at the beginning of the drag work a full season's work could probably have been saved and last season's drag work could have been finished in about 6 weeks. In this class of work the sweep can be aided by two launches or, if desired, the ship and two launches may tow the sweep with resulting greater speed and width. The speed of the sweep varies with the effective width and with the currents, but with the 15,000-foot sweep an average speed of 2½ statute miles per hour can be counted on.

The second class of area is that where it is not found practicable to take the long sweep into places where there is reason to expect a rock may be found. Accordingly, there will always be spots of deep water for various widths between the limits of the long sweep and the shore high-shoal water. This area could, of course, be covered with the drag at a minimum depth and sometimes this is done.

Third, the area that is left when the above-described operations have been completed is a long shoal survey of varying widths or general shoal areas surrounded by deeper waters. Alongshore area includes that surrounding islands or ledges. This area has to be covered by the drag, but especially in Alaska there are many features to be considered. The alongshore areas are generally ragged as in most cases the charts are lacking in information necessary to give desired depth control. Such shoals as have been found by the inshore sweep work are usually more or less uncertain in depth as shoal development is only incidentally a part of the sweep work. Currents are often stronger and more regular in the vicinity of shoals than in the main channels. With the methods available during the season of 1920, the adequate development of the shoal area at a speed commensurate with that of the sweep seemed impossible. With the methods developed during season of 1921, this class of area could be covered quite rapidly, though the ultimate possibilities with the apparatus now available have not yet been reached. It is essential, however, that preliminary soundings be taken in most places in advance of the drag work for depth control. The methods for obtaining the desired depth control have been improved.

A very interesting and important discovery of the 1921 season was due to the elimination of rope from the towline system. It was found that whenever a rock which is not covered by too much kelp is struck by the fast-moving

sweep a vibration is set up in the wire which produces a musical note of unmistakable character at the vessel or launch nearest the rock. In one case this note was clear and the rock was 4,000 feet away. This is the long-sought-for indication of grounding and adds greatly to the value of the sweep.

[Lieut. J. H. HAWLEY, Commanding Steamer *Wenonah*.]

SUMMARY OF RESULTS.—Magnetic work: 8 land stations occupied for magnetic declination; 1 station at sea at which ship was completely swung. Topography: 116 miles of general coast line surveyed; 3 topographic sheets finished, scale 1:20,000. Hydrography: 219 square miles of area covered; 914 miles run while sounding; 4,843 positions determined (double angles); 10,210 soundings made; 2 tide stations established; 6 hydrographic sheets finished, scales 1:20,000, 1:50,000, and 1:80,000.

At the beginning of the fiscal year the steamer *Wenonah* was engaged in combined operations in Clarence Strait and adjacent bays and sounds. This work was continued until July 5, when it was necessary to suspend operations and use the entire party for the precise triangulation over the first two figures of the scheme at the entrance to Clarence Strait. The party was thus employed until August 3 when the usual combined work was resumed and continued until October 15. Field work was discontinued for the season on October 15, and on the 16th the vessel left Saltery Cove, which was used for an anchorage for the last part of the work, and convoyed the two steam launches to Ketchikan, the wire-drag tender having preceded the party on the 15th. The weather was very stormy and it was necessary for the ship to proceed at a slow speed just ahead of the launches and spread oil on the water to enable them to make the passage across the strait.

From October 17 to 20 the party was at Ketchikan, engaged in hauling out and storing the three launches on Gravina Island and in tidal work in connection with the inspection of the automatic gauge. The engines of the two steam launches were removed for repairs and all launches were completely cleaned and painted. On the 20th the ship proceeded to Metlakatla to obtain a few items of equipment that had been left there at the beginning of the season and to take an inventory of equipment in the old boathouse, returning to Ketchikan on the same day.

On October 21 the vessel left Ketchikan for Seattle, arriving on the morning of the 24th. The weather for the trip south was very nearly perfect, which is quite remarkable in view of the fact that from the middle of September to within 12 hours of the time of leaving Ketchikan the weather had been continually stormy, while a southeast storm started on the morning the ship arrived in Seattle.

The general plan of operation adopted in this work was as follows: One subparty was engaged in recovering and preparing stations and in observations for precise and tertiary triangulation, and also observed for magnetic variation. A second subparty was engaged on inshore hydrography except during the period from July 6 to August 3. The third subparty was engaged in topography and the building of small signals for the control of hydrographic work. The ship was engaged in transporting the three parties mentioned above, in signal building, tidal work, and ship hydrography. The offshore hydrography was of comparatively small extent and required less time than the other work, so that it was arranged to take advantage of the best weather for such work.

Triangulation.—At the end of the fiscal year observations had been completed at five stations on the line Skin-Gravina and extended to the southward of this line, and at the end of the fiscal year observations were completed at five stations on and adjacent to this line. Night observations were then taken up over the first two figures of the scheme and the work extended northward to join the previous work and to complete the scheme from the line Chacon-Lazaro to the line Skin-Gravina. After this work was completed the party prepared the stations to the northward and completed the observations to the line Approach-Caamano.

Very little tertiary triangulation was done, as the number and location of stations previously established was quite satisfactory, while several intermediate stations had been located during the precise work. Ten supplemental stations of the 1912 scheme were recovered and re-marked when necessary.

Topography.—After July 1 the topography was completed on the west side of Gravina Island from the limit of previous work at Dall Head northward to a junction with previous work at Rosa Reef Beacon, in Tongass Narrows, including Guard Island and the north shore of Tongass Narrows from a point opposite Rosa Reef Beacon to Survey Point. Work was then resumed on the west side of the strait and extended from Chasina Anchorage northward to a

point about halfway between Island and Skowl Points, including High and Patterson Islands. Considerable attention was given to the form lines in the region covered by the topography and the ground was quite well covered, except in the area north of Chasina Anchorage, where it was necessary to discontinue work, on account of bad weather, before the form lines could be completed. Small signals for control of inshore hydrography were established and located by the topographic party along the shore line surveyed.

Inshore hydrography.—After July 1 the survey of the west shore of Gravina Island was taken up and the hydrography completed from a junction with previous work at Dall Head northward to a junction with previous work at Guard Island. Work on the west side of the strait was then resumed and completed from the Wedge Islands northward to Island Point and High Island, including the entrance to Cholmondeley Sound and a survey of Clover Bay. The launch party was also engaged for one day in developing the area adjacent to West Devil Rock. The ship towed the launch to the vicinity of this work and stood by until it was completed.

Offshore hydrography.—From the beginning of the season until June 30 the offshore hydrography executed by the ship was extended from the limits of previous work at the entrance of Nichols Passage and in Clarence Strait opposite Kendrick Bay northward to Chasina Anchorage. In July, while a precise triangulation party was observing at station Chacon, three days' work was done south of Cape Chacon and 68 soundings were obtained to fill in the vacant spaces on chart 8,102. Work was then resumed in the vicinity of Chasina Anchorage and extended northward to a junction with wire-drag work extending from Tongass Narrows up Clarence Strait. This work included a close survey of 20-fathom bank and the development of the shoalest water with the lead line.

Tidal work.—The automatic tide gauge was established at the entrance to Moira Sound, and was kept in operation from April 23 until September 14. In addition to the automatic gauge, staff gauges were established at various points and observations were obtained during the course of hydrographic work in the vicinity of each gauge. Staffs were established at Nichols Bay and Gardner Bay and connected with the bench marks established in 1920. New stations were established at Hidden Bay, Port Johnson, Vallenar Bay, Clover Bay, and Saltery Cove. The bench mark established in Niblack Anchorage in 1912 was recovered and two additional standard marks provided. Three bench marks were also installed at each of the new stations.

Magnetics.—Observations for declination were obtained at 11 triangulation stations in connection with the precise work. On July 5 inspection was made of the chart agencies of the survey at Ketchikan.

On September 14 the rock in Niblack Anchorage, shown as "P. D." on the chart, was located and the least depth of water on the rock obtained. On October 12 rocks at the entrance to Saltery Cove, Skowl Arm, were located, and on October 15 topography was executed to show the shore line on the east side of the cove from the limits of previous work to the east border of chart 8,077. On September 21 and October 17 to 20 an inspection was made of the automatic tide gauge at Ketchikan. Additional bench marks were established in the vicinity of the gauge and all marks were connected with the gauge by spirit levels.

[Lieut. J. H. HAWLEY, Commanding Steamer *Explorer*.]

SUMMARY OF RESULTS.—Magnetic work: 14 land stations occupied for magnetic observations; ship swung at 2 stations at sea; 53 course observations made. Topography: 56 square miles of area surveyed; 84 miles of detailed shore line surveyed; 2 topographic sheets finished, scale 1:20,000. Hydrography (wire drag): 92 square miles of area dragged; 245 miles run while dragging; 951 positions determined (double angles); 24 soundings made; 2 tide stations established; 2 hydrographic sheets finished, scale 1:40,000. Hydrography, supplemental: 9 square miles of area covered; 535 positions determined (double angles); 535 soundings made.

On March 14, 1922, the *Explorer* left Seattle, Wash., for Ketchikan, Alaska, arriving on March 20. From March 20 to 26 the party was at Ketchikan completing repairs to the launches. On March 27 the vessel with the launches *Helianthus*, *Scandinavia*, and wire-drag tender *No. 1* left Ketchikan and proceeded to Juneau, Alaska, arriving on the 29th.

The party remained in Juneau until April 2, overhauling launches and drag gear, taking coal, and other supplies. On April 3 two officers and seven men left Juneau in the launch *Helianthus* to take up precise triangulation and topography in Lynn Canal. On the 4th the vessel, with the remaining launches, proceeded to the south end of Stephens Passage and began the work of covering

splits in previous drag work at various places in the passage from Cape Fanshaw to South Island. This work was completed on April 13 and the ship and launches returned to Juneau, where the *Helianthus* joined the party on the 14th.

On April 17 the entire party left Juneau to take up combined surveys and wire-drag work in Lynn Canal and adjoining inlets. This work was continued until the end of the fiscal year.

Following are the details of the work accomplished: An observing party erected stands, marked stations, and completed precise observations from the line Wil-Bern, of the 1921 work, to the line Kabe-Slide. After this work was completed the party took up secondary triangulation in Lynn Canal and built signals, marked stations, and completed observations from a junction with previous precise triangulation at the lines Sentinal-Little and Sentinel-Bridget south to the eastern end of Icy Strait. Parties working from the ship extended secondary triangulation from the line Chil-Kabe, of the 1921 work, to the head of navigation in Chilkat Inlet; recovered and rebuilt signals at stations in Chilkoot Inlet north from Seduction Island; recovered the majority of the stations of the 1890 triangulation in Taiya Inlet, and connected this with the 1921 work.

Two topographic parties operated for the greater part of the time. Control was established by plane-table triangulation in the passage west of Sullivan Island and from the limit of previous triangulation to the head of Chilkoot Inlet. The following work was completed: Shore line and form lines on the west side of Lynn Canal from the vicinity of Sullivan Rock to Pyramid Harbor; form lines on sheet 3858 in the vicinity of Point Sherman; shore line and form lines on the east shore of Lynn Canal from a point about east from Eldred Rock to a point opposite Flat Bay; shore line and form lines of Sullivan Island and the Chilkat Islands; topography of the peninsula between Chilkat and Chilkoot Inlets from and including Kotchu Island in Chilkat Inlet to Battery Point in Chilkoot Inlet; 3 miles of shore line at the head of Chilkoot Inlet; and revision of form lines in the vicinity of Point Pybus, Stephens Passage.

The following wire drag and sweep work was completed: Dragging of splits in previous work in Stephens Passage from Cape Fanshaw to South Island; dragging of William Henry Bay and a small split to the eastward of the bay; completion of work from the limit of previous work in Lynn Canal north to Skagway. This last work, which was completed on June 27, included the dragging of the passage west of Sullivan Island, Chilkat Inlet, and the passages between the Chilkat Islands. Lines of soundings were run around the shores of Chilkat Inlet, at the head of the inlet between McClellan Flats and Pyramid Island, off the north side of the spit west of the south end of Sullivan Island, and around the Katzehin River spit.

For the work in Stephens Passage observations were obtained at old stations in Hobart Bay and Taku Harbor. For work in Lynn Canal an automatic gauge was established in Portage Cove on April 20 and operated until June 28, when it was removed. During the course of hydrographic work observations were obtained on supplemental staffs in William Henry Bay, back of Sullivan Island, and in Pyramid Harbor.

The ship was swung twice to determine the error of the compass, once in Stephens Passage, near Sail Island, and again in Lynn Canal, west of the Chilkat Islands. Six stations in Chilkat Inlet, seven in Chilkoot Inlet and Station Sed, in Lynn Canal, were observed with the compass declinometer. This work is not yet complete. Declination was observed while cruising at 53 points in Chilkat and Chilkoot Inlets and considerable local attraction was noted in both inlets.

The chart agency at Haines, Alaska, was inspected by an officer of the party on June 9.

[Lieut. A. M. SOBIERALSKI, Commanding Steamer *Wenonah*.]

SUMMARY OF RESULTS.—Magnetic work: 6 new auxiliary stations established; ship swung at 2 stations at sea. Topography: 119 square miles of area surveyed; 200.7 miles of detailed shore line surveyed; 17 miles of shore line of creeks surveyed; 4 topographic sheets finished, scale 1:20,000. Hydrography: 103 square miles of area sounded; 891 miles run while sounding; 4,021 positions determined (double angles); 8,762 soundings made; 8 tide stations established; 8 hydrographic sheets finished, scale 1:20,000.

Under instructions dated February 18, 1922, the *Wenonah* left Seattle, Wash., with the launch *Audwin* in tow, on March 18, and arrived at Ketchikan March

21. After coaling the necessary work on the launches was begun and the engine of the *Audwin* was repaired. The *Audwin* left Ketchikan March 27, and this party built 9 observing stands before the end of the month.

As soon as the launches were ready the vessel left Ketchikan and work was begun on the survey of Ernest Sound on March 31.

The launch *Audwin* took up the precise triangulation of Clarence Strait, while the ship was engaged in the survey of Ernest Sound. Two topographic parties and one hydrographic party were kept continuously in the field, and some hydrography was done by the ship.

The observations on the arc of precise triangulation connecting the work completed in 1921 in Clarence Strait with the work in vicinity of Zarembo Island were completed. The scheme used in 1916 was followed closely, the only change being the omission of two stations. The average triangle closure was 0.76 second, and the maximum a little over 2 seconds. Only a small amount of secondary triangulation was done as the 1916 scheme covers Ernest Sound and Zimovia Strait. A few stations were located in Menefee Inlet to furnish additional control for the topographer.

All of the western and northern shore of Ernest Sound has been completed to a junction with the previous work in Fool's Inlet. This includes Canoe Passage, Menefee Inlet, Southwest Cove, Southeast Cove, and part of Zimovia Strait as well as the numerous off-lying islands. Signals have been relocated on Onslow Island, in Fool's Inlet, and along the eastern shore in the vicinity of Point Warde. The southern shore has been completed from Lemeseurier Point to Eaton Point, including Union Bay and Vixen Inlet. Form lines have been shown as far into the interior as possible. Large scale subplans were made in the vicinity of canneries. The topography of Clarence Strait was started at the end of the month.

The inshore hydrography has been completed from Lemeseurier Point to Eaton Point, including Union Bay and Vixen Inlet. Along the north shore of Ernest Sound the work has been carried from a junction with completed work in the vicinity of Onslow Island up to the entrance of Zimovia Strait. The lines have been spaced 200 meters apart with additional development work as required. Special attention has been paid to the character of the bottom in order to furnish information for driving traps, etc. To complete the survey of Ernest Sound, there remains only the hydrography and topography of Seward Passage and the hydrography of the northern part of Ernest Sound.

The chart agency at Ketchikan was inspected on May 29 and report transmitted to office. One day was spent with the ship adjusting some discrepancy in previous season's work and a report was forwarded to the office.

A tide staff was erected in Union Bay and observations were made during the time hydrography was in progress and the necessary observations for a comparison were made. On May 12 an automatic tide gauge was installed at Menefee Inlet and has been in continuous operation ever since. A tide staff was also located at Santa Ana to be used during the progress of hydrography in Seward Pass and it is intended to use a tide staff at Ham Island for reduction of soundings at the head of Ernest Sound.

Observations with compass declinometer were made at six stations and ship swings were made in Puget Sound, Wash., and Ernest Sound, Alaska. The standard compass had a maximum deviation of 1½°, but the steering compass had such large deviations that it was adjusted. The maximum deviation is now less than 2°. An area of large local attraction in Union Bay was examined by observations on course.

[Lieut. H. B. CAMPBELL, in Charge of Launch *Wildcat*.]

SUMMARY OF RESULTS.—Topography: 10 square miles of area surveyed; 19 miles of detailed shore line surveyed, scale of topographic sheets 1:10,000. Hydrography: 7.78 square miles of area sounded; 59.6 miles run while sounding; 239 positions determined (double angles); 660 soundings made; 1 tidal station established, scales of hydrographic sheets 1:10,000 and 1:20,000.

In accordance with instructions issued February 14, 1922, a party was organized at Seattle and sailed on April 25 for Ketchikan to take up the survey of Icy Bay. The party arrived at Ketchikan and 10 days were spent in equipping the party. The launch arrived at Icy Bay on May 23, stopping at Juneau and Yakutat for oil and stores. Field work was begun on May 24. No difficulty was experienced in entering Icy Bay. The party at once started reconnaissance for triangulation and a base line was measured and observing done to locate signals for hydrographic and topographic use. It was deemed ad-

visable to go ahead with these branches of the work without waiting for conditions favorable for getting a position from the peaks and doing the azimuth measurement necessary for projections. It was evident from the reconnaissance that a favorable season would be required to complete the hydrography and no time was lost in starting it.

A base line of 1,700 meters was measured twice with an invar tape. The results were considered very satisfactory. Expansion from this base was made with two good figures in such a way that the two figures control the entire bay and served to locate sufficient intersection stations for topographic and hydrographic control.

Plane-table topography was started on the east shore of the bay on a scale of 1:10,000, where the signals located would be of immediate use for hydrography. By June 30 the topography of the east side was nearly completed.

Hydrography was started on June 26. The work inside the bay is on a scale of 1:10,000, while outside the scale is 1:20,000. The sounding done during June consisted of a number of widely separated lines run to determine the character of the work and fix the scheme. It is believed that a good channel has been located. It is planned to develop this first and then the parts of value commercially.

An automatic tide gauge has been established in Riou Bay on piling driven by the party. This was started on June 22.

No current work has been done as yet. There is a very strong current out of the bay, caused by glacial streams, and it is planned to determine the strength of this as well as the coastwise current.

Considerable time has been spent in the field in making improvements and repairs to the launch. A new wooden tank, the top of which is used as a bridge, installing sounding apparatus, calking decks, etc., have been necessary. In addition, the launch has been beached twice to locate and plug a bad leak and her hull has been copper painted.

The ice conditions have not appreciably interfered with field work. There is some floating ice and at times it becomes quite thick in places, but the currents are such that the beaches on the southern half of the bay are usually clear.

Geodetic Work.

[Lieut. H. B. Campbell, U. S. Coast and Geodetic Survey.]

Summary of results.—Triangulation, secondary: 65 square miles of area covered; 4 signal poles erected; 2 signals built of aggregate height of 18 feet; 6 stations occupied for horizontal measures; 13 geographic positions determined. Base line: 1 secondary base measured 1 mile long.

This triangulation is one of the combined operations carried on from the launch *Wildcat*, in Icy Bay, Alaska, for the control of hydrographic and topographic surveys. A base line was measured to control the lengths of the triangulation. The work was started about the middle of May and was in progress at the end of the fiscal year.

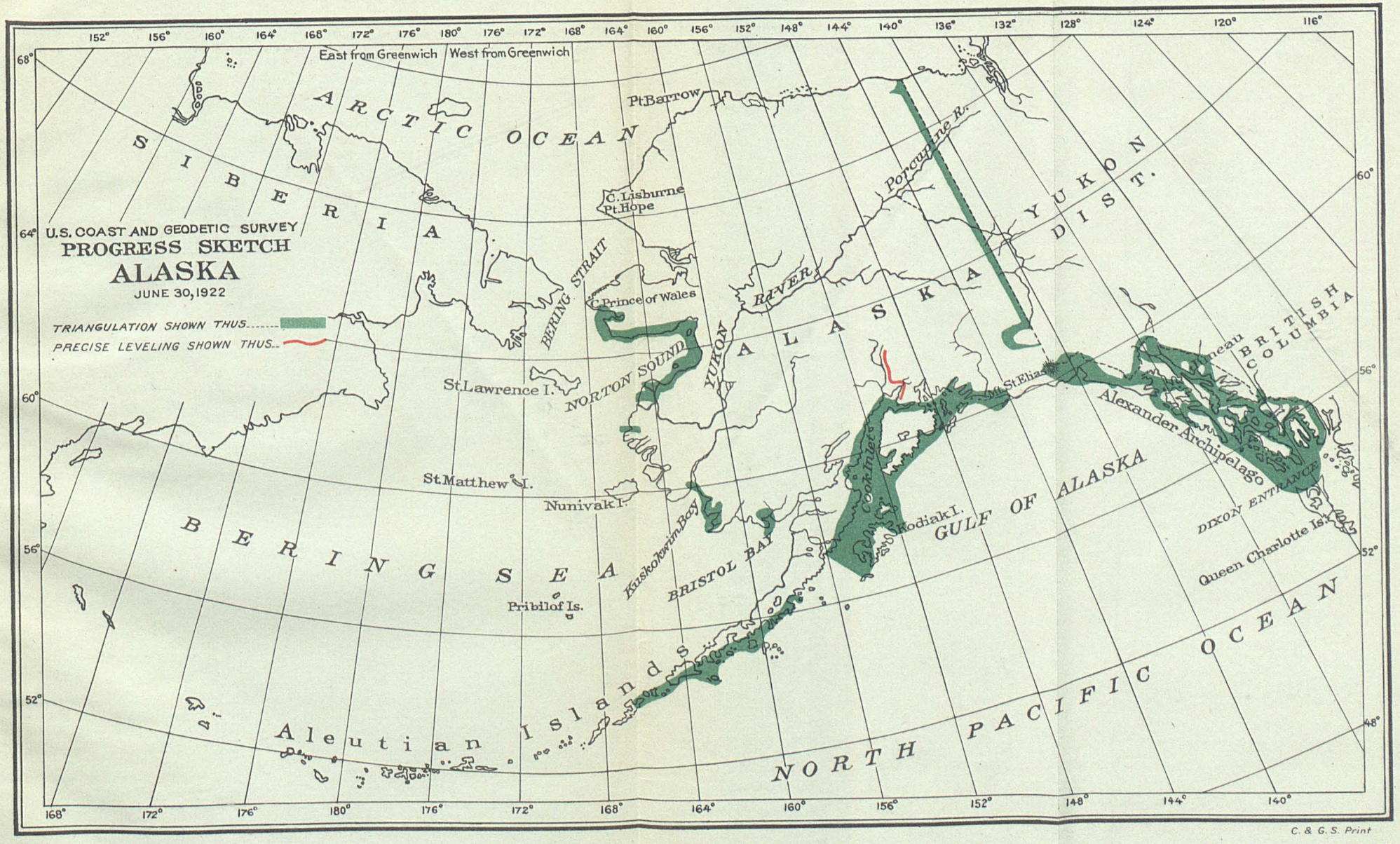
[Lieut. L C. Dyer, U. S. Coast and Geodetic Survey.]

Summary of results.—Reconnaissance: 12 stations selected for main scheme, length of scheme 34 miles; 1 base site selected. Triangulation, precise: 50 square miles of area covered, length of scheme 5 miles; 4 signal poles erected; 4 signals built of aggregate height of 140 feet; 4 stations in main scheme and 1 station in supplemental scheme occupied for horizontal and vertical measures.

On May 3, 1922, work was begun near Anchorage, Alaska, on an arc of precise triangulation extending toward Fairbanks. Eventually this arc will be extended to the point where the one hundred and forty-first meridian boundary between Canada and Alaska crosses the Yukon River. There it will connect with the arc of precise triangulation, now in progress, which extends northward from Puget Sound and which is being done by cooperation between the Geodetic Survey of Canada and the U. S. Coast and Geodetic Survey.

The nature of the country between Anchorage and Fairbanks makes reconnaissance and triangulation difficult to execute. The movements of the party are hampered by lack of roads and observations are often delayed by rain. It is necessary to use pack animals for transportation.

The chief of party is assisted by Lieut. (Junior Grade) E. O. Heaton, U. S. Coast and Geodetic Survey. Work was in progress at the end of the fiscal year.


U.S. COAST AND GEODETIC SURVEY
PROGRESS SKETCH
ALASKA
JUNE 30, 1922
TRIANGULATION SHOWN THUS
PRECISE LEVELING 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
NORTON SOUND
St. Lawrence I.
St. Matthew I.
Nunivak I.
Kuskokwim Bay
BRISTOL BAY
BERING SEA
Pribilof Is.
Aleutian Islands
Cook Inlet
Kodiak I.
GULF OF ALASKA
St. Elias
Mt. St. Elias
Juneau
BRITISH COLUMBIA
Alexander Archipelago
DIXON ENTRANCE
Queen Charlotte Is.
NORTH PACIFIC OCEAN

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[Lieut. J. H. HAWLEY, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, precise: 480 square miles of area covered, length of scheme 25 miles; 6 signal poles erected; 1 signal built, height 32 feet; 12 stations in main scheme occupied for horizontal measures; 9 geographic positions determined. Leveling: 9 permanent bench marks established; 6 miles of levels run.

On July 1, 1921, work was in progress on an arc of precise triangulation in Clarence Strait. This is a part of the arc of precise triangulation which eventually will extend from Puget Sound to the Yukon River and which is being done in cooperation with the Geodetic Survey of Canada.

The work of this season, which was one of the combined operations directed by the commanding officer of the steamer *Wenonah*, was in charge of Lieut. F. L. Peacock, U. S. Coast and Geodetic Survey.

A part of the stations are located on mountain peaks, difficult of access, on which it was necessary to make night observations. In order to provide light keepers for these stations it was necessary for the ship's party to assist the triangulation party. Bad observing weather interfered seriously with the progress of the work.

[Commander N. H. HECK, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance: 16 points selected for scheme; 2 base sites selected. Triangulation, precise: 55 square miles of area covered, length of scheme 15 miles; 18 signal poles and stands erected; 9 stations in main scheme occupied for horizontal measures; 11 geographic positions determined. Triangulation, secondary: 150 square miles of area covered, length of scheme 35 miles; 33 signal poles erected; 41 stations occupied for horizontal measures; 149 geographic positions determined. Leveling: 14 permanent bench marks established; 1 mile of levels run.

On July 1, 1921, work was in progress on an arc of precise triangulation in Stephens Passage and Lynn Canal. This is a part of the arc of precise triangulation which eventually will extend from Puget Sound to the Yukon River and which is being done in cooperation with the Geodetic Survey of Canada.

The work of this season, which was one of the combined operations directed by the commanding officer of the steamer *Explorer*, was partly in charge of Lieut. Jack Senior, U. S. Coast and Geodetic Survey, who was assisted by Ensign A. J. Hoskinson, U. S. Coast and Geodetic Survey, and partly in charge of Lieut. G. C. Jones, U. S. Coast and Geodetic Survey.

The topography of the region through which the work of this season extends is such as to make necessary the use of a small scheme and short lines. It was found that night observations on these short lines gave much better results than day observations, but, due to the limited number of men available, it was impracticable to make all the observations at night.

In order to have the necessary positions for the control of the hydrographic work in Lynn Canal, it was necessary to extend secondary triangulation in advance of the precise scheme. This work was in charge of Lieut. A. O. Ratti, U. S. Coast and Geodetic Survey.

[Lieut. A. M. SOBIERALSKI, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, precise: 430 square miles of area covered, length of scheme, 60 miles; 34 signal poles erected; 27 stations in main scheme occupied for horizontal measueres; 38 geographic positions determined. Triangulation, secondary: 8 stations in main scheme occupied for horizontal measures; 8 signal poles erected; 8 geographic positions determined. Leveling: 6 permanent bench marks established.

On March 27, 1922, work was resumed on the arc of precise triangulation in Clarence Strait, which was started in the spring of 1921. By the end of the fiscal year the work had been completed to the vicinity of Zarembo Island to a junction with the work done several years ago.

This triangulation, which was one of the combined operations directed by the commanding officer of the steamer *Wenonah*, was in charge of Lieut. C. A. Egner, U. S. Coast and Geodetic Survey. The launch *Audwin* was used in transporting the party and also as quarters for the party.

Practically all the observations were made in daylight. Several types of signals were tried, but the best results were obtained by using square center poles with one face turned squarely toward the observer in order to eliminate phase. This necessitated visiting each signal before observing on it, but was more economical than the use of light keepers. Excellent triangle closures were obtained.

[Lieut. J. H. HAWLEY, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, precise: 100 square miles of area covered, length of scheme, 20 miles; 12 stations occupied for horizontal measures; 12 geographic positions determined. Triangulation, secondary: 130 square miles of area covered, length of scheme 45 miles; 35 stations occupied for horizontal measures; 52 geographic positions determined. Leveling: 3 permanent bench marks established; 5 miles of levels run.

On April 17 work was resumed on the arc of precise triangulation in Lynn Canal, which was in progress during the summer of 1921. By the end of the fiscal year this arc had been completed to the head of Lynn Canal. This is a part of the arc of precise triangulation which eventually will extend from Puget Sound to the Yukon River and which is being done in cooperation with the Geodetic Survey of Canada.

An arc of secondary triangulation for the control of hydrographic and topographic surveys was started from the precise triangulation in Lynn Canal and extended to Icy Strait. Another arc of secondary triangulation was extended up Chilkat Inlet to the head of navigation.

[Lieut. Commander T. J. MAHER, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 720 square miles of area covered, length of scheme 50 miles; 38 observing tripods built; 21 stations in main scheme and 12 stations in supplemental scheme occupied for horizontal measures; 3 stations occupied for vertical measures; 78 geographic positions determined. Leveling: 3 permanent bench marks established.

Early in May, 1922, work was resumed on the triangulation on the western coast of Prince of Wales Island, which was started in the spring of 1921. This triangulation was one of the combined operations carried on from the steamer *Surveyor* for the purpose of furnishing control for hydrographic and topographic surveys. The work was in progress at the end of the fiscal year.

[Lieut. (Junior Grade) F. W. HOUGH, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Leveling, precise: 161 miles of levels run; 51 permanent bench marks established.

On May 8, 1922, work was started on a line of precise levels along the Alaska Railroad from Anchorage to Fairbanks. At the end of the fiscal year the line had been completed to the vicinity of Hurricane Siding.

The party used railway cars for living quarters and motor velocipede cars for transportation during the actual observing.

This is the first line of precise levels in Alaska. It is being run at the request of the U. S. Geological Survey and of other Federal map-making bureaus for the control of detailed mapping operations. The work will be extended as rapidly as possible, as the need for this control is urgent.

MAGNETIC WORK.

SITKA MAGNETIC OBSERVATORY.

[Magnetic Observer F. P. ULRICH, July 1 to August 31, 1921. Magnetic Observer ALBERT K. LUDY, September 1, 1921, to May 31, 1922. Magnetic Observer F. P. ULRICH, June 1–30, 1922.]

The work of the observatory was continued without material interruption throughout the year. The magnetograph was kept in continuous operation, requiring very little adjustment. Scale-value determinations were made once a month, absolute observations once a week and meterological observations daily. The chronometers were kept rated by means of the time signals received by cable at the local office of the Signal Corps of the Army.

The seismograph was kept in continuous operation but apparently lacked sensitiveness, only 14 earthquakes being recorded. Trouble was experienced with the seismograph paper because of the excessive moisture in the air, but this was overcome by keeping a small lamp burning in the seismograph room.

Magnetometer No. 38 and dip circle No. 56 were compared with the observatory instruments in June by means of simultaneous observations.

The buildings were painted and needed repairs to buildings, walks, and fences were made.

ALASKA, SIBERIA, AND WASHINGTON.

[Commander J. T. WATKINS.]

STATIONS OCCUPIED.—Alaska, Demarcation Point, Nome (2), Point Barrow, Point Hope, St. Michael (2), Teller City; Siberia, Emma Harbor (Providence Bay), Whalen (East Cape); Washington, Seattle.

The work began with a series of standardization observations at the old station at Seattle on May 30 and was concluded at the same station on November 4. At St. Michael station Hill Top was reoccupied very nearly and marked in a permanent manner. Another station was also established. Two stations were established at Nome. The old stations at Plover Bay and Port Clarence were not recovered and no trace now remains of the observatory established by the U. S. Signal Service at Point Barrow in 1881. At Demarkation Point observations were made near one of the magnetic stations of the boundary survey. All stations were marked in a permanent manner.

The work was made possible by the cooperation of the Coast Guard in furnishing transportation for the observer on the *Bear*. The places at which stations could be established were governed by the movements of that vessel and the time available for observations at a station depended upon the length of her stay, except that additional time at Point Barrow was secured by going from Nome to that place on a whaling steamer in advance of the *Bear*.

The three magnetic elements were determined at each station except Whalen, where work had to be stopped before intensity observations could be made. At most stations total intensity observations with the dip circle were made in addition to the usual horizontal intensity observations with magnetometer. Because of the high magnetic latitude and the limited diurnal variation data available, the observing program at each station was made as extended as possible, especially as regards declination, advntage being tken of the very long days. Altogether there were about 80 hours of declination observations. 13 sets of deflections, 55 sets of oscillations, 20 sets of total intensity, and 18 sets of dip.

Though the season was exceptionally good for that region, much time was lost on account of bad weather and many of the observations were made under unfavorable weather conditions.

PORTO RICO.

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

SUMMARY OF RESULTS.—Triangulation, tertiary: 98 square miles of area covered; 10 signal poles erected; 7 stations in supplemental scheme occupied for horizontal measures; 27 geographic positions determined. Leveling: 0.1 mile of levels run. Magnetic work: Ship swung at 2 stations at sea. Hydrography: 91 square miles of area dragged; 38 square miles of area covered by sounding; 480 miles run while sounding; 127 positions determined (double angles) while dragging; 1,487 positions determined (double angles) while sounding; 127 soundings made while dragging; 8,152 soundings made in regular hydrographic work; 1 tidal station established; 2 current stations occupied; 1 hydrographic sheet finished, scale 1:20,000.

The last report of the work of this vessel is that for the fiscal year ending June 30, 1921. At that time the *Ranger* was en route from New Orleans, La., to San Juan, P. R., effecting change of home port in accordance with the director's orders dated May 6, 1921, having taken in convoy at Key West, Fla., the two wire-drag launches *Marindin* and *Mitchell*. These launches had been left at Cape Hatien, Island of Haiti, on June 29, 1921, while the *Ranger* proceeded to Guantanamo, Cuba, where she took coal and water on June 30, 1921, and returned to Cape Hatien on July 1, 1921. The vessel with convoy departed from Cape Hatien at 4 a. m. July 3, 1921, and arrived at San Juan, P. R., at 1 p. m. July 5, 1921, after having twice put in to sheltered coves on the north coast of Haiti to relieve the peronnel of the launches which were making quite heavy weather.

On arrival at San Juan work was commenced at once to prepare the party and equipment for dragging operations. The drag tender, which had been shipped from New York, was received in an unseaworthy condition, due to damage which had been received some time previous, and repairs had to be made to the hull of this vessel before it could be put in the water. After this the motor had to be installed and some repair work had to be done to the equipment of the drag launches. During this time the *Ranger* also recovered some triangulation stations, built signals to control the drag work, established an automatic tide station at La Playa de Fajardo, P. R., and put down hurri-

cane moorings for the drag launches in the cove between Ovispo Cay and Zancundo Cay, Fajardo Harbor.

Drag work was commenced on August 9, 1921, and by the latter part of October the area to the eastward of Palominos Island, along Cordilleras Reef, through San Juan passage, and along the north coast of Porto Rico as far westward as Embarcaderos Point had been dragged and sounding in the inshore area from San Juan Harbor Entrance to Cape San Juan had been practically completed. This work had been pushed with considerable vigor as it was desired to complete the above area before stopping the work for periodic repairs to the equipment and before the annual stiffening of the trades, which would prevent, to some extent, effective work in that area. This work having been accomplished the week of October 24 to 30, 1921, was spent at San Juan, P. R., where the two drag launches and the tender were hauled out, painted, and repaired. The fleet returned to the drag field on October 31, 1921, and resumed work in the inside area to the westward of Palominos Island and Largo Reef. By the middle of January the work had practically been completed as far southward as Cabeza de Perro.

The area dragged is mostly rock and coral formation and although a very close lead survey had been made, several dangerous shoals were found. In all 84 separate shoals were located and charted.

The existence of two shoals previously charted was shown to have been an error in the previous survey. The 2½-fathom spot, 1 mile south of Ramos Cay, was shown to be clear to a depth of 23 feet. The 3½-fathom spot, about 1½ miles north of Pineros Island, was found clear to a depth of 30 feet. It has previously been recommended that these two soundings be removed from the chart.

A major accomplishment of the season was the dragging to its maximum depth of the ship channel around the eastern end of Porto Rico from Cape San Juan to Cabeza de Perro, the results of which work led to recommendations for changes in the sailing directions and aids to navigation in that area in order to take advantage of the best draft and avoid previously uncharted shoals the existence of which had been determined by the grounding of large vessels.

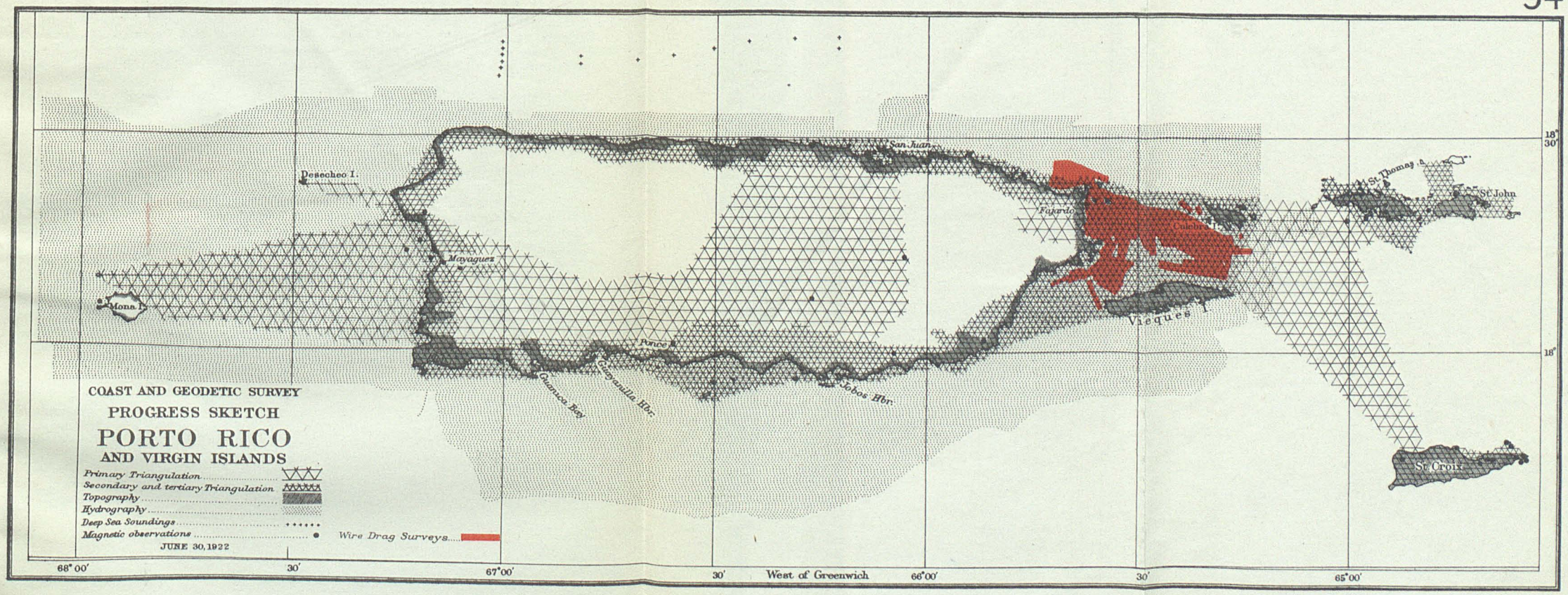
The positions of all signals used in the drag work were determined by triangulation. The automatic tide station was maintained continuously at La Playa de Fajardo and when not otherwise engaged the *Ranger* observed currents within the area dragged.

A secondary accomplishment of the season was the sounding out of the blank areas on hydrographic sheets Nos. 2874, 2876, 2877, and 2883, in accordance with paragraph 3 of the director's instructions of June 24, 1921. This area comprised the inshore hydrography from San Juan Harbor entrance to Cape San Juan, a distance of about 30 miles. The usual method of prosecuting a survey of this character could not be followed excepting at a considerable sacrifice of drag work as it was normally launch work and the only launches of sufficient size for this outside work which were available were the drag launches. Such sacrifice was not warranted either by the relative importance of the work or by the instructions for doing it. To overcome the handicap, it was decided that the *Ranger* must be used for doing the larger part of the sounding and that this could be done after determining the outer limits of the dangers to that vessel. To do this a number of natural objects were selected for use as signals and such others were built as proved necessary to control the work, their positions to be later determined as the work progressed. The two drag launches and the tender were then directed to proceed in line formation about 150 meters distance with the tender on the reef end of the line. In a single day these three lines of soundings were extended from Cape San Juan entrance, and thus the inner limits to which the *Ranger* could with caution work were established. The drag launches were then released for their normal duties. At a later date, when the drag fleet was at San Juan for hauling out, the tender was used to make additional development in the area within reach of San Juan.

[Lieut. F. B. T. SIEMS, Commanding Steamer *Ranger*.]

SUMMARY OF RESULTS.—Triangulation, tertiary: 6 signal poles erected; 4 stations in main scheme occupied for horizontal measures; 1 station in supplemental scheme occupied for horizontal measures; 2 geographic positions determined. Topography: 1 square mile of area surveyed; 2 miles of detailed shore line surveyed. Hydrography (wire drag): 142.2 miles of area dragged; 240.2 miles run while dragging; 1,574 positions determined (double angles); 44 soundings retained; 1 hydrographic sheet finished, scales of hydrographic sheets 1 : 20,000 and 1 : 40,000.

The command of the steamer *Ranger* was transferred to F. B. T. Siems on January 21, 1922. The wire-drag launches *Marindin* and *Mitchell* and tender *No. 3* were used in operation of the wire drag of this party.


COAST AND GEODETIC SURVEY
PROGRESS SKETCH
PORTO RICO
AND VIRGIN ISLANDS
Primary Triangulation
Secondary and tertiary Triangulation
Topography
Hydrography
Deep Sea Soundings
Magnetic observations
Wire Drag Surveys
JUNE 30, 1922
Desecheo I.
Mayaguez
Mona I.
Ponce
Guanica Bay
Guayanilla Hbr.
Jobos Hbr.
San Juan
Fajardo
Culebra I.
Vieques I.
St. Thomas I.
St. John
St. Croix
18° 30'
18°
68° 00'
30'
67° 00'
30'
West of Greenwich
66° 00'
30'
65° 00'

C.&G.S. Print

Wire-drag surveys were continued in Fajardo Roads and in passages off the east coast of Porto Rico, where more or less protection was had against the open seas of Vieques Sound, during the strong trade wind of the winter season. However, a considerable area in Vieques Sound was covered during a short period of moderate weather in February.

The chief of the division of hydrography and topography inspected the *Ranger*, and also the launches while the latter were hauled out at St. Thomas, Virgin Islands, from March 3 to March 11. At this inspection it was found advisable, at some future date, to sheath the hulls of these launches on account of the activities of the teredo; this was accomplished around the end of the fiscal year.

After the repairs to the launches, operations were resumed in Vieques Sound during the remainder of the month of March. During April the field work was necessarily confined to areas off the southeast coast of Porto Rico. Submarine maneuvers were carried on by the Navy in the waters around Culebra Island, making it impracticable to drag there at this time, as originally planned, and continue the work in Vieques Sound during favorable periods of weather.

During the last week in April the *Ranger* called at St. Thomas for semi-annual cleaning and painting of ship's bottom. This could not be accomplished at the time the launches were hauled out as the dry dock was not then available. It was also imperative that the hauling out of the launches should not be delayed.

The remainder of the fiscal year, May and June, was spent in continuing operations in Vieques Sound in the more exposed localities. The tender *No. 3* was unavailable during a large part of this period, having sustained some damage to the hull and also requiring engine repairs. This, and unfavorable weather, retarded the field work considerably during May. The vessel and launches finally proceeded to San Juan during the last week of June for extensive repairs to the launch engines and for sheathing the launches as stated before.

The automatic tide gauge at Fajardo, P. R., was kept in operation during the period of this report. Supplemental tide staffs were read at Ensenada Honda, Point Arenas, Culebrita Island, and at Great Harbor principally while operating in the respective localities.

A topographic traverse was run along the east end of Vieques Island to furnish positions for signals and to revise topography in the vicinity of Point Arenas.

A great number of triangulation stations in the field of work have been destroyed, apparently by curious natives, others have not been adequately marked and are not recoverable, leaving but few stations from which it was necessary to determine the locations of signals used. The work of supplementing the triangulation and re-marking of stations is in progress.

VIEQUES MAGNETIC OBSERVATORY.

[Magnetic Observer WALLACE M. HILL, July 1 to September 30, 1921. Magnetic Observer RALPH R. BODLE, October 1, 1921, to June 30, 1922.]

The work of the observatory was continued throughout the year without material interruption. The magnetograph was kept in continuous operation, scale-value determinations were made once a month, and absolute observations once a week. Trouble was experienced in keeping the vertical intensity variometer in satisfactory adjustment. Time was determined once a week, weather permitting, by the method of equal altitudes of the sun.

The seismograph was kept in continuous operation and 22 earthquakes were recorded.

Meteorological observations were taken daily and the results were reported monthly to the local weather bureau.

Extensive repairs were made to the office building and minor repairs to the other buildings.

HAWAIIAN ISLANDS.

HONOLULU MAGNETIC OBSERVATORY.

[Magnetic Observer H. E. MCCOMB.]

The work of the observatory was carried on without material interruption throughout the year. The magnetograph was kept in continuous operation, with only one change of adjustment; scale-value determinations were made

once a month and absolute observations once a week. The chronometers were kept rated by means of the wireless time signals sent out from Pearl Harbor.

The Milne-Shaw seismograph was kept in continuous operation except as noted below, and 89 earthquakes were recorded. A thorough study was made of the instrument under working conditions, the parts were remeasured and the constants were redetermined and a special report on the subject was prepared. In the course of this work, a number of improvements to the instrument suggested themselves, and these were made, so far as possible, under existing conditions. Plans were prepared for a new seismograph house.

The well was cleaned and the pump repaired, thus materially improving and increasing the water supply. Improvements were made to the hands' quarters.

During the summer of 1921 Dr. Arnold Romberg, of the University of Hawaii, and Dr. T. A. Jagger, of the Hawaiian Volcano Observatory, visited the observatory and gave the observer the benefit of their experience in his study of the seismograph.

A meridian line was established at Ewa Hill.

PHILIPPINE ISLANDS.

[Commander H. C. DENSON, Director of Coast Surveys, July 1, 1921, to March 11, 1922. Commander E. H. PAGENHART, Director of Coast Surveys, March 11, 1922, to June 30, 1922.]

During the period covered by this report one new activity, the division of photolithography, was added to the bureau, which is now prepared to print in Manila all charts of the Philippine Archipelago.

The field work accomplished included the following:

East coast of Luzon Island.—The offshore work between the Calagua Islands and Catanduanes Island was completed. There is an immense bank here with a depth of 30 to 40 fathoms, which extends from 30 to 50 miles offshore, from whence it drops off rapidly to deep water. The survey was carried out to the 1,000-fathom curve.

Deep-sea soundings were made between Catanduanes Island and Samar Island, the approach to San Bernardino Straits.

Revision work was executed in the vicinity of Albay Gulf and of Lagonoy Gulf. The shore line of Cacraray, Batan, and Rapurapu Islands, also the south shore of Catanduanes Island, and the southeast coast of Caramuan Peninsula were resurveyed. A hydrographic survey was made of the water area adjacent to the above-mentioned islands.

Sulu Sea.—The survey of the region around the Cagayanes Islands was completed. Numerous shoals lying around Palawan Island were located and developed.

Surveying operations were in progress on the west coast of Zamboanga Peninsula until the middle of December, when the strong northeast monsoon made it impracticable to continue the work.

Manila Bay.—At the request of the commandant of the Cavite Naval Station, some wire-drag work was done for the Government in the vicinity of Cochinos Point and Corregidor Island by the steamer *Pathfinder*, which was engaged for 10 days on this assignment.

Gravity determinations.—A station was occupied at the Manila Observatory for the determination of gravity.

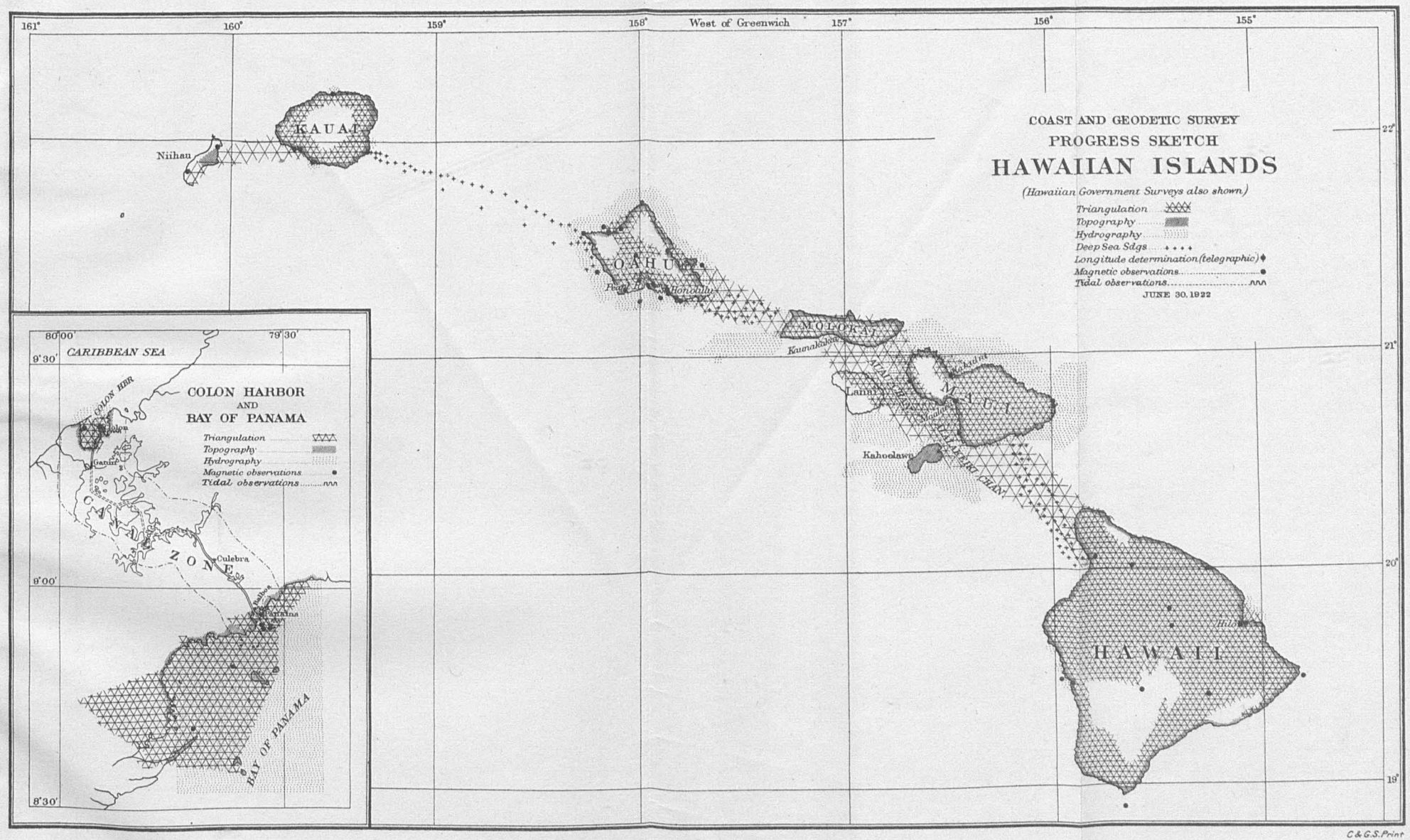
[Lieut. R. R. LUKENS, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Hydrography: 4,410 square miles of area covered; 2,740 miles run while sounding; 10,425 soundings made; 2 hydrographic sheets completed, scale 1 : 100,000 and 1 : 200,000.

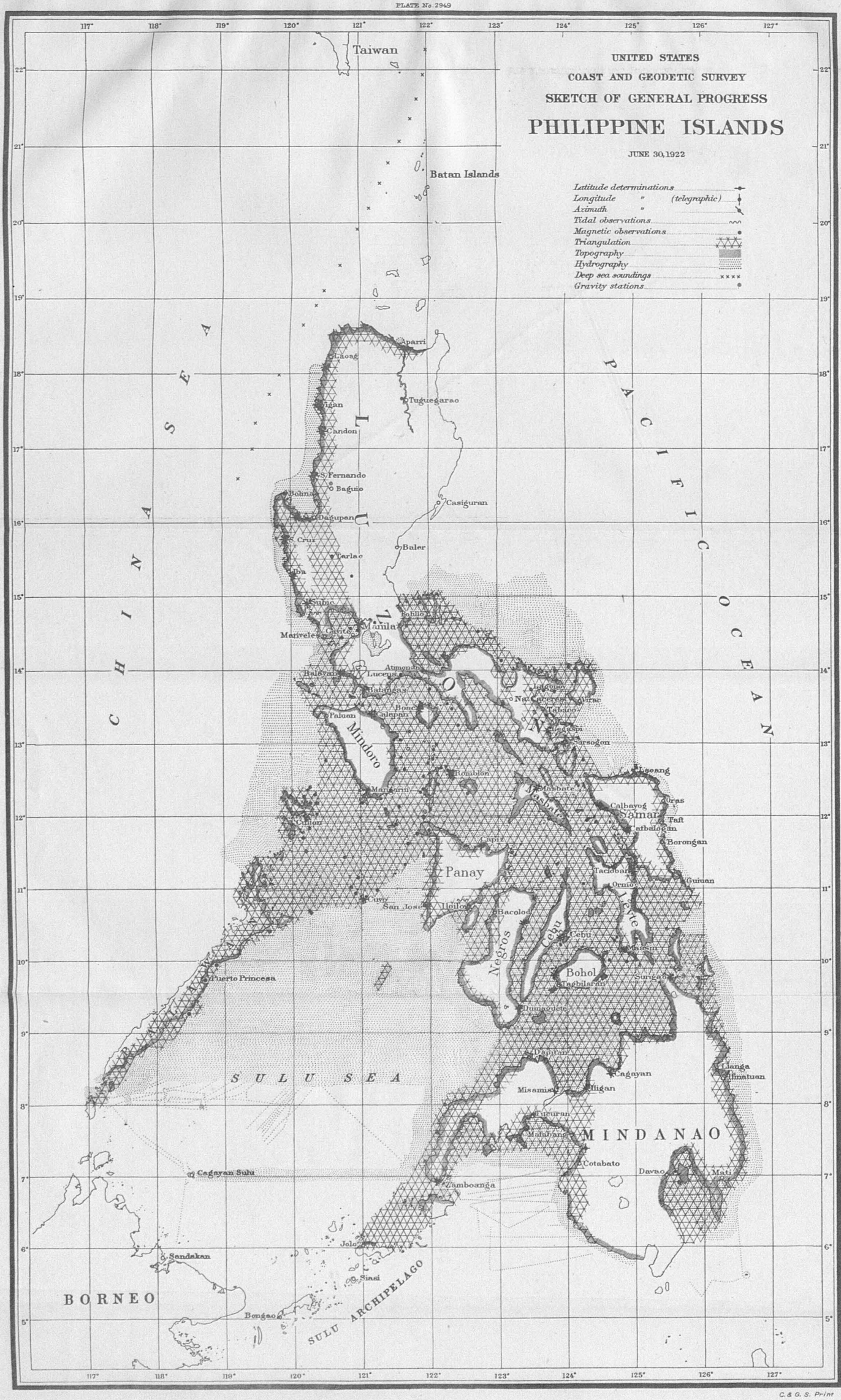
At the beginning of the fiscal year the *Pathfinder* was engaged in field work in continuation of that of the previous season in completing to the 1,000-fathom curve offshore hydrography from the Polillo Island group to Catanduanes Island. There is an extensive bank here, with a depth of 30 to 40 fathoms, extending 40 to 50 miles offshore, from whence it drops off rapidly into deep water.

Lines were run over this bank in a north and south direction one-half mile apart, and all sounding was done with the new Coast Survey sounding tubes. Beyond this bank deep-sea sounding lines were extended to the 1,000-fathom curve at intervals of from 3 to 5 miles.

Two sounding machines were used, one rigged for tube sounding and the other with piano wire for deep-sea sounding. Both could be used for tube work, so that the work was never held up by broken wire or repairs to the machine.


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, 1922
West of Greenwich
161°
160°
159°
158°
157°
156°
155°
22°
21°
20°
19°
KAUAI
Niihau
OAHU
Pearl
Honolulu
MOLOKAI
Kaunakakai
Lanai
MAUI
Kahoolawe
HAWAII
Hilo
COLON HARBOR
AND
BAY OF PANAMA
CARIBBEAN SEA
COLON HBR
Colon
Gatun
CANAL ZONE
Culebra
Balboa
Panama
BAY OF PANAMA
80°00'
79°30'
9°30'
9°00'
8°30'
Triangulation
Topography
Hydrography
Magnetic observations
Tidal observations

C&G.S.Print



U.S. Coast and Geodetic Survey

C. & G. S. Print

With the exception of a small area near the eastern extremity of the sheet, all work on the bank was controlled by three-point fixes on mountain peaks.

Uncharted rock in Lamit Bay.—Early in the morning of Sunday, July 31, as the *Pathfinder* was proceeding to an anchorage in Lamit Bay, and following the track usually taken, a slight jar was felt and the ship swerved somewhat off her course, but nothing was thought about it until some of the men, who were looking over the rail, reported that they saw rocks on the starboard side. After a short search the reef was found, which is about 20 meters across the top and has about 7 feet on it at mean low low water.

Coast of Camarines Norte.—This section of the coast of Luzon is but little developed and there is but little traffic. A few small coasters call at Mercedes as the terminus of their run from Manila, and a railroad steamer from Hondagua makes a weekly trip to Mercedes, calling at Mambulao and Paracale en route and connecting at Hondagua with the train to Manila.

There is an excellent stand of timber from Lamit Bay to San Miguel Bay, and two small sawmills are now operating, one in Lamit Bay and one near Mercedes.

After finishing the hydrography off the coast of Camarines Norte, deep-sea sounding was taken up between Catanduanes and Samar. All work extended from the outer edge of the sheet into the 100-fathom curve. A large bank was found to extend off San Bernardino Strait. Only the outer edge of this bank was determined. A large amount of work should be done to make the hydrography off this important strait complete.

On October 10 the deep-sea sounding was finished, and October 12 the *Pathfinder* sailed for Manila, where she arrived October 14, in time to witness the arrival and inaugural ceremonies of the new Governor General.

During the entire season of exactly seven months on the east coast of Luzon, the vessel used the Caracaran coal from the Batan mines. It is a satisfactory coal and gave good results.

On October 22 the *Pathfinder* was ordered to Corregidor, where a week was spent in doing some special wire-drag work requested by the Navy Department. Upon return to Manila arrangements were made for repairs necessary to the ship.

The work of repairing was under way from November 18 until December 23, when, upon completion, the vessel proceeded to Manila to take on supplies and prepare for work in the Sulu Archipelago.

On December 31 the vessel was ready to sail for the working grounds.

[Lieut. R. R. LUKENS, Commanding Steamer *Pathfinder*.]

SUMMARY OF RESULTS.—Triangulation: 2,120 square miles of area covered; 22 signal poles erected; 5 observing tripods and scaffolds built, heights 27, 42, 50, 57, and 60 feet; 10 stations in main scheme occupied for horizontal measures; 6 stations in supplemental schemes occupied for horizontal measures; 30 geographic positions determined.

On January 1, 1922, the *Pathfinder* was at Manila with all repairs finished, stores on board, and ready to sail for the working grounds.

The instructions to the commanding officer called for an extension of the secondary triangulation from Basilan Straits to the island of Jolo in the Sulu Archipelago. This triangulation is part of a scheme which will eventually control the whole group of islands extending from Mindanao to the coast of Borneo and also furnish points for the surveys in the vicinity of Basilan Island.

The *Pathfinder* sailed from Manila January 3 and arrived at Zamboanga January 6. Here, on the advice of the department commander of the Philippine constabulary, arrangements were made to take on board an armed guard to accompany the parties on shore.

After coaling at Malangas the *Pathfinder* sailed on January 9 for the working grounds via Zamboanga.

Field work was begun January 10. It was found that a large amount of cutting in the heavy timber would be required and that several tall signals would have to be built. Fortunately all of the stations were easily approached with the exception of Holland, which required about a day's journey for a loaded party.

By February 17 only two stations remained to be occupied, but these involved lines of 47 and 49 miles in length. When the scheme was laid out Pilas was assumed to be 919 feet high, as stated on the chart, and it seemed doubtful whether it could be seen from Station Pang. It was found, however, to be only 560 feet in elevation. Fortunately the stations were found to be intervisible and the scheme was completed as planned.

All of the observations in the scheme extending from Basilan Straits to the island of Jolo were finished, with an average closure of 2.8 seconds.

The currents in the locality of the work were found to be very strong, and often run from 4 to 6 knots in the passages between the islands.

On February 27 the *Pathfinder* returned to Manila via Zamboanga, arriving March 2. On March 9 the transfer of the vessel to the new commanding officer was effected.

[Lieut. F. G. ENGLE, Commanding Steamer *Pathfinder*, March 9 to June 30, 1922.]

SUMMARY OF RESULTS.—Triangulation: 265 square miles of area covered; 10 stations in main scheme occupied for horizontal measures; 14 stations in supplemental scheme occupied for horizontal measures. Topography: 34 square miles of area surveyed; 68.5 miles of detailed shore line surveyed. Hydrography: 988 square miles of area covered; 3,135.6 miles run while sounding; 21,052 soundings made; 2 tidal stations occupied; 2 miles of levels run; 4 bench marks established; 22 current stations occupied.

On March 9 the command of the steamer *Pathfinder* was transferred to Lieut. F. G. Engle and from April 1 to the close of the fiscal year the vessel was engaged in surveys on the west coast of Palawan.

[Lieut. H. A. COTTON, Commanding Steamer *Marinduque*.]

SUMMARY OF RESULTS.—Triangulation: 198 square miles of area covered; 17 signal poles erected; 13 stations in main scheme occupied for horizontal measures; 5 stations in supplemental scheme occupied for horizontal measures; 18 geographic positions determined. Topography: 41 square miles of area surveyed; 52¼ miles of general coast line surveyed; 1 mile of shore line of creeks surveyed; 8 topographic sheets finished, scales 1:10,000 and 1:20,000. Hydrography: 202.1 square miles of area covered; 1,905.2 miles run while sounding; 11,439 positions determined (double angles); 37,896 soundings made; 5 hydrographic sheets finished, scales 1:10,000 and 1:20,000.

Topography.—The following areas were included in the topography executed by the party:

(*a*) All of Rapurapu, Batan, and Cacraray Islands; also the smaller islands of Cagbulauan and Guininyan.

(*b*) The southern portion of Catanduanes Island inland to the first highlands (the sky line as seen from along the coast except for a few distant individual peaks).

(*c*) The southeast corner of Caramuan Peninsula from Pitogo Bay to Flat and inland to the first highlands (the sky line as indicated above).

Sufficient points were established by triangulation, or traverse, to supplement the existing triangulation and furnish control for the topography and hydrography.

The usual plane-table methods were employed in this topography. Over considerable areas it was impossible to see the inland country from the beach and the contouring had to be done by anchoring the ship offshore. Such was the case for the major portion of Rapurapu Island, for considerable areas between Virac Point and Sialat Point on Catanduanes Island, and for the western portion of the topography on Caramuan Peninsula. Several larger streams were located by magnetic traverse run in a boat.

All hydrographic signals were located by the topographer. Although the hydrography was not executed about the western portion of the southern coast of Catanduanes Island all necessary signals were located in anticipation of this work.

Hydrography.—The area surveyed comprised:

(*a*) Cacraray Pass and Rapurapu Straits.

(*b*) An area along the coast of Cararay, Batan, and Rapurapu Islands between the shore line and the 100-fathom curve. This hydrography commenced about 1 mile east of Port Sula Light and extended along the south coast of Cacraray and Batan Islands, continuing along the south, east, and north coast of Rapurapu Islands and on the westward as far as Naualang Point on the north shore of Batan Island.

All signals used for the control of this work were located either by the triangulation or the topographic parties.

No new dangers were found off the south coast of Cacraray, Batan, and Rapurapu Islands. About Cabugao Bay, a couple of new shoals were found in the anchorage area east of Virac and a 10-fathom spot about 1 mile south of St. John's Bank. In the unsurveyed area north of Rapurapu Island an extensive reef with a least depth of 2 fathoms was developed off Talisay Point, and between this and the entrance of Rapurapu Straits numerous flat shoals

were located with depths of 5–6 fathoms. It was found that the northeast corner of Rapurapu Island can be rounded close to with 7–8 fathoms, but the only practical navigation is to clear the shoal area in a similar manner as indicated on the present charts. The hydrography over the unsurveyed area of the northern entrance to Cacraray Pass developed an anchorage of rather limited extent and difficult approach. In Rapurapu Straits several shoaler spots were found, the most important being a 4-fathom spot off the entrance to Batan.

The new Coast Survey sounding tube was used during the major portion of the season with decidedly favorable results.

Tides.—A tidal record, which was practically continuous for the entire season, was secured on the automatic gauge established at Batan.

Tide staffs were established in Coal Harbor and Cabugao Bay. At both places tides were observed during near-by hydrography and simultaneous observations were made for comparison with the Batan gauge.

At all the above places the prescribed tidal bench marks were established.

[Lieut. H. A. COTTON, Commanding U. S. S. *Marinduque* January 1 to March 19, 1922. Lieut. R. L. SCHOPPE, Commanding U. S. S. *Marinduque* March 20 to June 30, 1922.]

SUMMARY OF RESULTS.—Topography: 24.8 square miles of area surveyed, 98.6 miles of detailed shore surveyed. Hydrography: 93 square miles of area covered; 942.9 miles run while sounding; 4,753 positions determined (double angles); 15,671 soundings made; 1 tidal station occupied; 3 tidal bench marks established. Magnetic work: 1 land station occupied for magnetic observations.

On January 1, 1922, the steamer *Marinduque* was undergoing repairs at Manila.

On March 20 the command of the vessel was transferred to Lieut. R. L. Schoppe.

From May 9 to the close of the year the *Marinduque* was engaged in surveys around Basilan and off-lying islands.

[Lieut. K. T. ADAMS, Commanding Steamer *Fathomer*.]

SUMMARY OF RESULTS.—Topography: 234.5 square miles of area surveyed; 37.9 miles of general coast line surveyed; 3 topographic sheets finished, scale 1:20,000. Hydrography: 1,737.6 square miles of area covered; 2,807.3 miles run while sounding; 10,554 positions determined (double angles); 42,234 soundings made; 2 tidal stations established; 10 hydrographic sheets finished, scales 1:10,000, 1:20,000, 1:40,000, and 1:100,000.

During the six months ending December 31, 1921, work was done by the *Fathomer* in 3 localities, roughly, as follows: July, 1921, vicinity of Cayagan Island; August, September, and to October 16, southeast coast Palawan Island; October 17 to December 10, west coast Zamboanga Peninsula. In the latter part of December the vessel was at Manila, P. I., undergoing repairs.

On July 1, 1921, small-boat hydrography was in progress in the Cayagan Islands, the ship hydrography having been practically finished. On July 11 the party proceeded to Cavili Island and began work in that vicinity, which was finished July 13. The ship then proceeded to Iloilo, P. I., for coal, sounding en route, and on return was caught in typhoon weather and had to seek shelter at Cagayancillo from July 19 to 25. The ship then proceeded to Palawan, sounding en route. The party was engaged on the southeast coast, Palawan, until October 15. The ship then proceeded to the west coast, Zamboanga Peninsula, where a camp party was established, the ship then going to Zamboanga for blowing down boilers. On return, October 28, the automatic tide gauge was installed and ship and launch hydrography started, and combined operations continued until December 10, when the ship proceeded to Manila in accordance with instructions, arriving December 14. Repairs at Engineer Island were started December 22 and continued till the end of the year.

Hydrography.—The work in the vicinity of the Cagayan Islands consisted of finishing up work already well in hand on June 30. The ship work was practically complete on that date, only a few days' work being done by the ship in July. The launch and whaleboat finished sheet P 1443. From July 11 to 13, inclusive, the party worked at Cavili Island, making a detached survey in accordance with instructions. No unfinished work was left in the vicinity of the Cagayan Islands.

The work on the southeast coast of Palawan Island consisted in finishing work, filling in gaps, and developing shoals in work already done by other

parties. Two inshore launch sheets were used in developing shoals, one 1:40,000 scale boat sheet for shoal area outside of Island Bay and one 1:100,000 offshore ship sheet. No work here was left incomplete except P. 1461, the ship sheet. On this sheet all work was finished complete as far as the party got, all shoals inside of the outer limits of the work being developed, and no holidays left. A detached survey by launch around Tagalinog Island was made. A small-boat survey of Caramay River was made.

Hydrography on the west coast, Zamboanga Peninsula, was resumed where it had been discontinued on January 27, 1921, about a mile and a half north of Port Santa Maria, and the ship and launch working in conjunction carried the hydrography up the coast as far as Sibalic Point. This work is complete as far as done. One day's work was done in the vicinity of Murcielagos Island, when weather conditions prevented work elsewhere.

Topography.—In the vicinity of the Cagayan Islands the only topography done was the location of signals for hydrography on Cavili and Arena Islands.

On the southeast coast of Palawan hydrographic signals were located on Tagalinog Island. A survey was made of Caramay River, and a 1:40,000 scale sheet of contours (no shore line) was done in the vicinity of San Antonio Bay.

On the west coast, Zamboanga Peninsula, topography was resumed where it had been discontinued January 27, 1921, and continued northeastward along the coast, completing two sheets. One day's work was done around Murcielagos Island when weather conditions prevented work elsewhere.

[Lieut. K. T. ADAMS, Commanding Steamer *Fathomer* January 1 to March 14, 1922.
Lieut. H. A. COTTON, Commanding Steamer *Fathomer* March 15 to June 30, 1922.]

SUMMARY OF RESULTS.—Topography: 528 square miles of area surveyed; 53.5 miles of detailed shore line surveyed; 12.65 miles of shore line of rivers surveyed; 189.24 square miles of area surveyed; 1 mile of levels run; 3 bench marks established; 5 topographic sheets finished, scale 1:20,000 and 1:40,000. Hydrography: 530 square miles of area covered; 1,232.4 miles run while sounding; 4,706 positions determined (double angles); 14,412 soundings made; 2 tidal stations occupied; 2 miles of levels run; 3 bench marks established; 4 hydrographic sheets finished, scales 1:20,000 and 1:100,000.

The steamer *Fathomer* was undergoing repairs at Manila on January 1, 1922. On March 15 the command of the vessel was transferred to Lieut. H. A. Cotton, and from April 4 to June 30 the vessel was engaged in surveys on the north coast of Zamboanga Peninsula and in the Sulu Archipelago.

SPECIAL DUTY.

INSPECTION DUTY, PACIFIC COAST AND ALASKA.

[Commander R. S. PATTON.]

Between August 6 and September 21 an inspection was made of the principal ports and of the vessels of the survey on the Pacific coast and in Alaska, and conferences were held with port authorities and other public officers and with the inspectors and chiefs of field parties of the Coast and Geodetic Survey with a view to possible improvements in the charts and to ascertain the localities where new charts are most urgently needed.

At San Diego, Los Angeles, and Portland, conferences were held with the members of the various port commissions directly concerned with harbor improvements and with their principals in the several chambers of commerce who have direct interest in the efforts of the survey to keep the charts up to date. At each place assurance was received that local interests would cooperate by promptly furnishing information showing results of any changes or improvements in the harbors.

At San Francisco and Seattle conferences were held with the inspectors of the Coast and Geodetic Survey at those places who are directly in touch with the authorities who have charge of matters relating to harbor improvements and changes affecting the charts.

At Eureka and Willapa Bay the port authorities were consulted.

During this trip the steamers *Natoma*, *Lydonia*, *Wenonah*, and *Explorer* were visited.

The Alaskan parties had been favored with good weather and were making excellent progress.

A special effort was made to ascertain any areas in southeastern Alaska for which the present charts are inadequate. Particular demand was found to exist

for additional charts of Prince William Sound. The additional surveys desired are of those waters off the beaten track which vessels must enter without adequate charts to guide them.

AERIAL SURVEYING.

[Lieut. G. C. MATTISON.]

The most important accomplishment of the year was the completion of the photography of the Mississippi River Delta. This project had been started in the spring of 1921, when the Naval Air Service photographed a portion of the area. An attempt was made to complete the work in October, 1921, but an accident to the plane caused a delay until December, when unfavorable conditions again necessitated a postponement of the project until April, 1922. During April and May 530 square miles were protographed, completing the whole portion of the Delta contained within the limits of Chart No. 194.

At the beginning of the fiscal year office work was in progress on the first set of photographs of the Delta. Mosaics were constructed of various sections of the Delta and reduced photographically to the scale of the chart. These reduced photographic mosaics were then used to compile and up-to-date map of the Delta for the use of the aviator in completing the project. At the same time an index map was made, showing the location of and area covered by each photograph. The office work on the photographs and also the triangulation computations were completed in September.

It was believed that favorable weather conditions would prevail during the fall months, but for the reasons previously mentioned the project was not completed until in May, 1922. During April and May flights were made on 16 different days in order to cover the 530 square miles. A preliminary examination and study of the photographs, which was made in the field, indicated that satisfactory results should be obtained in the office reduction. It was found that there were a few gaps in the work, but they will be covered in another hour's photographic flight.

Assistance was furnished the division of charts at various times during the year in the compilation of chart data from aerial photographs and mosaics.

The Army and Navy Air Services have furnished the bureau with obliques and mosaics that will be of use in our work. One hundred and sixty oblique views of important sections along the coast have been received from the Naval Air Service. The same service supplied mapping photographs of Annapolis, Md. The Army Air Service furnished mapping photographs of the lower end of the Susquehanna River. Mosaics have also been received of Boston, Mass., and Portland, Me. Considerable use has already been made of some of these photographs.

A transformer, to be used for the rectification of photographs, was received from the Corps of Engineers and installed in the photographic laboratory.

The Bureau of Standards was engaged during the year in the construction of a stereoscope of special design for use in the interpretation of aerial photographs.

No work was done along the lines of the study of aerial mapping from January 10 to March 31, as field work on the revision of the Hawaiian Coast Pilot was in progress during that time.

WASHINGTON.

[Lieut. (Junior Grade) H. C. WARWICK, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Traverse, primary: 10 miles of traverse measured; 6 geographic positions determined; 2 meridian marks set. Azimuth: 2 stations occupied for azimuth.

Between August 22 and October 10, 1921, the geographic position of the naval radio compass station at Ocean Park, Wash., was determined by traverse from the nearest recovered triangulation station, which is 10 miles distant. Two marks were set on the meridian through the compass station.

SUMMARY OF RESULTS.—Triangulation, secondary: 1 geographic position determined; 2 meridian marks set.

In August, 1921, the geographic position of the naval radio compass station at Port Angeles, Wash., was determined by triangulation from near-by stations. Two marks were set on the meridian through the compass station.

[Capt. WILLIAM BOWIE, U. S. Coast and Geodetic Survey.]

On March 9, 1922, the chief of the division of geodesy went to Buffalo, N. Y., to consult with the city engineer in regard to the geodetic work existing in the vicinity of that city and the needs of Buffalo for geodetic control for its detailed mapping and other engineering work. While in Buffalo he visited and inspected the plant of the Matthews-Northrup Co., one of the leading producers of maps for commercial and other industrial purposes in the United States. He also spoke at a meeting of the Buffalo Engineering Society on the use of the airplane in surveying and mapping.

DISTRICT OF COLUMBIA.

[Lieut. (Junior Grade) HERMAN ODESSEY, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Reconnaissance: 6 points selected for scheme. Triangulation, secondary: 2.7 square miles of area covered, length of scheme 3 miles; 7 signal poles erected; 7 stations occupied for horizontal measures; 6 geographic positions determined.

At the request of the U. S. Navy Department, the length and geographic position of a speed-trial course for airplanes along the Potomac River, just south of the mouth of the Anacostia River, were determined. The work was done by cooperation with the Navy Department, which furnished the necessary labor, transportation, and supplies. It was started on March 9 and completed on March 25, 1922.

[C. A. MOURHESS, Mathematician, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 2 geographic positions determined.

In September, 1921, a determination by triangulation was made for the proposed location of the "Zero Milestone" of the Lincoln Highway on the north side of the ellipse, back of the White House. The location of the monument in the center of the ellipse, marked "Meridian of 1890," was also determined.

NEW YORK AND NEW JERSEY.

[Lieut. (Junior Grade) H. W. HEMPLE, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 10 square miles of area covered; 6 signal poles erected; 8 stations occupied for horizontal measures; 12 geographic positions determined; 4 meridian marks set.

Between October 4 and 26, 1921, the naval radio compass stations at Sandy Hook, N. J., and Amagansett, N. Y., were located by triangulation. Two marks were set in the meridian through each station. This work was done at the request of the U. S. Navy Department.

[Lieut. Commander C. V. HODGSON, U. S. Coast and Geodetic Survey.]

On June 18 the assistant chief of the division of geodesy went to Asheville, N. C., to consult with the State geologist regarding geodetic control work needed in that State. While at Asheville he attended the Southern Appalachian Water Power Conference in session there and obtained considerable information which will be of value in connection with future geodetic surveys in that section.

NORTH CAROLINA AND VIRGINIA.

[Lieut. (Junior Grade) W. H. OVERSHINER, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation, secondary: 3 square miles of area covered; 4 signal poles erected; 5 stations occupied for horizontal measures; 3 geographic positions determined.

Between July 11 and 22, 1921, the naval radio compass station at each of the following places was located by triangulation: Virginia Beach and Hog Island, Va., and Poyners Hill, N. C. These determinations were made at the request of the U. S. Navy Department.

Old triangulation stations were recovered in the vicinity of each compass station and the determinations of the positions were readily made.

NEW YORK.

[H. W. HEMPLE.]

Exhibit of the Coast and Geodetic Survey at the National Motor Boat Show at New York.

An exhibit illustrative of the work of the U. S. Coast and Geodetic Survey was displayed at the National Motor Boat, Ship, and Engine Show in the Grand Central Palace, New York City, from February 17 to 25, 1922.

Only selected charts, coast pilots, and tide tables and other publications and photographs showing the various activities of the field force were exhibited.

Great interest was shown by the public in this exhibit, visitors being especially interested in the charts of their own immediate localities.

An officer of the survey was in attendance to furnish information and explain details. All of the expenses connected with the exhibit were paid by the National Motor Boat, Ship, and Engine Show.

INSPECTION DUTY.

[Lieut. Commander C. V. HODGSON, U. S. Coast and Geodetic Survey.]

Between August 12 and September 25, 1921, the assistant chief of the division of geodesy made an inspection trip to several of the geodetic field parties. These included a building party and a triangulation party in northern Texas, a reconnaissance party in northern Minnesota, and a double traverse party near the western end of Lake Superior.

At Duluth arrangements were made with the city engineer to run levels at frequent intervals over a number of test bench marks set by the traverse parties, in order to obtain data in regard to the disturbance of these marks by frost action during the winter.

During the month of March, 1922, the assistant chief of the division of geodesy inspected the triangulation party operating in Texas.

TENNESSEE.

[Lieut. Commander CLEM L. GARNER, U. S. Coast and Geodetic Survey.]

SUMMARY OF RESULTS.—Triangulation: 8 elevations determined trigonometrically; 1 geographic position determined. Leveling: 1 wye level elevation determined.

At the request of the Knoxville (Tenn.) Board of Commerce the elevation of Mount LeConte, a spur of the Great Smoky Mountains, near Knoxville, was determined. Work started on June 10 and was completed on June 25, 1922.

The elevation of a tower on one of the buildings at the University of Tennessee was determined carefully by wye levels from bench marks in Knoxville and then the elevations of Mount LeConte, and of Mount Guyot, and Clingmans Dome, which are near Mount LeConte, were determined trigonometrically from this tower.

TRIENNIAL CONFERENCE OF THE SECTION OF GEODESY OF THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION.

[Capt. WILLIAM BOWIE, U. S. Coast and Geodetic Survey.]

The chief of the division of geodesy attended the triennial conference of the section of geodesy of the International Geodetic and Geophysical Union and also the conference, held at the same time, of the International Astronomical Union, in May, 1922, at Rome, Italy. He attended these meetings as a representative of the U. S. Coast and Geodetic Survey and as a delegate from the United States, appointed by the president of the National Academy of Sciences on the recommendation of the National Research Council. In 1919, at Brussels, at an international scientific conference, there was organized the International Research Council with a number of branches, called unions. These unions were subdivided into committees or sections. The union which is of most interest to the U. S. Coast and Geodetic Survey is the Geodetic and Geophysical Union. It has a section of geodesy, which will continue the work of the old International Geodetic Association, which, shortly after the outbreak of the European war, had its designation changed to the Geodetic

Association Reduced Among Neutrals. At the Brussels meeting Captain Bowie was elected president of the geodetic section and at Rome, in May, 1922, he presided at the meetings of the section. Captain Bowie reported that the meetings of the two unions mentioned above, and especially of the section of geodesy, were very successful. Certain parts of the organization which could not be perfected at Brussels in 1919 were completed at Rome. Provision was made for an executive committee of seven for purely administrative purposes, and a permanent committee, with a representative from each country adhering to the section, which will have legislative functions between the regular conventions of the section. Instead of having a central scientific office, such as existed under the older associations, the section of geodesy adopted the plan of having each important branch of geodetic work assigned to some scientist who, on account of his work and the national organization of which he is a member, would be able to correlate the activities carried on in the several countries in the subject assigned to him. Each scientist to whom work has been thus assigned is termed a reporter. The theory of isostasy was assigned to the chief of the division of geodesy of the U. S. Coast and Geodetic Survey. A report in printed form was made by Captain Bowie to the section of geodesy at the Rome meeting which gives in some detail an account of the geodetic work performed in the United States during the 10-year period from January 1, 1912, to December 31, 1921. That report was printed as Special Publication No. 81 of the U. S. Coast and Geodetic Survey.

Respectfully,

E. LESTER JONES, *Director.*

To Hon. HERBERT HOOVER,
Secretary of Commerce.

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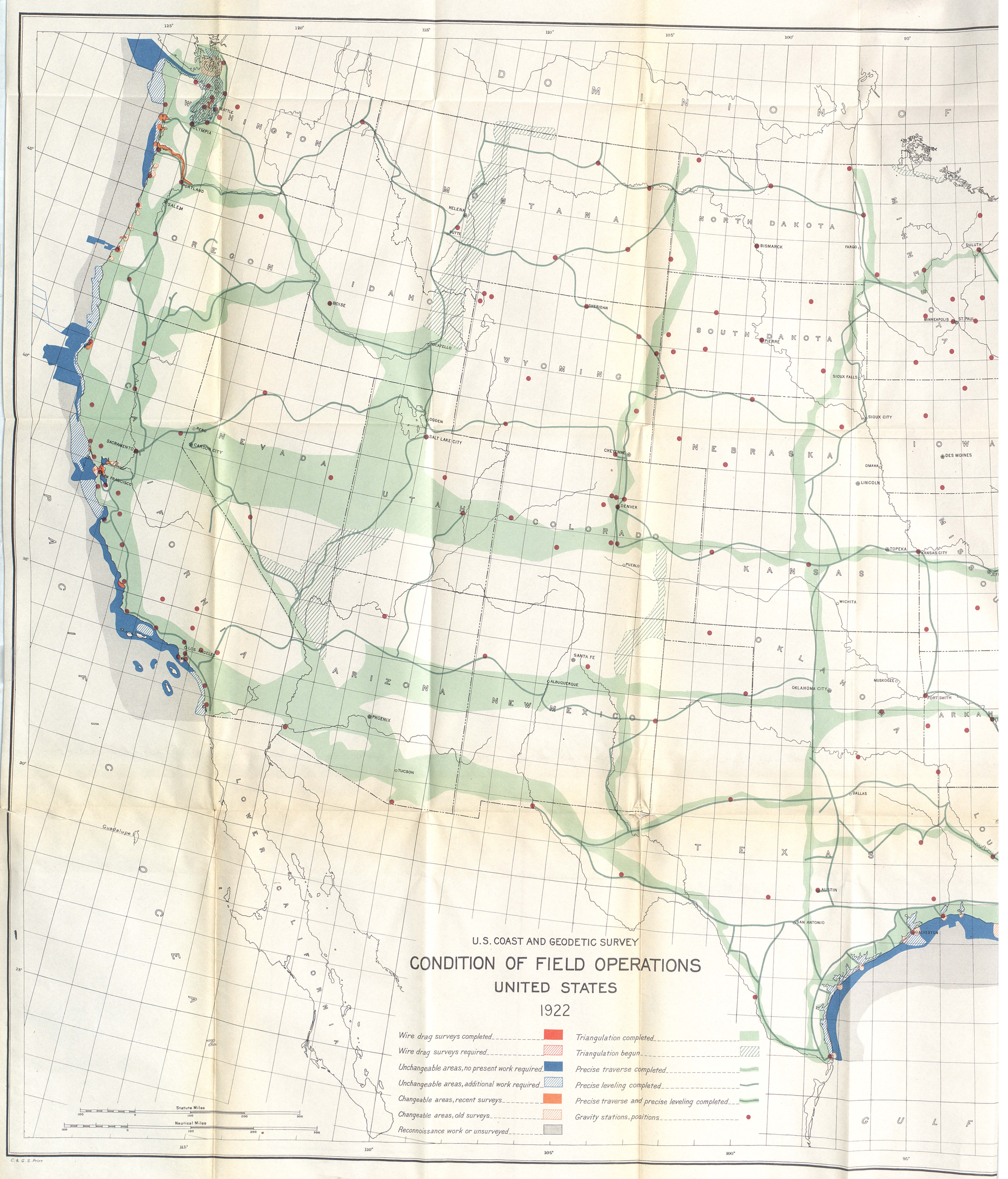
U.S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD OPERATIONS
UNITED STATES
1922
Wire drag surveys completed
Wire drag surveys required
Unchangeable areas, no present work required
Unchangeable areas, additional work required
Changeable areas, recent surveys
Changeable areas, old surveys
Reconnoissance work or unsurveyed
Triangulation completed
Triangulation begun
Precise traverse completed
Precise leveling completed
Precise traverse and 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
LOWER CALIFORNIA
PACIFIC OCEAN
GULF
Guadalupe I.
SEATTLE
OLYMPIA
PORTLAND
SALEM
HELENA
BUTTE
BISMARCK
FARGO
DULUTH
BOISE
SHERIDAN
PIERRE
MINNEAPOLIS
ST. PAUL
POCATELLO
SIOUX FALLS
SIOUX CITY
OGDEN
SALT LAKE CITY
RENO
CARSON CITY
SACRAMENTO
SAN FRANCISCO
CHEYENNE
DES MOINES
OMAHA
LINCOLN
DENVER
TOPEKA
KANSAS CITY
PUEBLO
WICHITA
LOS ANGELES
SANTA FE
ALBUQUERQUE
OKLAHOMA CITY
MUSKOGEE
FORT SMITH
PHOENIX
TUCSON
DALLAS
AUSTIN
SAN ANTONIO
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LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP.
MAINE
MASS.
CONN.
R.I.
NEW JERSEY
DEL.
MARYLAND
W. VIRGINIA
VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
ARKANSAS
MISSOURI
KANSAS
NEBRASKA
FLORIDA
ATLANTIC OCEAN
GULF OF MEXICO
BAHAMA ISLANDS
CUBA
DULUTH
MINNEAPOLIS
ST. PAUL
MADISON
MILWAUKEE
SIOUX CITY
DES MOINES
OMAHA
LINCOLN
CHICAGO
LANSING
DETROIT
BUFFALO
CLEVELAND
PITTSBURGH
WHEELING
COLUMBUS
INDIANAPOLIS
SPRINGFIELD
CINCINNATI
TOPEKA
KANSAS CITY
JEFFERSON CITY
ST. LOUIS
EVANSVILLE
LOUISVILLE
FRANKFORT
CHARLESTON
NASHVILLE
MUSKOGEE
FORT SMITH
MEMPHIS
LITTLE ROCK
BIRMINGHAM
ATLANTA
MONTGOMERY
JACKSON
MERIDIAN
MOBILE
TALLAHASSEE
JACKSONVILLE
BATON ROUGE
NEW ORLEANS
GALVESTON
TAMPA
KEY WEST
HABANA
RALEIGH
COLUMBIA
WILMINGTON
CHARLESTON
SAVANNAH
RICHMOND
NORFOLK
WASHINGTON
BALTIMORE
ANNAPOLIS
DOVER
PHILADELPHIA
WILMINGTON
HARRISBURG
TRENTON
NEWARK
NEW YORK
ALBANY
BURLINGTON
MONTPELIER
AUGUSTA
PORTLAND
CONCORD
PORTSMOUTH
BOSTON
WORCESTER
PROVIDENCE
HARTFORD
NEWPORT
NEW HAVEN

160°
170°
180°
170°
160°
150°
ARCTIC OCEAN
SIBERIA
Pt. Barrow
Icy Cape
Pt. Hope
BERING STR
Nome
St. Michael
YUKON
RIVER
KUSKOKWIM RIVER
St. Lawrence I.
60°
St Matthew I
Nunivak I.
Nushagak
BRISTOL BAY
Pribilof Is
BERING SEA
ALASKA
Unimak I.
Shumagin Is
Unalaska I
Attu I
ALEUTIAN IS
Kiska I
Tanaga I
Atka I
East from Greenwich.
180°
170°
160°

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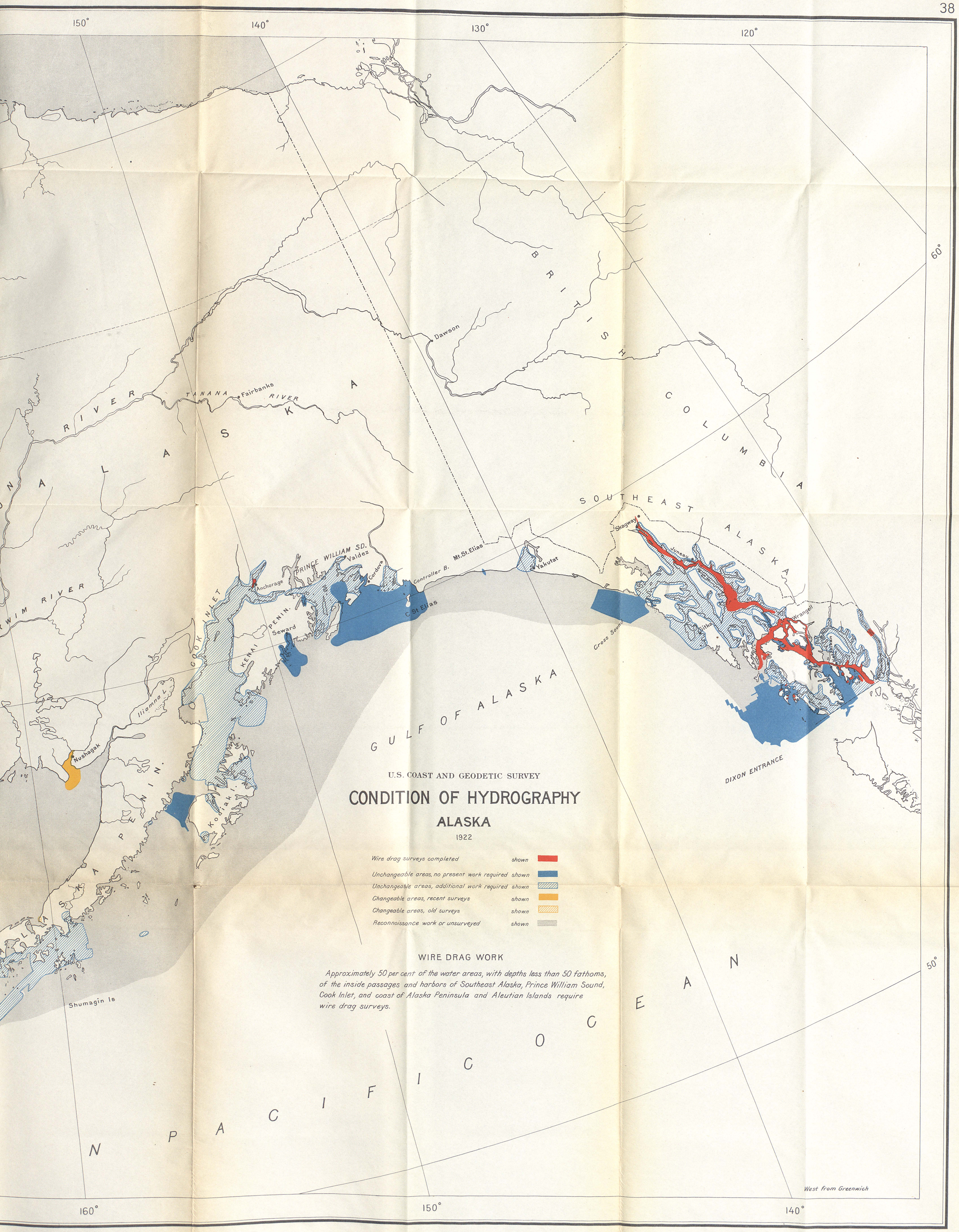

U.S. COAST AND GEODETIC SURVEY

CONDITION OF HYDROGRAPHY

ALASKA

1922

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.