SCRIPPS INSTITUTION OF OCEANOGRAPHY

LA JOLLA, CALIFORNIA, July 1, 1929.

To the President of the University.

SIR: I have the honor herewith to transmit the report on the Scripps Institution of Oceanography for the year 1928–29.

Changes in the Institution's scientific staff—

The Institution on August 10, 1928, suffered a great loss by the death of Dr. Calvin O. Esterly, zoologist of the Institution since its initiation. Dr. Esterly by his kindly personality endeared himself to every one within the range of his acquaintance. His scientific investigations were mostly on marine zooplankton, and especially on copepods, a group on which he was a recognized authority. His last paper entitled "The periodic occurrence of Copepoda in the marine zooplankton of two successive years at La Jolla, California" appeared in print just before his death. It is a unique study and is a model for that kind of research. Dr. Esterly's death deprived the Institution of an authoritative investigator in his field. He will long be missed by a wide circle of friends in both scientific and other pursuits.

On July 1, 1928, the appointment of Dr. A. Haldane Gee as assistant professor of bacteriology became effective. This appointment was an addition to the Institution's staff. The results of his first year's work are recorded on page 264.

Another addition to the scientific staff of the Institution on July 1, 1928, was the appointment of Mr. Eldon M. Thorp as assistant for marine sediments. An account of his work during the year is given on page 267.

The contributions received from the power, light, and water organizations made possible the employment of Dr. A. F. Gorton as associate in meteorology for the entire year, and of Dr. N. W. Cummings and Mr. Burt Richardson as associates in physics for a part of the year.

Work of the boat "Scripps"—

Dr. E. G. Moberg continued in charge of the scientific work and the navigation of the "Scripps." During July and part of August 1928, and June 1929, the boat was used once or usually twice a week for collecting trips to stations located five and ten miles from the Institution pier. At these stations surface and subsurface temperatures, water samples for various chemical analyses, and plankton samples were obtained.

During August 12 to 24, inclusive, a 586–mile trip was made around the Santa Barbara Islands, the farthest point reached being about sixteen miles southwest of Santa Barbara. This trip was made partly to obtain temperature records and water and plankton samples for the Scripps Institution and partly to obtain bottom samples for Dr. P. D. Trask. Observations and samples were taken at 176 stations and at twenty-seven of these, stops were made for subsurface work. At two stations, both outside the Santa Barbara Channel, samples for oxygen determinations were taken down to a depth of 1,000 meters, thus increasing the very limited knowledge of the oxygen content of the Pacific.

From August 28 to September 13 the boat was in operation almost daily making a detailed survey of the sea bottom near the Scripps Institution and of the kelp beds between La Jolla and Point Loma. Lieutenant C. M. Durgin, of the United States Coast and Geodetic Survey, had charge of the work.

Of the new equipment purchased for the boat may be mentioned a V. I. Pettersson plankton pump, four Nansen water bottles, and several Richter and Wiese reversing thermometers.

Experiments with anchoring in deep water have been successful and we are now anchoring at stations where the depth of the water is not over 760 meters. Anchoring eliminates drifting, which, in foggy weather or far from land, resulted in loss of position and, when bearings could be obtained, necessitated running back to position with consequent loss of time. Anchoring also makes direct current measurements possible.

Physical oceanography and marine meteorology—

These investigations were in charge of Dr. George F. McEwen; Dr. A. F. Gorton served as associate in meteorology throughout the year; Dr. N. W. Cummings was on duty as associate in physics from July 5 to September 15, 1928, and Mr. Burt Richardson, also associate in physics, was on duty from July 1 to September 15, 1928, and during June 1929. Captain S. W. Chambers, associate in physical oceanography, assisted throughout the year, Miss Evelyn Holliday from July 1 to October 1, and Miss Ruth Ragan from January 1 to June 30.

Physical oceanography—

The salinity of 2989 sea-water samples was determined in the Institution's laboratory during the year, and 15,728 records of ocean temperatures and 8050 records of winds and meteorological conditions at sea were received. Three hundred and six serial temperatures and salinities were obtained from the Institution's boat "Scripps" and fifty from the United States Coast and Geodetic Survey ships "Pioneer" and "Guide."

Data from shore stations have been averaged by weeks and months as usual. Surface data furnished by naval and other ships have been averaged by months and thirty-minute sections, and tabulated as usual on

special forms. Serial temperatures and salinities at stations 1 and 2, respectively ten and five miles west of La Jolla, have been averaged by two-week intervals for each depth.

Arrangements were made with the Director of the International Fisheries Commisssion, Dr. Will F. Thompson, for Dr. McEwen to make the dynamic computations of oceanic circulation through each of four sections of seven stations, each in the Gulf of Alaska. Dr. Thompson is senior author of a report on this work which is being published by the International Fisheries Commission. Dr. McEwen collaborated in the preparation of certain sections on Physical Oceanography for the National Research Council volume on Geophysics.

Treatment of numerical series—

In connection with our meteorological investigations in seasonal weather forecasting, Dr. McEwen carried on studies for the purpose of finding the most suitable methods of dealing with types of meteorological series for the purpose of analysis and interpretation. These studies included a search for the best methods of determining from our data on sea-water temperatures and salinities the smoothed values and gradients.

At the same time a similar and related study was made relative to the statistical treatment of our plankton data. A preliminary report on this work was presented at the Fourth Pacific Science Congress in Java during May 1929.

Dr. E. R. Parker, assistant in orchard management at the Citrus Experiment Station at Riverside, asked for suggestions relative to statistical problems arising in a series of fertilizer experiments. Some correspondence was carried on relative to this problem of field plots, and a day's conference was arranged at the Scripps Institution.

Interrelations between the sea and atmosphere with reference to seasonal weather forecasting—

Investigations bearing on the problem of estimating evaporation have been continued by Dr. N. W. Cummings and Mr. Burt Richardson. This work included:

(1) The preparation of an alignment diagram for computing the ratio (Bowen's ratio, R) of heat lost by convection and conduction to that lost by evaporation.

(2) The computation of (R) from observations made three times a day at San Diego Bay for a period of one year.

(3) Experiments on the relation of depth of evaporation to the area of the containing vessel when it is thermally insulated.

(4) Experiments on the relation between evaporation rate from fresh water and sea water.

(5) Computation of daily and monthly insolation averages at La Jolla for one year from pyrheliometer records. Arrangements have been made with Dr. Kimball, of the United States Weather Bureau, for the publication of our weekly averages of insolation.

(6) Computation of evaporation by the insolating method from all lakes and bays where suitable evaporation data are available.

(7) Preliminary experiments on the penetration of light in the ocean which indicated that an especially constructed thermocouple arrangement would serve this purpose best.

During his year's work in residence at the Scripps Institution as associate in meteorology, Dr. A. F. Gorton in searching for indices of seasonal rainfall conducted an extensive investigation of various meteorological and oceanographic observations. In connection with this work, characteristics of long rainfall records for various regions were studied for the purpose of determining periods of excess and deficiency as well as trends. At the same time a regional classification into rainfall districts was worked out. Along with such statistical studies of observations, Dr. Gorton has reviewed a large number of articles pertaining to the general subject of seasonal forecasting. He has nearly completed a detailed account of his year's work for publication in the *Electrical West*.

Chemical investigations—

The chemical investigations were, as in preceding years, in charge of Dr. E. G. Moberg.

As in former years the routine work has consisted in analyzing the water samples collected by the "Scripps" and daily at the Institution pier for phosphate, silica, hydrogen ions, and oxygen.

During July 1928, and June 1929, several vertical series of water samples from ten miles off shore were analyzed for calcium.

During the spring of 1929 Van Slyke's manometric carbon dioxide apparatus was used for the first time for determining the carbon dioxide content of sea water. Several vertical series of samples were analyzed and it was found possible to check the results to within 1 per cent. On many of the same samples carbon dioxide was also determined by titration, a method that has been severely criticized by various authors, and it was found that the results agreed surprisingly well with those obtained by the Van Slyke apparatus. Determinations of carbon dioxide, as well as of calcium, will be contiuned throughout the year in order to obtain information concerning the seasonal variations of these substances in sea water.

In January 1929, studies of the calcium carbonate equilibrium in sea water were begun jointly with the bacteriology laboratory. (This subject is further discussed under the account of the bacteriological investigations.)

During the past year the following persons have worked in this laboratory: Miss Maurine Leslie was engaged as half-time assistant until January 1929, and subsequently as full-time assistant. During 1928 half her time was devoted to completing a thesis for a master's degree in Oceanography. Miss Leslie also carried out the chemical work in connection with a survey of Monterey Bay made by Dr. H. B. Bigelow, of Harvard University. In connection with this work she spent the month of July at Pacific Grove and April and May at Cambridge.

Dr. D. M. Greenberg, of the Department of Biochemistry at Berkeley, worked at the Institution during July 1928, and June 1929. His work consisted in making calcium and carbon dioxide determinations on sea water and some of the analyses required for the carbonate-equilibrium experiments.

Mr. Marston Burdick and Mr. O. M. Elliott acted as assistants during July and August 1928, partly in the laboratory and partly on the boat.

In September and October, Miss Lucina Stanford of Hopkins Marine Station, was at the laboratory to learn the methods used in chemical oceanography, and, toward the end of June, Mr. H. W. Graham, of the Carnegie Institution of Washington, arrived here for the same purpose.

Dr. Moberg devoted some time to the preparation of a manuscript on the chemistry of sea water, to form a part of the volume on geophysics to be published by the National Research Council.

Biological investigations—

Bacteriology.—These investigations were in charge of Dr. A. H. Gee.

The bacteriological program has been initiated on a broad fundamental basis in preference to immediate limitation to specific problems or localities. This course was adopted after the assembling and abstracting of relevant publications in oceanographical and bacteriological literature. It may be concluded from this survey that little of lasting value is known about marine bacteria generally, and nothing about those of the Pacific. Limited general laboratory equipment was therefore installed for the initiation of the basic physical and chemical studies of marine bacteria, on which the solutions of the specific problems depend.

The first experiments have been concerned with methods for sampling, enumeration, and the culturing of as many different organisms as can be found in the water. This work has shown that water at the end of the pier is applicable for the development of culture media and for some of the physical studies, since the bacteria characteristic of extensive land drainage and contamination are not abundant.

It has been demonstrated also that an evaluation of the share of bacteria in ocean economy away from shore, demands cultural studies immediately after sampling, i.e., on board ship. The usual bacteriological methods cannot be used at sea. New and special methods of culture have

been devised which permit work on board with bacteriological safety. They have been tested on the "Scripps" and found entirely successful. The sampling of water for bacteriological analysis requires special apparatus, which has not previously been available for oceanographical investigation. An instrument for the purpose has been designed, constructed, put into service, and shown to operate satisfactorily at considerable depths off shore.

The Florida calcareous muds, surmised to have been bacterially precipitated, have received attention as a future specific problem. This consideration has shown that, in addition to the general bacteriological studies which have already been commenced, physico-chemical laboratory experiments on sea water must precede a complete understanding of the origin of limestone mud. This chemical study has been undertaken in collaboration with Dr. Moberg.

This and other investigations at the Institution call for information on the circulation of calcium in the ocean. Opinions differ widely as to the circumstances under which calcium and carbonate may be removed from sea water and deposited as solid calcium carbonate in tests, shells, or precipitates. A study of the equilibrium shows that it cannot be handled mathematically from the usual routine chemical analyses and on the basis of present-day physico-chemical concepts. Thermostatic experiments have therefore been set up similar to the methods adopted for investigating the behavior of calcium in blood. They contradict the frequently asserted statement that sea water generally is highly oversaturated with calcium carbonate, and they show also that the equilibria which affect the calcium content are displaced only with extreme slowness. Dr. E. G. Moberg and Dr. D. M. Greenberg have cooperated on this problem, the study of which is being continued beyond the period covered by this report.

Diatoms and dinoflagellates.—Professor W. E. Allen has charge of the investigation of these organisms. In the academic year of 1928–29 about two thousand catches of microplankton have been added to the permanent series of pier and boat collections, and about five hundred catches to collections including temporary or discontinuous series. A little more than half of these have been taken in southern California localities, but two important boat series are included in the total list, one from Monterey Bay in July 1928, by Dr. H. B. Bigelow, of the Museum of Comparative Zoology of Harvard University, the other a winter series from the Gulf of Alaska by Dr. W. F. Thompson, of the International Fisheries Commission at Seattle.

About two thousand catches have been studied in 1928–29, those from Monterey Bay being the only ones obtained within the year. A report on the Monterey material was written by Professor W. E. Allen for use by Dr. Bigelow in his general report of his investigations there. A report

on several series taken by ships of the United States Coast and Geodetic Survey (mostly between San Francisco and Seattle) has been written by Miss Easter Cupp, graduate assistant. Other reports are in preparation, on which progress is slower than formerly because of the use of double records to distinguish numbers of organisms in good and bad condition.

Four reports on plankton investigations and three papers of less technical character were published within the year.

Miss Cupp has been doing special research on the character and range of variation in plankton diatoms in preparation for her thesis.

In consideration of reaching the end of a decade of pier collections, considerable time has been given to the study of possibilities of improving methods, before beginning the second decade. As a result of this it is probable that the pier collecting at La Jolla will be changed slightly in 1930.

Fishes.—During the year investigations on fishes by Professor F. B. Sumner and his assistant, Mr. A. B. Keys, were as follows:

(1) Several lines of experimentation upon fishes were commenced jointly with Mr. Ancel B. Keys. One of these related to the responses of flounders to conditions of background and illumination, this being a continuation of studies conducted by Dr. Sumner many years earlier. A report of these latest results is already in press. Experiments with the effects of temperature differences during the early development of *Lebistes reticulatus*, and others upon the effects of different backgrounds on pigment formation are still under way.

(2) Mr. Keys has been continuing independent studies of the ecology and physiology of fishes under Dr. Sumner's general supervision. These have been conducted upon a local marine fish, *Fundulus parvipinnis*, and relate to the factors concerned in individual differences of viability, in the presence of various lethal agents. An extended statistical analysis of certain morphological differences has been carried out, in the course of which Mr. Keys was led to a new mathematical formulation of the relation between length and volume during growth (results already published). Mr. Keys has also been concerned with a study of the oxydative metabolism of his fishes, as related to viability and acclimation, and has devised special apparatus for this purpose.

Deer mice (Peromyscus).—Dr. Sumner has continued his studies of heredity and geographic variation in deer mice (*peromyscus*), under a grant made two years ago by the Carnegie Institution of Washington. Chief among these labors have been: (*a*) the statistical analysis of an intergrading series of mice collected in Florida and Alabama in 1927 (results published in full); (*b*) analytical treatment of data derived from hybridization experiments among three subspecies; (*c*) the commencement of experiments with apparatus designed to record individual and racial differences in general bodily activity.

Marine bottom deposits—

During the entire year, July 1, 1928–June 30, 1929, Mr. Eldon M. Thorp acted as assistant to the Director in the study of marine sediments, and by the end of the year he had very nearly completed a preliminary study of 188 deep-sea bottom samples from the western north Atlantic and the Carribbean Sea. The paper needs some revision and supplements before it will be ready for publication, but as regards the general account of the sediments described in it, satisfactory progress was made.

Foraminifera—

The Director of the Institution devoted all of the time that he had for research to the continuation of his studies of the genera of the larger foraminifera and during the year he prepared a number of papers for publication. He was assisted throughout the year by Mr. Donald W. Gravell and for parts of the year, July 1–August 15, 1928, and June 1–30, 1929, by Mr. G. Leslie Whipple. Mr. Whipple had nearly completed two papers on fossil foraminifera in two tropical Pacific islands in connection with a study of the coral reefs of those islands. A paper entitled "Ecologic relations of some foraminifera" which deals altogether with modern species of foraminifera, was put into final form for publication by Mr. Richard D. Norton. Considerable work on foraminifera was done at the Institution by visiting scientists and students, listed elsewhere in this report, who were not attached to the Institution's scientific saff.

Visiting scientists—

The following is a list of visiting investigators who worked at the Institution during the year and the subjects on which they were engaged:

Dr. D. M. Greenberg, University of California; amounts of calcium in sea water, July 1–31, 1928.

Professor C. M. Child, University of Chicago; physiological investigations, mostly on the hydroid *Corymorpha*, July 1–September 13, 1928.

Mr. J. J. Karol; studies of *Peromyscus*, as Carnegie Institution of Washington assistant to Professor F. B. Sumner, July 1–August 6, 1928.

Mr. Donald M. Fry, California Fish and Game Commission; life-history of the California spiny "lobster," July 1–October 13, 1928.

Dr. Florence Peebles, Christian College, Pasadena; physiological investigations, July 1–September 4, 1928.

Dr. Parker D. Trask, research associate, American Petroleum Institute; collecting marine bottom deposits on the Institution's boat "Scripps," August 12–24, 1928; and at the Institution several times during the year.

Lieut. C. M. Dürgin, United States Coast and Geodetic Survey; making hydrographic surveys off the sea front of the Institution's property, August 21–September 22, 1928.

Mr. H. A. Harris; studies of *Peromyscus* as Carnegie Institution of Washington assistant to Professor F. B. Sumner, September 5, 1928–February 13, 1929.

Mr. H. J. Main, University of Oregon, Eugene; physiology of the dog fish, September 5–22, 1928.

Miss Lucina Stanford, Hopkins Marine Station, Pacific Grove; chemistry of sea water, September 9–October 13, 1928.

Dr. Y. Yamada, Assistant Professor of Botany, Imperial University, Sapporo, Japan; marine algae, September 13–18, 1928.

Professor Howard S. Reed, Citrus Experiment Station, University of California; use of library and conferences, September 15–October 2, 1928.

Dr. R. Stohler, zoologist, Basel, Switzerland; marine invertebrates, November 18–December 12, 1928.

Mr. L. Ross; studies of *Peromyscus* as Carnegie Institution of Washington assistant to Professor F. B. Sumner, June 23–30, 1929.

Other visitors to the Institution were Dr. Robert F. Weill, zoologist, Paris, France; Professor L. B. Becking, plant physiologist, Jasques Loeb Laboratory, Pacific Grove; Professor Victor Burke, bacteriologist, State College, Pullman, Washington; Dr. Lawrence Martin, geographer, Chief, Division of Maps, Library of Congress, Washington, D. C.; Professor H. J. Van Cleave, zoologist, Department of Zoology, University of Illinois; Dr. Arthur L. Day, geophysicist, Director of Geophysical Laboratory of Carnegie Institution, Washington; Mr. H. O. Wood, seismologist, in charge of the seismological laboratory of the Carnegie Institution of Washington at Pasadena; Professor H. H. Gran, botanist, specialist on phytoplankton, University of Oslo, Norway; Professor N. Yamasaki, geographer, Director Geographical Institute, Imperial University, Tokyo, Japan; Dr. Tage Skogsberg, and Mr. Gene Scoffield, zoologists, Hopkins Marine Station, Pacific Grove; Dr. Paul S. Galtsoff, marine biologist, United States Bureau of Fisheries, Washington, D. C.; Dr. T. G. Thompson, chemist, University of Washington, Seattle; Dr. W. F. Thompson, ichthyologist, Director International Fisheries Commission, Seattle; Professor Edwin B. Wilson, physicist and mathematician, Harvard School of Public Health, Boston; Dr. Whitman Cross, geologist, Chevy Chase, Maryland. Several of those whose names are listed came to the Institution for important conferences on oceanographic investigations.

Lectures by visitors—

Lectures were given at the Institution during the year by the following visitors:

President Walter E. Clark, University of Nevada; Mr. Francis Saunders, Pasadena, California; Mr. Dean Blake, United States Weather Bureau, San Diego; Professor C. M. Child, Department of Zoology, University of Chicago; Miss Mary Jeffers, extension lecturer, University of California, Pasadena; Dr. Florence Peebles, zoologist, Christian College, Pasadena; Professor H. H. Gran, University of Oslo, Norway; Professor Naomasa Yamasaki, Geographical Institute, Tokyo Imperial University, Japan; Mr. R. R. McLean, San Diego County Horticultural Commission; Dr. R. A. Whiting, Director of Research, Zoological Society, San Diego.

Students—

The students registered at the Institution during the year, with their subjects were as follows:

Miss M. Kathryn McGee; foraminifera, July 1–August 31, 1928.
Donald W. Gravell; foraminifera, July 1, 1928–June 30, 1929.
G. L. Whipple; foraminifera, July 1–August 15, 1928, June 1–30, 1929.
Eldon M. Thorp; marine bottom deposits, July 1, 1928–June 30, 1929.

Ancel B. Keys; physiology of the fish *Fundulus*, July 1, 1928–January 1, 1929, June 12–30, 1929.

Miss Maurine Leslie; chemistry of sea water, July 1–December 31, 1928.

H. C. Godsil; growth-rate of the California sardine, September 5, 1928–June 30, 1929.

R. C. Lewis; phytoplankton, July 1–September 26, 1928.

Miss Easter Ellen Cupp; phytoplankton, August 13, 1928–June 30, 1929.

Nelson A. Wells; oxygen consumption of fishes, June 13–30, 1929.

In addition to those whose names are given above, Mrs. Dorothy K. Palmer (Mrs. Robert H.) studied foraminifera at the Institution from April 29–June 30, 1929, and Mr. Horace G. Buley was here for a few days during November, completing a paper on the food of the California mussel.

Attendance of members of the Institution's staff at scientific meetings and work on committees—

The Director of the Institution, as a member of the Committee on Oceanography of the National Academy of Sciences, attended a meeting at Woods' Hole, Massachusetts, from August 16 to 17, 1928. On March 27, 1929, he sailed from San Francisco for Java to attend the Fourth Pacific Science Congress held there from May 16 to May 25. At the Congress he was the leader of the delegation from the United States and he reported as chairman of both the International Committee on the Oceanography of the Pacific and the International Committee on the Coral Reefs of the Pacific. He presented on behalf of the members of the staff of the Scripps Institution abstracts of fifteen papers. He was requested at the Congress to deliver summary lectures on the present status of oceanographic research on the Pacific and on the investigation of the coral reefs of the Pacific. He also gave a paper entitled "Suggestions for Oceanographic Exploration of the Pacific." After leaving Java he made a journey up the Malay Peninsula, across Siam, and across French Indo-China in order to get information on oceanographic activities in those countries, especially for the Committee on Oceanography of the National Academy of Sciences.

Professor McEwen delivered a lecture on oceanography at the session on water supply conducted by the School of Citizenship and Public Administration of the University of Southern California. His paper, entitled "The Water Cycle between the Ocean, Atmosphere, and Land," has been prepared for publication. Mr. Burt Richardson presented a paper entitled "Evaporation as a Function of Insolation" before the special Committee on Hydraulics of the American Society of Civil Engineers in October 1928. It will be published in the September issue of the *Proceedings* of the American Society of Civil Engineers.

Dr. A. F. Gorton presented at the Commonwealth Club of San Francisco, a paper entitled "The Problem of Seasonal Forecasting" in December, 1928, and at the general meeting of the American Association for the Advancement of Science in Berkeley in June, two papers, "The

Problem of Seasonal Weather Forecasting in California and the Performance of Certain Indices of Pacific Origin,'' and ''Secular Trends in Records of Rainfall, Temperature and Sun-Spot Numbers, as shown by the Method of Accumulated Departures, and Their Bearing on Long-Range Forecasting.''

Dr. E. G. Moberg and Dr. H. A. Gee attended the midwinter meeting of the Western Society of Naturalists in Pacific Grove in December 1928, and took part in conferences on oceanographic subjects.

Professor Allen, in June, attended the meeting at Berkeley of the American Association for the Advancement of Science and gave a paper, entitled ''Ten Years of Statistical Studies of Marine Phytoplankton at Scripps Institution of Oceanography.''

Additions to scientific equipment—

The principal additional scientific equipment for the Institution during the year was the outfitting of the bacteriological laboratory for the investigations of Dr. A. H. Gee and the construction of apparatus for the conduct of experiments on the physiology of fishes by Mr. A. B. Keys.

The purchase of apparatus for the boat ''Scripps'' has already been mentioned in the account of the boat-work. Two Negretti-Zambra thermographs for recording sea-surface temperatures were ordered during the year but were delivered after July 1, 1929. Other equipment, not yet delivered, was also ordered.

Improvement of the grounds—

The only work of significance on the grounds of the Institution during the year was the continuation of the planting program, which has been mentioned in each report for several years past. Although it was expected that the general planting program would be completed during the year covered by this report, one additional season of planting is necessary.

Library—

The total number of accessioned volumes in the library is 10,470, 95 having been added during the year, but a large number of unbound volumes are ready for the bindery and therefore the number of volumes accessioned does not represent the actual increase in the library. Catalogued reprints number 13,495, 592 having been added during the year.

Museum, Aquarium, and Supply Department—

Mr. P. S. Barnhart, Curator of the Biological Collections, reports as follows:

Museum.—Accessions to the museum and biological collections of the Institution for this year include the gift of Mrs. Grace Chapman Wernham, of 3040 mounted seaweeds representing species from the Bahama Islands, New England, Florida, Washington, California, and Hawaiian Islands;

44 fishes from local and Baja California waters, some of which are new to this locality; and many shells from Dr. Fred Baker, as additions to the Kelsey-Baker collection. Six specimens were added to the mounted fish exhibit.

There were 3627 visitors to the Institution who registered, and probably as many more who did not register.

Aquarium.—Owing to unsatisfactory attendant care, the Curator spent much time in aquarium work. The aquarium itself is in a very run-down condition. Bad water, cracked glasses, and broken tanks are a constant source of worry and aggravation. Because of the systematic care and feeding which the Curator took upon himself, many fishes have grown and thrived under aquarium conditions as in no other year, and some very interesting observations were made with regard to breeding habits of some fishes.

During the year there were exhibited 790 invertebrates representing 20 species, and 649 fishes representing 37 species.

Supply department.—Sales from the supply department amounted to $678 which includes about 650 live fishes collected for the Steinhart Aquarium of San Francisco.

Other work.—Two public exhibits were furnished, one for the carnival of the American Legion held in La Jolla, the other for the Pacific-Long Beach Exposition.

Special acknowledgments—

The Institution has continued to receive assistance in its work from sources mentioned in previous reports, namely, the transports of the United States Navy plying between Bremerton, Washington, and the Canal Zone; the United States Naval Mission in Peru and the Peruvian Navy; the United States Naval Attaché in Chile and through him from the Grace Steamship Line; the officers of the Coast and Geodetic Survey in command of vessels operating in the north Pacific; the Bureau of Lighthouses; and the Los Angeles Steamship Company.

Gifts and special contributions—

For the year 1928–29 the Institution received gifts as follows: Miss Ellen B. Scripps, for the salary of the Director and general purposes, $9000, supplemental contributions for general purposes, $10,000, special contribution toward improvement of the grounds, $450, total, $19,450; Mr. R. P. Scripps, for general purposes, $5000, and a special contribution of $2000, total $7000; the Director of the Institution contributed $750 toward the maintenance and improvement of the grounds.

Because of their interest in the endeavor being made at the Institution, to find a basis for forecasting whether the rainfall of the rainy season in southern California may be average, above average, or below average in amount, several organizations combined and raised a fund of

$6500 for the meteorological investigations being conducted at the Institution. These contributions are not to be regarded as gifts but as contributions toward certain investigations in which contributors are interested. The names of the contributors are as follows: Bureau of Power and Light, City of Los Angeles; The California Oregon Power Company, Medford, Oregon; Coast Counties Gas and Electric Company, San Francisco; Coast Valleys Gas and Electric Company, Salinas; Los Angeles Gas and Electric Corporation; Western States Gas and Electric Company, San Francisco; San Diego Consolidated Gas and Electric Company; San Joaquin Light and Power Corporation, Fresno; Great Western Power Company, San Francisco; Southern California Edison Company, Los Angeles; Pacific Gas and Electric Company, San Francisco; Southern Sierras Power Company, Riverside; California Mutual Water Companies Association, Ontario; Southern California Gas Company, Los Angeles; Mr. John Treanor, Los Angeles. The whole of this amount was carried forward for expenditure during the fiscal year, 1929–30.

Concluding statement—

In the report for last year several needs were pointed out. One of these is appointment on the staff of the Institution of a specialist on marine zooplankton to take the place of Dr. C. O. Esterly whose death on August 10, 1928, left the staff without a competent authority on that subject. A suitable successor to him has not yet been found. Nor has it yet been practicable to make the appointment of an expert on marine sediments. These are two outstanding deficiencies in the present scientific staff of the Institution. In this connection it may also be remarked that, in order to get the maximum service out of the Institution's boat there should be on the staff of the Institution someone who can divide the responsibility of the boat work with Dr. Moberg. Dr. Moberg has efficiently performed all of his duties, but it is expecting too much of him to ask him to take entire charge of the operations of the Institution's boat, in addition to the prosecution of his own scientific researches.

Respectfully submitted,

T. WAYLAND VAUGHAN,
Director, Scripps Institution of Oceanography.