[Reprinted from the Annual Report of the Secretary of Commerce, 1941]

COAST AND GEODETIC SURVEY

The principal functions of the Coast and Geodetic Survey are the surveying of all coastal waters under the jurisdiction of the United States and the production of the nautical charts and coast pilot publications required for the navigation of those waters; the compilation of aeronautical charts for air navigation; and the accomplishment, throughout our country and its possessions, of geodetic control surveys which provide essential basic data for nautical charting and topographic mapping.

In connection with its coastal charting work this Bureau carries on comprehensive tide and tidal current observations along our coasts to secure data of this nature for chart construction and for the preparation of annual tables of predicted tides and currents. It conducts investigations required to obtain information concerning the earth's magnetism, necessary for water and air navigation, and is in charge of governmental activities contributing to a widely cooperative program of earthquake study.

NATIONAL DEFENSE

Operations in all branches of the Bureau's work during the past year were governed almost entirely by the need for its products and services in connection with national defense. The expansion of our Navy, merchant marine, and air forces, inaugurated in the spring of 1940, brought an immediate increase in the demand for charts and other navigational publications which continued throughout the year. To fill orders for nautical and aeronautical charts during the year it was necessary to issue over 1½ million copies, an increase of 76 percent over the previous year and more than double the number distributed in 1939.

The supply of over 290,000 nautical charts to the Navy and some 575,000 aeronautical charts to the Army Air Corps represented approximately a threefold increase in the quantities required by those services under normal conditions. The needs of the Civil Aeronautics Administration, Coast Guard, and other defense agencies were correspondingly augmented.

In addition to the issue of nautical charts from current stocks the Bureau was called upon for the construction of a considerable number of special charts and for the accumulation of a substantial reserve supply of charts, coast pilots, and tide tables for naval use. The exceptionally heavy demand for aeronautical charts was due both to the general expansion in aviation and to their use in pilot training courses. Besides meeting this demand it was necessary to undertake during the year, as a defense measure, additional charting programs which will involve the construction of several hundred new charts.

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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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Other office activities included the supply of extensive compilations of control data to all Army corps areas; advance tide predictions for use in planning the launching of vessels; the supply of special tide and seismological data for construction projects; services in connection with the construction and procurement of instrumental equipment for military use; and assistance to various defense agencies in projects and studies involving the earth's magnetism.

In the field the Bureau continued to expedite surveys, previously in progress, of the Aleutian Islands and other areas where adequate charts are especially important for naval operations. The remainder of the force available for coastal charting work was engaged during the greater part of the year on special projects required by the Army and Navy.

These included surveys of four island bases in the Caribbean region; topographic surveys in Puerto Rico; the wire-dragging of water areas to be used for submarine trials; field work in various localities to obtain additional information for the construction of special charts for naval use; hydrographic examinations of the approaches to several water terminals in Alaska; and a considerable number of smaller projects.

On June 19, 1941, the President issued an Executive Order transferring three of the Bureau's survey ships to the Navy Department and providing for the transfer of three substitute vessels from that department to the Department of Commerce. Preparations for these transfers were in progress at the end of the year.

A substantially greater appropriation for geodetic surveys enabled the Bureau to expand the progress of this class of work to about five times the volume accomplished during recent years. The immediate purpose of the greater part of the work carried on during the past year was the establishment of essential control for topographic mapping in strategic areas as designated by the War Department. In addition to this, control surveys were executed in a number of localities to provide data for various other defense projects.

At the request of the War Department one of the Bureau's officers was assigned to the Field Artillery School, Fort Sill, Okla., for about 3 months and two officers were detailed to duty with the First Observation Battalion, Fort Bragg, N. C., for 1 month. The mission of these officers was to cooperate in the development of control survey methods suitable for use in directing mobile artillery fire.

The heavy burden of work thrown on the Bureau by the defense program completely overtaxed its facilities. This condition was met to some extent by increases in appropriations for personnel and equipment and by the transfer of funds by the War and Navy Departments to cover the costs of certain special projects. The demands upon the Bureau, however, continued to increase at a faster rate than the gain in its resources and this situation was aggravated by the difficulty in obtaining qualified technical personnel. Consequently the need for the immediate accomplishment of urgent defense projects made it necessary to forego during the year a considerable part of the routine work, both in the field and office, which ordinarily is carried on from year to year in order to provide for the adequate maintenance of the Bureau's products.

COOPERATION WITH AMERICAN REPUBLICS

The Coast and Geodetic Survey participated in the program of the State Department for cooperation with the American Republics, through two scientific and technical projects, which consisted of gravity surveys and the establishment of instruments and equipment for the measurement of coastal tides. These projects introduced Coast and Geodetic Survey methods and instruments into eight American Republics.

A field party was engaged in the determination of a number of base gravity stations in Peru. This work was completed in June and the party then transferred to Bogota, Colombia, where observations were in progress at the end of the year. Two other field parties accomplished the installation of tide stations at Valparaiso, Chile; Matarani, Peru; Guayaquil, Ecuador; Buenaventura, Colombia; La Guaira, Venezuela; Puntarenas, Costa Rica; La Union, El Salvador; and Salina Cruz, Mexico.

All of the countries mentioned contributed to the cost of this work and, with respect to the tide stations, have made arrangements to operate and maintain the stations and to forward the records to the Washington office of the Bureau for analysis.

Reports of the officers engaged on these projects, concerning contacts made and the cordial reception afforded them in all countries visited, as well as expressions from officials and prominent scientists in these countries, indicate that this cooperative scientific program is well worth while.

Funds were also provided for the preparation of a new edition of the Bureau's Hydrographic Manual in order to acquaint hydrographers in the American Republics with the modern methods and equipment developed by the Coast and Geodetic Survey for this class of work.

CHART PRODUCTION

The essential nature of nautical and aeronautical charts in connection with defense activities is indicated by the following table, giving the number of charts issued annually, and the percentage increases, for the last 4 years. The 1939 issue, compared with that for 1938, represents the steady growth in the normal demand for charts which has been experienced for a number of years. The 1940 issue shows the effects of the early stages of the defense program, while the 1941 issue reflects this program well under way. All indications are that the demand for these charts will continue to parallel the rapid expansion of our defense forces.

Charts	1938	1939	1940	1941
Nautical	351,150	350,062	407,186	621,663
Aeronautical	299,094	366,353	463,917	912,339
Total	650,244	716,415	871,103	1,534,002
Annual increase:				
Number		66,171	154,688	662,899
Percent		10	22	76

The total number of individual nautical charts for the use of the mariner published at the end of the year was 804 of which 163 were printed in Manila. To produce the 568,063 copies printed in Washington there were 661 printings as follows: 15 new charts, 100 new editions, 478 new prints, and 68 reprints. Of the 15 new charts, 9 were constructed at the request of the Navy.

The 7 new charts cataloged for sale are as follows:

572. Head of Chesapeake Bay.
686. St. Johns River.
687. St. Johns River.
688. St. Johns River.
938. Pillsbury Sound, Virgin Islands.
1262. Apalachicola to Cape San Blas.
5007. Point Mugu to Ventura.

The principal data received during the year for the improvement and correction of nautical charts consisted of 175 topographic surveys, 110 hydrographic surveys, 1,090 surveys from other organizations, and 763 letters containing charting data. Dangers requiring hand corrections and other navigational information were supplied to the U. S. Coast Guard for announcement in its weekly Notice to Mariners. Although a considerable portion of the charts were reprinted at least twice during the year it was necessary, due to rapid changes in important navigational information, to apply 1,848,553 hand corrections to revise the charts on the date of issue.

The aeronautical charts for the use of the aviator, consisting of 87 sectional, 17 regional, 6 direction-finding, and 2 planning charts, as well as a series of 9 Alaskan charts, now practically cover the United States and Alaska. Other large programs of charting for the Army Air Corps and the Civil Aeronautics Administration involving the construction of several hundred charts were started during the year. These include a series of radio facility charts; a series of airport and instrument approach charts for the principal airports of the United States and Alaska; and a series of 5 sectional charts of the Philippine Islands, the latter being compiled at Manila.

During the past year the fourth edition of Practical Air Navigation and the Use of the Aeronautical Charts of the Coast and Geodetic Survey was issued. Through a cooperative arrangement requested by the Civil Aeronautics Administration, which has recognized its value to the aviator, this book is now published as Civil Aeronautics Bulletin No. 24. It is the required text in air navigation in the ground course of the Civil Pilot Training Program. The sales of this book amounted to approximately 100,000 copies during the past year.

Assistance rendered to other governmental agencies included special reproduction work for the Office of Production Management, Bureau of the Budget, Maritime Commission, Civil Aeronautics Administration, Federal Power Commission, and the Federal Communications Commission.

Cooperation with the Canadian Government was carried on to an increasing extent through the exchange of map information of mutual value for the construction of aeronautical charts.

At the suggestion of the Bureau of the Budget numerous conferences were held with representatives of other reproduction agencies which have resulted in standardizing cost accounting systems and the methods of making quarterly reports to the Bureau of the Budget.

COASTAL SURVEYS

Results accomplished during the past year in hydrographic and topographic surveys and coastal triangulation are summarized in the following table:

Locality	Hydrography			Topography		Coastal triangulation		
	Sounding lines	Area	Soundings	Shore line	Area	Length of scheme	Area	Geographic positions
	Miles	*Square miles*	*Number*	*Miles*	*Square miles*	*Miles*	*Square miles*	*Number*
Gulf of Maine	8,107	3,912	85,109					
Casco Bay	1,686	[1] 106	70,956	23		3	2	1
Boston Harbor	786	[2] 31	43,921					
Nantucket Sound	7,062	772	95,130	58	42	15	60	14
Atlantic Coast, Block Island to Cape Romaine	2,343	[3] 665	30,954					
Chesapeake Bay	3,997	144	140,126	463	540	4	9	5
James River, Va	81	3	1,841					2
Indian River, Fla	1,395	78	60,371					
West coast of Florida				2,947	1,743			
Gulf of Mexico	11,412	15,218	116,568					
Santa Barbara Islands						93	2,003	21
San Francisco Bay	294	14	11,797	25	4	11	22	18
Coast of northern California	921	15	8,296					
Grays Harbor, Wash	389	14	15,428	67	13	6	12	66
Northern Puget Sound	5,397	386	114,293	53	2	115	381	205
Southeastern Alaska	1,654	150	39,999	66	67	7	10	6
Central Alaskan coast	7,196	1,651	83,765	58	5	34	340	76
Cook Inlet	771	60	13,670	5	1	18	164	33
Alaskan Peninsula	12,255	9,731	133,932	13	32	68	663	90
Aleutian Islands	9,250	6,752	72,630	116	165	133	1,008	85
West Indies	2,684	[4] 49	150,846	70	20	25	71	218
Philippine Islands	11,621	1,833	157,726	232	20	134	1,284	69
Total	89,301	41,584	1,447,358	4,196	2,654	666	6,029	909

[1] Includes 17 square miles of wire drag.
[2] Includes 11 square miles of wire drag.
[3] Includes 43 square miles of wire drag.
[4] Includes 4 square miles of wire drag.

To carry on this work the Coast and Geodetic Survey operates 10 survey ships and 10 smaller vessels. Two of the ships, engaged in surveys of the Philippine Islands, are provided by the Insular Government which defrays their operating expenses.

On the Atlantic coast the survey ship *Oceanographer* continued offshore surveys in the Gulf of Maine; engaged for a short time on surveys off the South Carolina coast; accomplished hydrographic and topographic surveys in the vicinity of Port of Spain, Trinidad; and began surveys in Casco Bay, Maine, which will include extensive wire-drag investigations. The *Lydonia* completed her part of the hydrographic project on Nantucket Shoals; executed surveys in Cape Cod Bay, at the entrance to Chesapeake Bay off the Virginia Capes, and in the vicinity of the Island of Antigua in the Caribbean; and began wire-drag surveys off Block Island.

Wire-drag investigations in Boston Harbor were carried on during the summer of 1940 under supervision of the commanding officer of the ship *Oceanographer*. This survey was temporarily discontinued in 1941 to permit utilization of personnel and equipment on surveys of particular importance to the national defense in other New England areas.

The *Gilbert* continued work on the survey of Nantucket Shoals and began surveys in the James River, Va. The latter project was interrupted by her assignment to surveys at Kingston, Jamaica, upon completion of which she joined the *Lydonia* in wire-drag surveys off Block Island.

The launches *Mitchell* and *Ogden* carried on combined operations in Chesapeake Bay, continued surveys in the Indian River, Fla., and began wire-drag operations in Casco Bay in cooperation with the *Oceanographer*.

During the summer and early fall of 1940 the launch *Elsie III* continued operations as a mobile revision unit along the intracoastal waterways of the Atlantic coast.

A shore party under direction of the officer in charge of the magnetic observatory at San Juan, P. R., began extensive detailed topographic surveys of the east end of the island.

In the Gulf of Mexico the ship *Hydrographer*, with the tender *Faris* operating as a subparty, continued on surveys of the central and eastern parts of the Gulf. During the winter months the vessel was engaged on surveys of Mayaguana Island in the Bahamas, and at Kingston, Jamaica.

On the Pacific coast all vessels were employed on a program of winter surveys. The ship *Guide* operated north of Cape Mendocino, Calif., and in Carquinez Straits, San Francisco Bay. The *Pioneer* executed a scheme of triangulation in the Santa Barbara Islands, Calif., and began a combined operations project in south San Francisco Bay. The *Discoverer* continued revision surveys in Grays Harbor, Wash.

The *Explorer*, *Surveyor*, *E. Lester Jones*, and *Westdahl* completed winter assignments in the Juan de Fuca-San Juan Islands area in Washington.

In southeastern Alaska the *Westdahl* continued surveys in Glacier Bay during the summer of 1940. In the spring of 1941 this vessel was assigned to surveys in the vicinity of Sitka because of the military and naval activities in that area.

The *Surveyor* continued work on the project of original surveys of the Alaskan coast between Cape Fairweather and Cape St. Elias. The *E. Lester Jones*, during 1941, was engaged on revision surveys in the vicinity of Anchorage.

In southwestern Alaska the *Explorer* and the *Pioneer* continued surveys in the Aleutian Islands westward from Yunaska Island. The *E. Lester Jones* assisted on this work during 1940.

The *Discoverer*, assisted by the tender *Wildcat*, continued operations along the south coast of the Alaska Peninsula in the vicinity of Deer Island and Cold Bay. The *Guide* continued work on the Bering Sea side of the Peninsula on the project extending northeastward from Cape Sarichef.

In the Philippine Islands the *Pathfinder* and *Fathomer* continued surveys in the Sulu Sea area and took up operations in the vicinity of Manila Bay. The name of the *Pathfinder* was changed to *Research* to make the former name available for the new ship being constructed at Seattle, Wash.

Planimetric maps compiled from air photographs taken with the Bureau's 9-lens camera were completed of the vicinity of Eastern Bay, Choptank River, and adjacent tributaries of Chesapeake Bay, and of the west coast of Florida from Apalachee Bay to Tarpon Springs. The field and office operations necessary for the production of these maps were performed by parties at Baltimore, Md., and Tampa, Fla.

An air photographic project was undertaken in collaboration with the U. S. Coast Guard to obtain 9-lens photographs for mapping certain areas in Alaska. At the end of the fiscal year this party was located at Kodiak, Alaska. Photographs were obtained of the shore line from Dry Bay to Tsivat River along the northeast coast of the Gulf of Alaska.

A Coast Pilot revision party completed the collection of data for a new edition of Section A, Atlantic Coast Pilot, covering the coastal area from the Canadian boundary to Cape Cod. A similar party made a field inspection of the Pacific coast for a new edition of the California, Oregon, Washington Coast Pilot.

The 13 United States Coast Pilot volumes, which are kept current by annual supplements, contain a wide variety of important information supplemental to that shown on the chart, such as detailed description of the coast and information concerning the waterways, as well as maritime data for the ports of the United States and possessions. New editions of Coast Pilots are published as often as warranted by the changes which occur and the amount of new information available. Six supplements to United States Coast Pilots and one to the Hawaiian Coast Pilot were published during the fiscal year. A new edition of the Coast Pilot, Section B, was published. Manuscript was prepared for a new edition of the Coast Pilot, Section A, covering the Atlantic coast from the Canadian boundary to Cape Cod.

Offices for the processing of field records continued in operation at Norfolk, Va.; Pensacola, Fla.; Oakland, Calif.; and Seattle, Wash.

Twenty-eight cadet officers of the United States Maritime Commission were given instruction aboard Survey vessels, to familiarize them with the many Bureau activities benefiting the merchant marine officer. The larger ships had at various times from two to six cadets assigned during the field season on the Atlantic, Gulf, Pacific, and Alaskan coasts.

Contracts were let and construction was begun on two modern survey ships: The *Pathfinder*, a 230-foot vessel powered by a 2,000-horsepower steam turbine, with a cruising radius of 8,000 miles; and the *Patton*, a sturdy 88-foot wooden tender.

Recording fathometers have been installed on many of the surveying launches. This type of equipment greatly expedites operations in shoal water.

National Youth Administration facilities were utilized for the overhaul and repair of several small boats.

GEODETIC WORK

The results of geodetic control surveys carried on during the year are summarized in the following tables:

Locality	Length of scheme	Area
	Miles	*Square miles*
First-order triangulation		
Placerville to Lake Tahoe, Calif.	70	1,160
Trout Creek, Mich., to Elcho, Wis.	80	960
Pocahontas to LeMars, Iowa	65	650
Sioux City, Iowa, to Brocksburg, Nebr.	155	1,860
Kingman to Arcadia, Kans.	170	1,700
Bentonville to Harrison, Ark.	55	715
Eagleville, Calif., to Salt Lake City, Utah	380	13,800
Vicinity of Baltimore, Md.	15	120
Skykomish to Coulee City, Wash.	100	1,600
Great Falls, Mont., to Spokane, Wash.	270	4,050
Stillwater, N. J., to Herkimer, N. Y.	145	1,450
Kingston to Owego, N. Y.	100	1,000
Paron, Ark., to Arcadia, La.	165	1,650
Lake Charles to Minden, La.	155	1,550
Cusseta to Forney, Ala.	130	1,690
Vicinity of Camp McClellan, Ala.	15	100
Opelousas to Monroe and Winnfield to St. Joseph, La.	185	1,850
Bagley to Goodridge, Minn.	70	840
Fredericksburg to Danville, Va.	160	1,600
Imperial Valley, Calif. (reobservations for earthquake investigation)	210	2,100
Total	2,675	40,445
Second-order triangulation		
Vicinity of Fort Hancock, N. J.	10	30
Boston Harbor, Mass.	25	95
Buzzards Bay, Mass., to Long Island Sound, N. Y.	55	275
Willamette Valley, Portland, to Cottage Grove, Oreg.	135	3,700
Lucerne Valley to Santa Barbara to Maricopa, Calif.	175	3,855
Cartersville to Warm Springs and Jonesboro to Frolona, Ga.	160	1,830
Roanoke to Rockford, Ala.	60	600
McMinnville to Tillamook, Oreg.	85	1,540
Oglethorpe University, Ga.	1	5
Vicinity of Dahlgren, Va.	10	60
Crescent City to Cape Mendocino, Calif.	120	1,800
Cape Ann, Mass., to Portland, Maine	80	800
Vicinity of Copper Center, Alaska	75	1,400
Total	991	15,990
First-order base lines		
Baltimore, Md.	3.1	
Valdez, Alaska	2.0	
Total	5.1	
Second-order base line		
Humboldt Bay, Calif.	4.1	
First-order reconnaissance		
Wurtsboro to Port Jervis, N. Y.	20	100
Goldendale to Leavenworth, Wash.	135	2,565
Vicinity of Baltimore, Md.	15	120
Philipsburg, Pa., to Cumberland, Md., and Blain to Johnstown, Pa.	165	2,200
Bedford, Ind., to Elkton, Ky., and Louisville, Ky., to Winslow, Ind.	215	2,150
Olive Branch to Greenwood and Clarksdale to Water Valley, Miss.	145	3,000
Vicinity of Camp McClellan, Ala.	15	100
Seattle to Bellingham, Wash.	80	1,120
Total	790	11,355
Second-order reconnaissance		
Warm Springs to Cartersville and Jonesboro to Frolona, Ga.	160	1,830
Willamette River, Oreg.	60	2,625
Vicinity of Tillamook, Oreg.	40	800
Vicinity of Rogersville, Tenn.	10	80
Crescent City to Cape Mendocino, Calif.	120	1,800
Buzzards Bay, Mass., to Long Island Sound, N. Y.	55	275
Big Bend area, Tex.	170	3,450
Kent, Tex., to Roswell, N. Mex.	185	4,800
Oglethorpe University, Ga.	1	5
Vicinity of Dahlgren, Va.	10	60
Richmond to Port Royal and Beaverdam to King William, Va.	80	800
Cape Ann, Mass., to Portland, Maine	80	800
Valdez to Rapids, Alaska	160	2,240
Total	1,131	19,565

State	First-order	Second-order	State	First-order	Second-order
Leveling	*Miles*	*Miles*	*Leveling*—Cont.	*Miles*	*Miles*
Alabama	52	284	Nevada	437	269
Arizona	311	77	New Mexico	3	194
California	513	388	North Dakota	26	516
Colorado		251	Oregon	892	113
Indiana	7		Pennsylvania	299	
Kansas	72	415	South Dakota	12	420
Kentucky	69	226	Virginia	5	766
Maryland	306	17	West Virginia	10	77
Michigan	30				
Minnesota	249	3	Total	3,489	4,292
Missouri		86			
Nebraska	196	190			

State	Determinations			State	Determinations		
	Latitude	Longitude	Azimuth		Latitude	Longitude	Azimuth
Astronomy				*Astronomy*—Cont.			
Arkansas			1	New York	1	1	1
Louisiana			2				
Minnesota			1	Total	1	1	6
Nevada			1				

State	Determinations		State	Determinations	
	New	Repeat		New	Repeat
Gravity			*Gravity*—Cont.		
Alabama	2		Missouri	5	1
Arkansas	5		North Dakota	10	1
Illinois	3	1	Ohio	2	
Indiana	2		South Dakota	1	
Iowa	2		Virginia	2	
Kansas	1		Wisconsin	3	
Louisiana	2		Peru, South America	11	
Michigan	5	1	Colombia, South America	1	
Minnesota	3	1			
Mississippi	6		Total	66	5

To accomplish this work there were in operation throughout the year 4 double-unit triangulation parties, 3 triple-unit leveling parties, 3 triangulation reconnaissance parties, and 1 gravity party. Variation of latitude observatories at Ukiah, Calif., and Gaithersburg, Md., were continued in operation and an astronomical party was in the field for about 1 month.

The triangulation and leveling parties operated in 36 States and in Alaska. Their work was carried on largely in accordance with priorities established by the War Department to meet the need for control of topographic mapping in strategic areas. Other than this they accomplished a number of special surveys which, while contributing to the mapping program, were also of immediate value for other purposes. The more important of these projects are mentioned below.

Control was completed in the general area of New York Bay as a means of correlating various United States Engineer data in those regions. Similar projects have also been extended in the general vicinity of Boston, Narragansett Bay, and Block Island.

First- and second-order triangulation was extended along the coast from the vicinity of Cape Ann, Mass., to Portland, Maine, as a means of coordinating the United States Engineer and other control surveys in that region. This work was initiated in May and the greater part of it had been completed at the end of the year.

First-order triangulation initiated during the previous year was continued to completion along the Arkansas River from the vicinity of Muskogee, Okla., to its confluence with the Mississippi River in order to furnish the necessary control for flood-control maps in the Arkansas River Basin.

First- and second-order triangulation was extended southward from the Columbia River in the vicinity of Portland, Oreg., along the Willamette Valley for a distance of 100 miles to Cottage Grove, Oreg., for the control of traverses, cadastral surveys, etc., in the floodwater area.

First- and second-order triangulation was extended over the Humboldt Bay, Calif., region and in Carolina County, Va., for the double purpose of coordinating surveys of the Corps of Engineers and to complete a gap in the fundamental triangulation in these areas.

About 750 miles of lines of first-order leveling in the vicinity of Lake Mead were rerun during the winter season in cooperation with the Bureau of Reclamation. This was for the purpose of investigating certain problems concerning settlement in the area due to the water load resulting from filling Lake Mead which began some 5 years ago. It is certain that this repeat leveling over lines originally run in 1934, for studying the settlement problem, will furnish valuable information of particular significance in regard to problems of dam structure, water pressure, etc., and also with regard to geophysical problems of importance in many fields.

Funds were provided by the War Department to cover the cost of special projects executed for the United States Engineers and the Bureau of Reclamation defrayed the cost of the Lake Mead project.

The Bureau's appropriations provide a small sum each year for triangulation and leveling in earthquake regions as a means of determining horizontal and vertical ground movements. During the past year surveys for this purpose were made in the Imperial Valley, Calif., region in order to study the March 1940 earthquake. This work was undertaken on the recommendations of various persons and committees particularly interested in seismological problems. The most active group is the Committee in Seismology of the Seismological Society of America.

In the office, progress was made in the computation and adjustment of the results of field surveys. Valuable assistance was rendered in this work by two field offices in New York and Philadelphia, maintained by the Work Projects Administration and sponsored jointly by the Coast and Geodetic Survey and the Army Corps of Engineers. These offices are also engaged in the computation of military grid coordinates for a large number of triangulation and traverse stations in the United States.

In the Washington office the development of a system of plane coordinates for Puerto Rico, initiated during the previous year, was completed. The size and shape of this island made it possible to select a system of coordinates well adapted for both commercial and military purposes.

TIDE AND CURRENT WORK

The increased hydrographic operations of the Bureau, as well as the expanded activities of the Navy and merchant marine and the accelerated industrial development of coastal property, have materially affected the Bureau's tide and current work during the year. Hydrographic operations have called for additional processing of tide and current records. Special observations and predictions have been required by the Navy and merchant marine, while tidal data and information concerning tidal bench marks in increased volume have had to be compiled to meet the needs of surveyors and contractors engaged on harbor improvements and industrial developments.

During the fiscal year, 46 primary and 47 secondary tide stations were in operation: 47 on the Atlantic coast and 46 on the Pacific coast. Of these stations, 58 were conducted in cooperation with other agencies including the United States Engineers, the Navy Department, Territory of Hawaii, city of New York, city of Santa Monica, port of Willapa Harbor, Los Angeles Harbor Department, Oxnard Harbor District, Woods Hole Oceanographic Institution, Chesapeake Biological Laboratory, and the Oceanographic Laboratories of the University of Washington. The data secured from these observations are necessary for hydrographic surveys, for the reduction of the results of short series of observations to mean values, for the accurate determination of datum planes, and for the determination of secular changes in relation of land to sea.

Shorter periods of observations at approximately 100 additional stations were obtained in connection with hydrographic surveys and other activities.

The tide survey of the Sacramento-San Joaquin Rivers was completed early in the fiscal year, and the tide survey of the Connecticut River, in cooperation with the office of the district engineer at Providence, R. I., was discontinued at the end of the calendar year. A new project covering a tide survey of the Columbia River was started during the year in cooperation with the United States Engineer Office at Portland, Oreg. Nineteen stations have been established on this project.

Observations of currents for a number of stations were obtained by hydrographic parties, and long series of observations were secured at several important lightship locations. Through the cooperation of the United States Coast Guard, a 12-month series of hourly current observations was completed at *Overfalls* lightship. Approximately 11 months of similar observations were secured at *Portland* lightship, and a series of observations was started at *Frying Pan Shoals* lightship.

Reciprocal agreements for exchange of tide data between the United States and England, Canada, and India were continued in effect. The exchanges with France, The Netherlands, and Germany, however, were broken off because of the war, necessitating the prediction of the tides for the ports in those countries.

In addition to the marked increase in the requirements of the Navy and the merchant marine for tide and current publications, special reprints of the tide and current tables were required to meet the demand of the Naval Reserve for these tables for use in training courses.

MAGNETIC WORK

Magnetic information was obtained continuously at five observatories located at Cheltenham, Md.; Tucson, Ariz.; Honolulu, T. H.; Sitka, Alaska; and San Juan, P. R. During the first half of the fiscal year additional repeat observations needed for the isogonic map of the United States and maps for Alaska showing all the magnetic elements were completed, and at the end of the year the maps were in preparation. The magnetic information made available through field and observatory work is used to improve the magnetic survey and to keep record of the changes in the earth's magnetism. These data are used by land surveyors, navigators of sea and air, explorers for oil and mineral resources, radio and telegraph communication companies, scientific investigators, and the military services. The daily character of the magnetic conditions is given by radio broadcasts and otherwise.

The new magnetic observatory at Sitka, Alaska, was completed and put into operation.

The distribution of magnetic observations during the year is shown in the following table:

Region	Repeat stations			Other stations	Total
	New	Old			
		Complete	Declination only		
Alaska	1	2	3	57	63
Arizona			4		4
California	2	1	5	5	13
Connecticut			1		1
Idaho			1		1
Indiana	1				1
Maine	2	1	5	6	14
Massachusetts	2		2	2	6
Missouri		1			1
Nevada	1	1	3		5
New Hampshire	1		1	3	5
New Jersey			3		3
New Mexico		1	3		4
New York			2	9	11
Oklahoma		1			1
Oregon		1	1		2
Pennsylvania			1		1
Rhode Island		1	1		2
Texas	1			1	2
Vermont		1		9	10
Virginia				1	1
Washington	3	1		56	60
Philippine Islands				19	19
Canada				4	4
West Indies				11	11
Total	14	12	36	183	245

Among a number of projects carried on for the Army and Navy were magnetic observations at airports, to provide for the testing of airplane compasses, and an investigation, with the cooperation of the Navy, to determine the extent to which local magnetic disturbances are felt in the air. It was found that such disturbance may extend to a height of 3,000 feet.

The following activities were continued with the cooperation of the department of terrestrial magnetism, Carnegie Institution of Wash-

ington: Operation of a cosmic ray meter at Cheltenham observatory; maintenance at Cheltenham observatory of international magnetic standards; atmospheric and earth electric currents at Tucson observatory (the Mountain States Telephone & Telegraph Co. and Bell Telephone Laboratories also cooperating); and daily and weekly radio broadcasts of magnetic conditions, in which the Navy Department and Science Service have also aided.

The United States Antarctic Expedition, with aid from the Bureau and the department of terrestrial magnetism, Carnegie Institution of Washington, completed a series of observations in the vicinity of a former observatory at Little America.

Cooperation has continued with the American Geophysical Union and the National Research Council. International meetings to which the Bureau has made important contributions have been practically suspended during the emergency, though certain activities have continued without interruption.

Office processing of field data was considerably expedited by work accomplished by the computing offices at New York, Philadelphia, and San Juan maintained by the Work Projects Administration under the sponsorship of the Bureau. With the assistance of the University of Puerto Rico, ionosphere observations were undertaken at San Juan.

SEISMOLOGICAL WORK

The seismological work of the Bureau is designed to map the areas affected by all significant earthquakes in the United States and its possessions, and to determine the destructive effects and nature of the motions causing destruction. One of the main purposes is to safeguard life and property by giving data to the engineer which will enable him to determine where, and to what degree, earthquake resistant designing of structures is needed. This valuable information was furnished to many organizations, scientists, and other persons during the past year.

Seismographs were operated at Survey observatories in Tucson, Ariz.; Honolulu, T. H.; Sitka, Alaska; San Juan, P. R.; and Ukiah, Calif. Assistance was given for the maintenance of seismographs at seven colleges. A similar number of independent stations sent their records or readings to the Bureau for study and interpretation. Results from these stations are used to map seismic areas.

Sixty strong-motion seismographs were in operation at the close of the year at 52 stations in California, Nevada, Utah, Montana, and the Canal Zone. Thirty strong-motion records were obtained for 14 earthquakes. All of the strong-motion instruments were recalibrated during the year.

Vibration tests were made in eight buildings for the study of earthquake effects on buildings. Ground vibration tests were made at four locations for the study of probable action of certain soil response to earthquakes.

Three tilt meters were operated on a cooperative basis with the University of California. They were operated near earthquake faults to observe any tilt effects preceding and following earthquakes which might occur in the vicinity of the instruments.

Questionnaire coverage was made for 20 earthquakes which approached destructive character. In all, more than 2,500 reports were received for some 275 earthquakes.

Arrangements were continued whereby Science Service paid for the transmission of earthquake code messages from a number of foreign stations as well as the United States for the immediate determination of epicenters. The determinations of 35 epicenters were made and sent to all cooperating stations.

The operation of seismographs in the region of Lake Mead was carried on with funds transferred by the Bureau of Reclamation and, with the assistance of the National Park Service, earthquakes were located in a routine manner. Preparations were made for similar installations at Shasta Dam, Calif., and Grand Coulee Dam, Wash.

Close cooperation continued with the California Institute of Technology, especially the seismological laboratory in the study of seismological problems, also with its engineering department with regard to structural problems.

Seismographs were operated cooperatively with the University of South Carolina, University of Chicago, Nebraska Wesleyan University, Montana State College, University of Utah, University of Alaska, and University of Hawaii. There was some seismological cooperation with the Massachusetts Institute of Technology, University of Vermont, Panama Canal Zone, Bermuda Biological Station, Montana School of Mines, and Utah State Agricultural College. Temporary arrangements were made for interpretation of seismograms of two Greenland stations at Ivigtut and Scoresby Sund.

INSTRUMENT WORK

The Bureau's Instrument Division continued to render noteworthy service in the development, improvement, and maintenance of instrumental equipment. Besides handling an exceptionally large volume of work for the Bureau, this Division was able to extend assistance along similar lines to a number of other governmental agencies.

Experiments are being conducted in the development of new and more powerful signal lamps for triangulation, making use of recent technological developments in electric lamps and reflectors.

Theodolites are being improved by better design of illumination of graduated circles, by more positive methods of microscope adjustments and by a superior form of horizontal circle and its bearing, providing more rigid parts and less expensive and more accurate construction.

Standard tide gages have been improved by removal of the heavy cast clock housing, reducing the weight of the instrument by about 15 pounds and lowering its cost. Experiments have been conducted to redesign the portable tide gage to provide more accurate recording and cheaper manufacture.

A completely rebuilt magnetograph containing many improvements was installed in the new variation building at Tucson, Ariz., observatory. A similar installation for San Juan, P. R., observatory was nearing completion at the end of the year. Insensitive variometers were designed and installed to obtain the complete record of the largest magnetic storm. Improvements were made to some of the seismographs.

A transit magnetometer attachment, which makes it possible to measure horizontal intensity in addition to declination, was perfected.

A new governor for seismograph recorder motors was developed which controls the speed to a far greater accuracy than has ever before been attained in such recorders.

PERSONNEL AND FINANCES

The Bureau had a personnel of 1,752 on duty at the close of June 30, 1941—507 (20 commissioned and 487 civilian, including 18 civilians paid from emergency allotments) on duty in the Washington office, and 1,245 (146 commissioned and 1,099 civilian) in the field service. The field personnel included 59 civilian employees on duty at the Manila field station and 132 members of the crews of the ships *Fathomer* and *Research* paid by the Philippine Government but under the jurisdiction of this Bureau.

Acquisitions by the library and archives included 110 hydrographic and 175 topographic sheets, representing new Bureau surveys; 1,040 blueprints (mostly by Army engineers); 7,132 maps; 1,778 charts: 8,337 field, office, and observatory records; 327 negatives; 2,051 prints; 597 lantern slides; 1,565 books; and 3,197 periodicals.

Collections covering miscellaneous receipts, including nautical and aeronautical charts and publications, totaled $144,864.88, as compared with $133,246.64 during the preceding year.

The following funds, from the sources indicated, were available to the Bureau during the fiscal year 1941:

Regular appropriation	$3, 481, 000. 00
Supplemental appropriation, Second Deficiency Act	1, 560, 000. 00
Total appropriations	5, 041, 000. 00
Transfers and reimbursements to credit of appropriation for:	
Coastal surveys	24, 216. 54
Federal, boundary and State surveys	30, 287. 69
Repairs of vessels	2, 112. 45
Pay, officers and men on vessels	15, 241. 37
Salaries, office	7, 506. 77
Office expenses	4, 558. 36
Aeronautical charts	64, 928. 19
Travel	1, 561. 62
Total transfers and reimbursements	150, 412. 99
Working funds received from:	
Bureau of Reclamation (seismological work, Grand Coulee Dam)	15, 000. 00
War Department (special control surveys)	6, 500. 00
Navy Department (topographic surveys, Puerto Rico)	6, 000. 00
Navy Department (wire drag surveys)	9, 800. 00
Navy Department (pay of expert in magnetic work)	767. 00
War Department (special aeronautical charts)	20, 000. 00
War Department (control surveys in Alaska)	50, 000. 00
Bureau of Reclamation (seismological work, Boulder Dam)	5, 000. 00
State Department (cooperation with American republics):	
Tide surveys	10, 000. 00
Revision of Hydrographic Manual	5, 000. 00
Gravity surveys	9, 000. 00
Work Projects Administration (administrative expenses)	35, 000. 00
Total working funds	172, 067. 00

Allotments from:	
Civil Aeronautics Administration (aeronautical charts)	$12,000.00
Work Projects Administration (special magnetic work)	7,180.00
Work Projects Administration (administrative expenses)	299.00
Department of Commerce (travel)	23,000.00
Department of Commerce (printing and binding)	56,497.00
Department of Commerce (contingent expenses)	2,850.00
Total allotments	101,826.00
Total funds available	5,465,305.99

U. S. GOVERNMENT PRINTING OFFICE: 1942