

La Jolla, California
July 1, 1931

To the President of the University of California.

Sir: I have the honor herewith to transmit the report of the Scripps Institution of Oceanography for the year 1930-31.

General remarks -

Since the scientific program of the Institution has been outlined in previous reports and as the special reports that follow these introductory remarks conform to the program, there is no necessity for repeating it.

A comparison of the report for this year with that for last year shows that there has been advance in every one of the Institution's major activities. The Institution's boat has been improved by the construction and equipment on board of a laboratory in which many chemical determinations may be made at sea. During the year it was utilized for conducting an important investigation of the depth of the penetration of light in sea water, as well as for collecting water and plankton samples and measuring temperatures and recording other conditions at sea. There have been important advances in the investigations in physical oceanography and marine meteorology as regards both theoretical matters and the possible practical value of the results obtained. The results of the investigations in the chemical laboratory have been satisfactory. Although all of the work is important, the investigations of the calcium and carbon dioxide relations in sea water are outstanding. The progress in these researches has been in a considerable measure due to the valuable assistance which has been rendered by Dr. D. M. Greenberg and Dr. Paul L. Kirk, both of the Division of Biochemistry of the University of California at Berkeley. It appears that at last we have a solid foundation on which to base the investigation of these complicated relations in sea water. The bacteriological researches have also made satisfactory progress. Attention was directed mostly to studying the possible influence that bacteria might have in precipitating calcium carbonate in sea water. The most notable feature of the investigation of the plankton diatoms was the completion for the Marine Laboratory in Batavia, Java, of a large report by Professor Allen and Miss Cupp on "The plankton diatoms of the Java Sea." Progress was also made in the study of the plankton diatom floras of the waters off the west coast of North America. Several investigations on foraminifera yielded results of interest. The work of Mr. Myers on the life history of certain local species and the steady progress of the investigations of the relations of foraminifera to environmental conditions in the sea may be mentioned. The investigations of Dr. Sumner on changes in color and shade of fishes according to changes in background and other visual stimuli have yielded definite results. The researches of Mr. Wells on the influence of temperature and other factors upon the oxygen consumption of fishes have shown a marked positive correlation between oxygen consumption and the temperature of the surrounding waters. Three investigations

conducted by visiting scientists, Prof. W. R. Coe and Dr. W. W. Lepeschkin, and a graduate student, Dr. Florence O. Austin, have added to knowledge of important biological phenomena. The investigation of marine bottom deposits has made satisfactory progress, and one valuable paper on the subject was published during the year.

In last Year's report, under the caption "Concluding remarks," three special needs for the further development of the Institution were mentioned. Although the measures contemplated were not realized during the year covered by this report, provisions for two of them have been made for the year which began July 1, 1931. During the session of the Legislature in the spring of 1931, an appropriation of \$40,000 has made possible a large amount of work on the general reconditioning of the Institution's property. During the year a plan for the siting of the additional buildings on the Institution's grounds was prepared and adopted by the Regents. The commission which made the report was composed of Mr. Louis J. Gill, Chairman, Prof. J. W. Gregg, and Mr. W. P. Stephenson. What may be accomplished by the utilization of this appropriation belongs in the report for the year 1931-32. The Institution has been able to provide for the year which began July 1, 1931 a physiologist who, it is hoped, will bridge the gap between the study of physical and chemical conditions in the sea and the study of the empirical relations of organisms to their environment. The third need mentioned, which is "provision for more extended operations at sea," is under consideration, and it is hoped that the outcome will be successful.

It will be noted from an examination of the information given on visiting scientists and graduate students, that both increased in number during the year. It is hoped that, after the new building of the Institution, Ritter Hall, has been occupied, there may be further increase in the number of those who utilize the facilities of the Institution for research. The number of scientists who visited the Institution for conference or to inspect the equipment and scientific work of the Institution was gratifyingly large.

In this general summary statement special mention should be made of the increase of the Institution's library. This was mostly, but not entirely, due to a donation from the Director of the Institution. The Institution's library is an important one, but it is not yet adequate to meet the demands of those engaged in the different lines of research now being prosecuted at the Institution.

Work on the boat "Scripps" -

During the past year there have been two important developments relating to the work of the boat. During the summer of 1930 Prof. Burt Richardson used the boat to develop a method for studying the penetration of light in sea water in this locality. After the method had been perfected several series of measurements of submarine illumination were

were made at depths ranging from the surface to about 50 meters. Although the photo-electric cell used was of a different type from those used by previous workers, the quantity of light observed at different levels was practically the same as that observed by other workers in different localities.

During the spring and summer of 1931 the laboratory on board the boat was equipped for chemical work, and pieces of special apparatus necessary for this work have been designed and constructed. For the first time it is now possible to make determinations of salinity, oxygen, phosphate, silica, hydrogen ion concentration, and possibly other substances on board. Facilities for such determinations are not essential when the boat is operating in localities from which it is possible to bring the samples to the shore laboratory within a few hours of collection, but they are absolutely necessary when chemical work is to be carried out on cruises of more than one day's duration.

Physical oceanography and marine meteorology -

The 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 15 to September 10, 1930, and Mr. Burt Richardson, also associate in physics, was on duty from July 1 to September 11, 1930, and June 7 to June 30, 1931. Captain S. W. Chambers, associate in physical oceanography, assisted throughout the year. Miss C. Landgraf was employed as clerk during July, August, September, and half of the months of October and December. Mrs. Ethel Myers was employed as a clerk during half of February and from March to June, 1931. Miss C. Stern was employed as a clerk and computer from September, 1930 to March, 1931. Miss Ruth McKittrick was employed as a clerk and computer from April to June, 1931, and Mrs. Elise Driese was employed as a computer for the same period.

Physical oceanography. - The salinity of 3,171 sea-water samples was determined in the Institution's laboratory during the year, and 11,411 records of ocean temperatures, and 10,671 records of winds and meteorological conditions at sea were received.

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. These tabulations have filled nearly a thousand pages, the period being from 1925 to 1931. The work of plotting the results on special charts began in April. The records in this form are to be used as a basis for a detailed study of surface drift.

The serial temperatures, salinities, and hydrogen-ion measurements at stations 1 and 2, respectively 10 and 5 miles west of La Jolla, have been averaged by two-week intervals for each of the depths at

which observations are regularly made. "Smoothed" values corresponding to the first and middle of each month have been computed for station 1. The material in this form is appropriate for use as an index for seasonal weather forecasting and for the computation of rates of diffusion and of upwelling.

The work of making dynamic computations of oceanic circulation in the Gulf of Alaska was continued in accordance with arrangements already made with Dr. Will F. Thompson. Dr. McEwen has charge of this work and is senior author of a published report on the results obtained from observations made in 1928. The second report, based upon observations made in 1929 has been prepared for publication, and the manuscript was sent to Dr. Thompson in December, 1930.

Dr. McEwen continued to collaborate in the preparation of certain chapters of the book on physical oceanography, one of the series of bulletins on "The physics of the earth's crust" being published by the National Research Council. He arranged with Dr. T. G. Thompson of the University of Washington to prepare a chapter on "The physical properties of sea-water," and with Dr. Arnold Schumacher of the Deutsche Seewarte at Hamburg to prepare a descriptive chapter on "Our present knowledge of oceanic circulation, the distribution of temperature and salinity, and instruments used in physical oceanography." Dr. McEwen prepared a chapter on a "Summary of basic principles underlying modern methods of dynamical oceanography." All three of these manuscripts are complete and publication of this volume is expected to begin in September, 1931.

Interrelation 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.

Dr. Cummings conducted a series of tests of a sinker of Monel metal made for use in standardizing our salinity determinations, and expects to prepare for publication a paper on the results, including tables for facilitating the computations. He wrote a paper on "Energy relations in transpiration," in which he has presented an interpretation of transpiration results published by Briggs and Shantz fifteen years before, and outlined a new technique for making transpiration investigations.

Several translations in rough form of papers on evaporation and radiation, printed in Russian, have been made by Mr. Alexander Brees of the U. S. Weather Bureau at Fresno. Dr. Cummings expects to prepare a critical review of these papers.

Mr. Richardson carried on experiments for the purpose of developing a technique for measuring light intensities below the surface of the sea, and measured the light intensity at a series of depths from the "Scripps." He presented a report on these investigations at a meeting of the Western Society of Naturalists, Stanford University, December 24th, under the title "The photoelectric measurement of the penetration in seawater of light (wave length 2900 to 4800 Ångström units)." He also worked on the computation of evaporation of sea water from a tank by changes in salinity, using experimental results obtained on board the "Scripps," August 13-24, 1928. Mr. Richardson's program for the period July, 1931 - July, 1932 includes

1. Additional photoelectric measurements of the penetration of light in seawater, using three photoelectric cells which are sensitive to wave lengths from 2900 to 7000 Ångström units.
2. Insolation records, 1926-1931, at Pasadena and La Jolla, and a comparison with the records from six United States Weather Bureau Stations.
3. Investigation of a proposed unit for "clearness of day" defined as the ratio of observed insulations to computed insolation at the exterior of the earth's atmosphere, using monthly records of pyrliometer stations in the United States during the period 1925-31.
4. Collaboration with Dr. H. F. Blum on investigations of the motion of sea life toward a light source.

Dr. Gorton remained on duty during the year and continued his investigations of the relations between seasonal rainfall in California and meteorological elements in various parts of the world and of cycles in rainfall and runoff revealed by statistical methods, in particular Streiff's method of successive integration. Among the cycles revealed by these methods the important ones are in their order of length the secular cycle of 45-55 years, the Brückner cycle of 22-33 years, the Hellman cycle of 5-6 years, and the Clough cycle of 2-3 years. The 5-6 year cycle seems to be the most important for forecasting purposes.

The scope of the forecasting program is rapidly broadening, due to the interest which various individuals and corporations all over the country have taken in our efforts. We have received requests to predict both summer rainfall and winter temperatures for the eastern half of the country. In fact it would seem impossible to make a forecast of seasonal precipitation in California without at the same time specifying the course of rainfall in the Pacific northwest, the Great Lakes regions, and even the Atlantic Coast.

Although negotiations have not been completed we expect shortly to begin making tentative predictions for the Sao Paulo district in accordance with a proposal from the Brazilian Traction, Light, and Power Company. The Company expects to contribute to the support of our work and has already taken steps to install thermographs on steamers plying between Canada and the Brazilian East Coast.

The persistence of abnormal temperatures month after month during the last two years in Southern California (and to some extent in all California and the Pacific Coast, as well as in the eastern parts of the country), points to the possibility of a direct relation between the climate of southern California and temperatures in the adjacent ocean, since the latter have been observed to be above normal during the same period. Investigation was therefore made of atmospheric temperatures during the fall at four stations on the coast of southern California and water temperatures observed at La Jolla during the mid-summer period, and a high degree of correlation was found. This led to a study of the consumption of gas used for domestic heating in San Diego and Los Angeles with the result that La Jolla ocean temperatures during midsummer seem to be an equally good index of gas consumption as well as temperature during the following season. The investigation is being continued, using data supplied by the Pacific Gas and Electric Company for a northern district (Fresno).

Forecasts of temperature would be of value not only to the public utilities, manufacturers, and retail establishments which are all affected by seasonal anomalies, but also to the important agricultural interests. The combination of abnormal temperatures and erratic precipitation peculiar to the last eight or ten years has made serious inroads into crop yields all over the country. Particularly in southern California, where the question of early seasonal production is of prime importance, the forecasting of temperature is a matter of vital concern.

The annual forecast was released as usual on October 15. Through the aid of the University Clip Sheet and the Associated Press it was given wide distribution in the East and in foreign countries, as well as in California. The same forecast appeared in the Bulletin of the American Meteorological Society and the Associated Press. In this forecast use was made of a composite forecasting index developed by McEwen during the summer of 1930. This fits rainfall departures in southern California much more exactly than the original McEwen index, which was simply the average surface temperatures at La Jolla from the thirtieth to the forty-first week inclusive. The new index takes into account the time of occurrence of the maximum temperature and rapidity with which the temperature falls off after the peak value, as well as the actual magnitude of the average temperature. The same procedure applied to surface temperatures observed at Pacific Grove gives a reliable indication of rainfall departures in the north coast region.

The increasing interest in water supply and conservation is shown by invitations to give lectures before various local organizations and by the wider publicity given to our forecasting work by newspapers and magazines. Non-technical descriptions of our methods have appeared in the Los Angeles Times Sunday Magazine, Popular Mechanics, The California Citrograph, Science News Letter, and certain leading newspapers.

Chemical investigations -

These investigations are in charge of Dr. E. G. Moberg. As in the past years determinations of a number of substances for which rapid and accurate methods are available have been made on water samples collected daily from the Scripps Institution pier. A good deal of time has been devoted to the study of methods for substances that cannot now be accurately determined, and a number of other problems concerned with the chemistry of sea water have been investigated. The subjects given particular attention are as follows:

Salinity.- During several months a comparative study of various methods for determining salinity was made. Water samples on which the salinity was determined by Captain Chambers with the balance method were titrated for chloride, using Dr. T. G. Thompson's modification of the Knudsen method. The accuracy of Thompson's method was also investigated by titrating standard sea water prepared by the Hydrographic Laboratories at Copenhagen.

Boron.-This substance probably plays an important rôle in the biological chemistry of the sea and is by many workers thought to be present in sufficient quantity to take an important part in regulating the hydrogen ion content of sea water and thus to constitute an unknown quantity in the study of carbonate equilibria. At present even the approximate quantity of boron in sea water is unknown, chiefly because no satisfactory methods for its determination have been developed. During the past year we have experimented with two different methods and it appears probable that within a short time it will be possible to ascertain at least the order of magnitude of the boron content of sea water.

Calcium.- During the summer of 1930 Dr. P. L. Kirk of the Division of Biochemistry of the University of California made a number of determinations of the calcium content of sea water, using a biochemical micro-method somewhat similar to the one previously used here by Dr. Greenberg. It was found that, although this method gave reproducible results, the values obtained were slightly too low. Dr. Kirk has continued his studies of the method during the past year in Berkeley and now considers it entirely satisfactory. A number of water samples have recently been sent him for analysis.

Nitrite.- This substance has been determined at frequent intervals throughout the year by means of a method developed elsewhere. With this method it is possible to detect quantities of nitrite nitrogen down to 0.002 parts per million and we have found that, except on one or two occasions, the nitrite content of the water at the pier is less than this amount.

Ammonia.- This substance constitutes an important source of nitrogen for marine plants and a rapid method for its detection has recently been developed by European workers. We have made numerous attempts to use this method but our attempts were not successful, probably because of the fact that conditions in the present laboratory do not permit the preparation of ammonia-free reagents. This work will be continued in the new building where a special room has been provided for work on nitrogen compounds.

Carbon dioxide.- We feel that considerable progress has been made in the study of the interrelation between the hydrogen ion concentration, carbon dioxide, carbonates, and titrable base in sea water. A number of experiments and analyses bearing on this problem have been carried out by Miss Esther Allen who has been working in this laboratory since February 1, 1931. During this summer the data have been analyzed and prepared for publication by Dr. D. M. Greenberg of the University of California at Berkeley. Contrary to the opinion of most chemical oceanographers, it has been found that the total carbon dioxide in sea water can be determined both by a titration method and by Van Slyke's gasometric method. By each method it is possible to make the determinations to an accuracy of about one half per cent and the agreement between the two methods is within about one per cent. In connection with these studies, a convenient technique for equilibrating sea water with calcium carbonate has been developed and a means of detecting changes in the calcium carbonate content of the water without analyzing for calcium has been discovered.

A considerable amount of time has been devoted to preparing plans for the new building and its equipment, and to considering a number of problems that have come up during the construction of the building. A memorandum discussing various problems concerned with future work at sea by the Scripps Institution was prepared and tentative plans for such work were outlined. The most suitable type of boat, a research program, and personnel were discussed after a thorough study of a number of existing research vessels and their equipment had been made. Throughout the year assistance has been given the Carnegie Institution of Washington in connection with preparing the chemical results of the "Carnegie" Expedition for publication.

Miss Elsa Brumlop was assistant in the chemical laboratory during July and August, 1931. Since September 1, 1930, Maynard W. Harding has acted as research assistant, and during the entire year Miss Corinne Copeland served as half-time clerical assistant.

Biological investigations -

Bacteriology. - Research in the bacteriological laboratory has centered around the problem of lime deposition in the ocean and the influence of bacteria in this process. Human physiology and oceanography are jointly interested in the chemical aspects of this problem.

Dr. Haldane Gee spent two months at the Tortugas, Florida, laboratory of the Carnegie Institution of Washington. During this period additional information was obtained on chemical aspects of the problem, and representative bacterial cultures were collected from the region. The Florida region was selected for this work because it lies in a zone of active lime deposition where bacterial activity as an accessory factor has already been discussed by several investigators.

The physico-chemical studies in Florida were an extension of previous work at the Scripps Institution in collaboration with Dr. Erik G. Moberg and Dr. D. M. Greenberg. There was devised at the island an apparatus for displacing the general chemical equilibrium in the water apart from biological activity. The displacement of equilibrium was intended to simulate possible biological processes. It was carried out step by step until the zone of precipitation was reached. The controlling factors were measured by chemical analyses performed at each intermediate stage. This work agrees with previous chemical investigation at the Scripps Institution with regard to the nature of the lime equilibrium in the ocean. It emphasizes also the inadequacy of previous ideas on the subject and at the same time provides some definite information as to when and how lime may be precipitated or dissolved.

It was found that the influence of ammonia on the process can not be so great as was previously thought. Precipitation by ammonia production alone requires an acidity range outside the normal, even under tropical conditions. It would seem that the production of ammonia, for example by bacteria, can never be more than an accelerating factor in the process. The removal of carbon dioxide, however, was shown to be one direct factor in controlling the lime solubility, and is known to be extensively varied by normal biological processes.

Although distinct from the physiology of bacteria, this chemical investigation has required bacteriological methods in addition to chemical analysis in order that the process might be studied in the absence of the otherwise universal bacterial growth. Methods were introduced also for storing and shipping sea water with less spontaneous chemical change than has previously been possible.

Preliminary studies of the bacterial cultures indicate that the organisms are universal ammonia producers. To this extent they act as precipitating factors for lime. Quantitative determinations of the power of ammonia production resulted in an improvement of methods for analysis of ammonia in culture media.

The Florida collection was subsequently extensively studied by Mrs. Catherine B. Fejtham, bacteriological assistant. Contrary to expectation the types have not been found to produce carbon dioxide. The organisms can thus be regarded qualitatively as accessory factors in lime deposition, although they are apparently not capable of causing the deposition unaided under natural conditions.

The investigation, chemically, is a step in the understanding of the unusually complicated lime system in sea water. Biologically, it suggests fuller attention to the quantitative consumption of carbon dioxide by marine organisms within the zones of lime deposition. It has shown also that the exact share of bacteria in the process will not be definite before possible anaerobic organisms are included in the study.

Plankton diatoms.- The most notable feature of the diatom work of the year was the completion of a taxonomic report on "Plankton diatoms of the Java Sea" under the joint authorship of Professor Allen and Miss Cupp. The detailed work of preparation of this report for publication in "Treubia", as requested by Director H. C. Delsman of the Marine Laboratory at Batavia, was performed by Miss Cupp. It included diagnoses of one hundred twenty-seven species and varieties, illustrated by three hundred and forty-one drawings in forty-eight plates. Since the time that the work was completed in April the material has been in frequent use for comparison in studies of diatoms of California waters and other parts of the east Pacific.

Aside from her work on the Java diatoms the time of Miss Cupp has been devoted mainly to her studies of the taxonomic features of variation in frustules of plankton diatoms. She has also given considerable time to study of methods of mounting plankton diatoms for taxonomic studies. A report by Miss Cupp on the geographic distribution of diatoms and dinoflagellates as indicated by several series of catches taken between Seattle and the Canal Zone in the period from 1924 to 1928 appeared in the Transactions of the American Microscopical Society in July, 1930.

For more than a year Professor Allen has been chiefly occupied with the problems of completing, organizing, and interpreting the statistical records of diatom and dinoflagellate collections taken daily through ten years at the Institution pier and at Pt. Hueneme pier, about one hundred and twenty-five miles north of La Jolla. Computations for diatom totals at these two stations have been completed for the ten years and a limited amount of tabulation and graphing has been done. A little of the laboratory study and a considerable amount of the computation for three or four other stations occupied for less than ten years is not yet completed, and not much has been done with the highly important records of individual species which may prove to have great value as "indicators."

Professor Allen has also given considerable time to work on the report on diatom catches made by boat in 1927, the records for which present certain important peculiarities very difficult to interpret confidently on the basis of the limited and irregular information available.

Several hours each month have been spent by Professor Allen in cooperative activities having importance greater than the limited use of his time would indicate. These deal with the "fouling organisms" so much detested by those interested in keeping ship bottoms free from injurious and obstructive growths. In cooperation with officers of the United States Navy Professor Allen has made regular trips to the Navy Fuel Base each month to assist the officer in charge in inspecting "Paint Test Panels." installed there. At a few other times he has gone to the Destroyer Base to inspect the growths on bottoms of destroyers, brought out for cleaning. A little more time has been spent each month in caring for and collecting growths from blocks (of wood and cement construction) at the Scripps Institution pier, from which material was obtained for study of life histories, seasonal differences in distribution and prominence, and certain other relationships of fouling organisms by W. R. Coc of the Osborn Zoological Laboratory of Yale University.

At the invitation of the Ecological Society of America Professor Allen organized and conducted a symposium on "Environmental units" at the Cleveland meetings in January, 1931, at which he also delivered a paper on "Environmental units," later accepted for publication by the Scientific Monthly. As a result of discussions at the Cleveland meetings the Ecological Society appointed a Committee on Nomenclature and Professor Allen was named as its chairman. At the Pasadena meetings of the Ecological Society in June, 1931, he presented a paper on "Subsurface distribution of plankton diatoms in summer." He was invited to participate in a symposium on ecological problems of the Pacific Coast which was not completed because of lack of time at the session. These activities in connection with the Ecological Society have taken a considerable amount of time and effort.

Although most of Professor Allen's routine work of the past year has been devoted to material to be included in the ten year report he has maintained daily collections of diatoms and dinoflagellates at the Institution pier. Similar series of collections have been taken at Pt. Huoneme, near Oxnard, California, at the light house on the Farallone Islands, and at the light house at Scotch Cap in the Aleutian Islands. In addition a few series of catches from boats have been taken, notably one by Mr. P. S. Barnhart off the coasts of Lower California. Altogether, about fifteen hundred catches have been added to the collections of plankton diatoms at the Institution (which in several respects are probably the best in the world), giving the Institution the unique distinction of possessing remarkable collections of representatives of both

of the two kinds of organisms which have contributed largely to marine bottom deposits, i.e., the foraminifera and the diatoms.

Foraminifera.- During the year Mr. Earl H. Myers was a graduate student at the Institution and devoted virtually his whole time to a study of the life history of certain local species of foraminifera. Mr. Myers was able to observe the production of asexual megalo-spheric individuals in many of his cultures. He also observed many instances of conjugation which, in every instance, was followed by the production of objects which are tentatively designated as "zoo-spores," but he has not up to the time of the preparation of this report been able indubitably to establish the history of the objects which follow the conjugation of two individuals. He is continuing his investigation in the hope that he will be able to ascertain the fate of the so-called "zoo-spores."

Mr. D. W. Gravell, who was a research assistant at the Institution from July 1, 1928, to August 13, 1929, continued work that he had begun on collections while he was at the Institution. He completed a paper entitled "The genus Orbitoides in America, with description of a new species from Cuba," which was published in the Journal of Paleontology, September, 1930. He also completed a manuscript entitled "Larger Tertiary foraminifera of Venezuela," which has not yet been submitted for publication. The first paper above mentioned by Mr. Gravell is of interest because it gives the first authentic record of the genus Orbitoides in the Cretaceous deposits in America. The second paper constitutes an important addition to our knowledge of the stratigraphic and geographic distribution of several genera of foraminifera which are important in the Tertiary formations in northern South America.

Mr. G. Leslie Whipple was assistant for the work of foraminifera at the Institution during the month of July, 1930. He devoted most of his time to the study of larger foraminifera of the Tertiary formations of the Island of Trinidad. This investigation was not quite completed.

Mr. E. M. Thorp, in his studies of marine bottom deposits mentioned later, has made careful studies of the foraminiferal faunas associated with the different bottom samples examined by him.

Assistance was given at the Institution to Mr. Manby L. Natland in both planning and providing for an investigation of the marine bottom deposits and associated foraminifera between Long Beach and Avalon Bay, California. Along this line the conditions in the water range from those of shallow lagoons to those in nearly 600 fathoms in depth. The field work by Mr. Natland is being done during the late summer months of 1931.

During the year the Director of the Institution devoted such time as was available to a continuation of his study of the morphology, classification, and stratigraphic distribution of several genera of

larger foraminifera. Although he was able to accomplish a little, except one brief note, no papers were completed for publication.

Biology of fishes.- Work upon the biology of fishes has been continued along two different lines. One of these has dealt with changes in color and shade which figure conspicuously among the reactions of fishes and some other organisms to their environment. Dr. Sumner, with the assistance of Mr. N. A. Wells, has been engaged in studies of the effects of various backgrounds and of other visual stimuli upon the colors assumed by certain species of fish. In the course of these experiments, large numbers of one small viviparous species, Lebistes reticulatus, have been reared from birth in variously colored jars. The effects of prolonged or of briefer exposure to such conditions have been studied microscopically upon both living and dead material, and numerous microphotographs have been taken. Attention has been given both to the movements of the pigment within the chromatophores, by which the rapid changes of color are effected, and the actual increase or decrease in the amount of pigment which is responsible for the slower adjustments.

A method was also devised whereby the eyes could be covered with transparent discs of celluloid, variously tinted or painted, so as to control the stimuli received by the retina. Interesting, and, in some cases, very striking color reactions on the part of the fishes were produced in this way.

Dr. Sumner's available time for the foregoing work has been considerably curtailed during the past year by the necessity of having to prepare a rather extended summary of his seventeen-year study of deer-mice (*Peromyscus*), now concluded. The resulting paper has been contributed to the series of monographic articles published under the title "Bibliographia Genetica."

Mr. Wells devoted much of his time to the continuation of investigations upon the oxygen consumption of fishes, and the influence upon this of temperature and other factors. Mr. Wells is employing an apparatus, originally constructed at this Institution by Dr. A. B. Keys, but considerably modified by Mr. Wells himself. As was to be expected, a marked positive correlation was found to exist between oxygen consumption and the temperature of the surrounding water. The nature and extent of this correlation have been studied with special care by Mr. Wells. An extended series of experiments upon two independent series of fishes during the year have revealed a rather striking degree of consistency in the relations between these two sets of phenomena.

Miscellaneous biological investigations.- Several investigations completed or initiated during the year at the Institution can not be classified under any of the topics that are given above. During the year Prof. W. R. Coe of Yale University completed a manuscript entitled "Season of attachment and rate of growth of sedentary marine invertebrates and algae at the pier of the Scripps Institution of Oceanography, La Jolla, California," and it is now in press as one of the technical bulletins of the Scripps Institution. Professor Coe has also completed, on material sent him from the Scripps Institution, a manuscript entitled "Sexual phases of *Ostrea lurida*," which will be submitted for publication as one of the bulletins of the Institution.

Dr. Florenc Olive Austin, who was a graduate student at the Institution from October 1, 1930, to June 30, 1931, devoted her time to the study of the anatomy and physiology of the digestive organs of the California mussel, *Mytilus californianus*. A few years ago Mr. Horace M. Buley, while research assistant at the Institution, made a study of the food of the California mussel and found that the stomach contents of the organisms consisted mostly of dinoflagellates and diatoms, but he did not conduct any investigations on the feeding organs and the capacity for digestion by the mussel of the organisms found in its digestive tract. Dr. Austin has shown that there are in the digestive tract of the mussel enzymes that will digest proteins, sugars, and fats; but cellulose is not digested. The results of her work constitute a valuable addition to our knowledge of the life processes of the California mussel.

Dr. W. W. Lapeschkin, while a visitor at the Institution during the summer of 1930, conducted experiments and has submitted a short paper, "Some experiments on the influence of light and poison on marine copepods," which is now in press as one of the technical bulletins of the Scripps Institution. In this paper Dr. Lapeschkin has expressed the opinion that exposure to direct rays of sunlight decreases the power of certain copepods to resist the harmful effects of such a poison as mercury bichloride, but that ultra-violet rays increase the resistance. The paper suggests interesting lines for further research, and provisions for them are now under consideration at the Institution.

Geological investigations -

Marine bottom deposits.- Mr. Eldon H. Thorp, who acted as research assistant for marine sediments from July 1, 1930, to May 7, 1931, completed for publication a manuscript entitled "Descriptions of some deep-sea bottom samples from the Western North Atlantic and the Caribbean Sea," which was published during the year as one of the technical bulletins of the Institution. After the manuscript above mentioned had been submitted for publication Mr. Thorp undertook a study of the shallow-water calcium-carbonate bottom-deposits collected by the Director of the Institution during some years' field work in the Bahamas and along the Florida

keys. At the time when Mr. Thorp left the Institution to return to Berkeley for additional courses he had completed the descriptions of many of the samples, and the work was far advanced toward completion. The two investigations conducted by Mr. Thorp at the Scripps Institution are mutually complementary. By the time that he has finished the second investigation he will have made a very careful study of the marine deposits, particularly of the calcium-carbonate deposits, from the beach line and shallow water in Florida and the Bahamas to the great depths in the Western North Atlantic and the Caribbean Sea.

Besides the investigations on marine bottom deposits above indicated, during the year the Institution received a complete set of the bottom samples collected by the vessel "Carnegie" during its operations in the Pacific Ocean. Mechanical analyses of all those samples of which the material was sufficient were made in the Institution's sediment laboratory by Mr. Alfred E. Barker under the supervision of Mr. Thorp. Fractions of all those samples of which the quantity was adequate were forwarded to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and chemical analyses of those fractions are now being made by Sharp, Schurtz Company. The work preliminary to the description of the samples has been nearly completed.

In connection with the study of marine bottom deposits it should be mentioned that Dr. W. H. Dore, Chemist in the Experiment Station, University of California at Berkeley, has undertaken to make X-ray spectrograms of the fractions of silt and clay size of a number of the marine deposits being studied at the Institution. The first experiments have given very promising results. It appears that we shall be able to get at least an approximate idea of the mineral constituents of those fractions of the sediments the particles of which are too small for mineralogical identification by ordinary microscopical methods.

The bacteriological investigations by Dr. Gee and the chemical investigations by Messrs. Moberg, Groenberg, and Kirk, and their associates, bear upon important problems that have to be considered in the investigation of marine bottom deposits, and therefore should be mentioned in this connection.

Attendance at scientific meetings -

During the year the Director of the Institution was president of the Pacific Division of the American Association for the Advancement of Science, and in that capacity he attended the midwinter meeting of the Association at Stanford University, December 22-23, 1930. The Director also took part in the national summer meeting of the American Association

in Pasadena, June 15-20, 1931. He organized a symposium on "Major problems of modern oceanographic research," and gave the first paper which was entitled "Outstanding problems in the oceanography of the Pacific." During the latter part of April and the first part of May the Director attended the annual meeting of the National Academy of Sciences and the annual meetings of the divisions of Foreign Relations, Geology and Geography, and American Geophysical Union, of the National Research Council in Washington, D.C. While in Washington he had conferences with the officers of several organizations that are assisting the Scripps Institution in its investigations.

Professor Allen attended the national meeting in Cleveland of the American Association for the Advancement of Science during the Christmas and New Year holiday season, and gave a paper entitled "Environmental units."

Dr. Gorton attended the meeting of the American Institute of Electrical Engineers in Portland, Oregon, on September 5, 1930, and gave a report on the present status of the forecasting system used at the Scripps Institution.

During September Dr. E. G. Moberg gave a paper before the meeting of the National Academy of Sciences in Berkeley on "Circulation of the waters of the Pacific Ocean as indicated by their physical and chemical properties."

In addition to the Director, the following members of the staff of the Institution attended the meeting of the American Association for the Advancement of Science at Pasadena, June 15-20, and each of them presented one or more communications: Messrs. Sumner, McEwen, Allen, Moberg, Gorton, and Wells. Besides the attendance at the meetings of different scientific societies members of the staff of the Institution gave numbers of lectures before organizations of several different kinds. Those who gave such lectures were the Director, and Messrs. Allen, Barnhart, Gorton, and McEwen. Some of these lectures were of a popular nature and were intended to disseminate information regarding the purpose and the work of the Scripps Institution.

The Director of the Institution has continued to devote much attention to the work of the International Committee on the Oceanography of the Pacific and the National Committee on the Oceanography of the Pacific for the United States, of both of which he is chairman; the National Research Council, Division of Geology and Geography, Committee on Submarine Configuration and Oceanic Circulation, of which he is chairman; and the Committee on Oceanography, National Academy of Sciences. During the year he has endeavored to help the Executive Committee of the Fifth Pacific Science Congress in organizing the different programs on oceanography for that Congress. Dr. McEwen and Professor Allen were also connected with oceanographic committees to which they have given some attention during the year, and Dr. Moberg is the secretary of the Western Society of Naturalists.

Publications -

The total number of publications by members of the staff during the year was a few more than forty. Four papers were published in the Bulletin of the Scripps Institution, while a few others were in press at the end of the year, June 30, 1931.

Visiting scientists -

The visiting investigators during the year, with the subjects on which they worked, were as follows:

- Harry C. Godsil, California Fish and Game Commission; Growth rate of the California sardine, July 1 - September 16, 1930.
- Dr. Leo Loeb, School of Medicine, Washington University, St. Louis; engaged in completing the manuscript of a book, July 1 - September 15, 1930.
- Prof. C. M. Child, University of Chicago; Physiological investigations, July 1 - 29, 1930.
- Dr. W. W. Lepeschkin, Biochemical Laboratory, Desert Sanatorium, Tucson, Arizona; Physiological investigations, July 1-15, 1930.
- Prof. Warren H. Lewis, Professor of Anatomy, Johns Hopkins University, July 1-12, 1930.
- Dr. P. L. Kirk, Division of Biochemistry, University of California; Methods for the determination of calcium in sea water, July 1 - August 2, 1930.
- D. M. Gravell, Paleontologist, Houston, Texas; Study of collections of fossil foraminifera, July 28 - August 2, 1930.
- Dr. Parker D. Trask, Research associate, American Petroleum Institute; Conferences with members of the staff and study of oceanographic data for the eastern Pacific in connection with his investigation of marine bottom deposits as possible source beds of petroleum, March 8-12, 1931.
- R. I. Rasmussen, University of Illinois; Study of the ecology of species of barnacles, March 3-16, March 28-April 24, 1931.
- Ernest H. Quayle, San Diego Museum of Natural History; Study of fossil corals, at irregular intervals throughout the year.
- Dr. D. M. Greenberg, Division of Biochemistry, University of California; Calcium and CO₂ relations in sea water, June 1 - 30, 1931.
- Dr. H. F. Blum, Division of Physiology, University of California; Physiological investigations, June 3-30, 1931.
- Dr. H. S. Shoup, Vanderbilt University, Nashville, Tenn.; Physiological investigations, June 23 - 30, 1931.
- M. L. Natland, Paleontologist, Shell Oil Company, Long Beach, California; Examination of collections of foraminifera, and conferences, at various times throughout the year.

Lecturers -

Lectures were given by visitors as follows:

- Dr. Paul L. Kirk, Division of Biochemistry, University of California.
Prof. Leo Loeb, School of Medicine, Washington University, St. Louis.
Dr. A. B. Smith, Scripps Memorial Hospital, La Jolla.
Mr. Joshua L. Bailey, Jr., San Diego.
Dr. C. L. A. Schmidt, Division of Biochemistry, University of California.
Dr. H. F. Blum, Division of Physiology, University of California.
Mr. A. W. Billings, Vice-President, Brazilian Traction, Light, and Power Company, Sao Paulo, Brazil.
Dr. W. E. Ritter, Director Emeritus, Scripps Institution of Oceanography.
Dr. Myrtle Johnson, San Diego State College.
Dr. Parker D. Trask, Research associate, American Petroleum Institute, Princeton, N. J.
Dr. E. W. Nelson, formerly chief, U. S. Biological Survey.
Dr. Robert O. Harwood, San Diego State College.

In addition to the visiting scientists who actually conducted investigations at the Institution and those who delivered lectures, a number of others visited the Institution for scientific conferences or to inspect its scientific work. Of such visitors the following will be mentioned:

- Dr. W. H. Welch, Medical School, Johns Hopkins University, Baltimore.
Dr. W. T. Swingle, Director, U. S. Government Date Farm, Indio, Calif.
Dr. Gwendoline H. Faulkner, Commonwealth Fellow, Bedford College for Women, University of London.
Mr. E. W. Higgins, Division of Inquiry in Respect to Food Fishes, U. S. Bureau of Fisheries, Washington, D.C.
Prof. A. R. Davis, Division of Plant Physiology, University of California.
Prof. A. C. Redfield, Department of Physiology, Harvard University, Medical School.
Messrs. N. B. Scofield, W. L. Scofield, and H. L. Nidever, California Fish and Game Commission.
Dr. Bains Prashad, Officiating Director, Zoological Survey of India.
Prof. C. H. Abbott, Department of Zoology, Redlands University.
Mr. H. A. Barre, Chief Engineer, Southern California Edison Company.
Dr. Isaiah Bowman, Director, American Geographic Society, New York.
Lieut. Comdr. H. N. Wallin, U. S. Navy, Mare Island, Calif.
Prof. Joe Ueta, Department of Astronomy, Kyoto Imperial University, Japan.
Captain T. J. Maher, U. S. Coast & Geodetic Survey, San Francisco.
Dr. Roy L. Moodie, Paleopathologist, Santa Monica.
Dr. Josef Petrik, Director, Physiological Institute, Masaryk University, Brno, Czechoslovakia.
Mr. Donald Fry, California Fish and Game Commission.

- Dr. A. F. Shull, University of Michigan.
 Major E. A. Goldman, U. S. Biological Survey.
 Dr. Juan Cuesta, Marine Biological Laboratory, Santander, Spain.
 Dr. Alexander Breese, U. S. Weather Bureau, Fresno.
 Dr. E. C. Watson, Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena.
 Dr. F. E. Clements, Plant Ecologist, Carnegie Institution of Washington, Santa Barbara.
 Miss Thilde Gødölley, Marine Biologist, Prague University, Czechoslovakia.
 Mr. Claro Martin, Division of Fisheries, Bureau of Science, Manila.
 Mr. L. C. Lanier, Assistant Superintendent. Steinhart Aquarium, San Francisco.
 Prof. E. S. Sundstroem, Division of Biochemistry, University of California.
 Dr. Roderick Craig, Division of Biochemistry, University of California; Dr. Marcel Homes, Department of Botany, University of Brussels.
 Dr. A. H. Hutchinson, Department of Botany, University of British Columbia.
 Dr. Karl F. Kellerman, Associate Chief, Bureau of Plant Industry, Washington, D.C.
 Dr. C. W. Lowe, Botanist, University of Manitoba and Marine Biological Station at Nanaimo, B. C.
 Dr. C. B. Rigg, Department of Botany and Oceanographic Laboratories, University of Washington.
 Prof. W. H. Twenhofel, Department of Geology, University of Wisconsin.
 Dr. S. H. Cook, and Dr. Erik Ogden, Division of Physiology, University of California.
 Prof. F. M. McFarland, Professor of Histology, Stanford University.
 Mr. J. H. Gordon, Meteorologist, U. S. Weather Bureau, Yuma, Ariz.
 Dr. H. L. Wieman, Department of Zoology, Cincinnati, Ohio.

Students -

Graduate students registered at the Scripps Institution, with their subjects for the year, were as follows:

- G. L. Whipple, foraminifera, July 1 - August 2, 1930.
 Easter Ellen Cupp, plankton diatoms, July 1, 1930 - June 30, 1931.
 Maynard W. Harding, chemical oceanography, Sept. 1, 1930 - June 30, 1931.
 Earl H. Myers, life history of foraminifera, July 1, 1930 - June 30, 1931.
 N. A. Wells, influence of temperature changes on the oxygen consumption of the California killifish, July 1, 1930 - June 30, 1931.
 E. M. Thorp, marine bottom deposits, June 1, 1930 - May 7, 1931.
 Florence O. Austin, the anatomy and physiology of the digestive organs of the California mussel, *Mytilus californianus*, Oct. 1, 1930 - June 30, 1931.
 Esther C. Allen, CO₂ determinations in sea water, Feb. 19 - June 30, 1931.

Addition to scientific equipment -

During the year only those additions to the scientific equipment of the Institution were made that were regarded as most urgent. This policy was adopted because of expected provision of equipment for those sections of the Institution's work that will be housed in the new laboratory building. Therefore, except more or less routine supplies, the only equipment purchased consisted of two additional rather high-grade microscopes and one computing machine.

Improvement of property -

The only noteworthy improvements of the Institution's property during the year were in the nature of repairs and replacements. The iron pipe from the Institution's salt water supply-tank to the east end of the pier was replaced by lead pipe, and the interiors of all of the Institution's cottages were repainted. Some other improvements were made in connection with the cottages, but at the end of the year the exteriors had not been repainted.

New building -

The new building, mentioned in last year's report, for which \$40,000 had been appropriated by State Legislature, \$40,000 contributed by an anonymous donor, and \$40,000 allotted by the Rockefeller Foundation, making a total of \$120,000, had not been quite completed by the end of the fiscal year. The general construction was finished by the first of July, 1931, but the installation of the furniture, the plumbing connections, laying of floors, and the painting of the interior, remained to be done. The Regents of the University decided to name the building for the first Director of the Institution, Dr. William E. Ritter, its name, therefore, is Ritter Hall. It would seem that an account of this building might more appropriately be given in next year's rather than this year's report.

Library -

An increase of 1,767 volumes and 6,244 reprints has been made to the library, bringing the total number of accessioned volumes to 12,557, and of catalogued pamphlets to 21,963. During the year the scientific library, consisting of 1,334 volumes and 5007 reprints, given by the Director, has been catalogued, accessioned, and added to the regular library of the Institution.

Museum, aquarium, and supply department -

Museum.- Mr. P. S. Barnhart, the Curator of the Institution's biological collection, has made steady progress in the scientific arrangement and classification of the Kelsey-Baker collections of shells of the Pacific region. Seventy-two shells representing thirty-six species were received from Dr. Fred Baker. Dr. Coe of Yale University has furnished the Institution Museum with six interesting Riker mounts which illustrate the growth rate of Ostrea lurida, Pectin latiauritus, and Balanus tintinnabulum, from material collected from the Scripps Institution pier. Six species of southern California fishes, new to our collections, and a number from Baja California, have been obtained through the local fish markets.

Identification of specimens and information relating to marine life are constantly being given to individuals, societies, and schools. Two popular lectures on the anatomy and habits of fishes were given in San Diego. An exhibit illustrating the work of the Institution was furnished for the Pasadena meeting of the American Association for the Advancement of Science.

The present museum of the Institution is housed in the library building, and the space being utilized by it will eventually be needed for library purposes. On the other hand, the space is very limited and little suited for museum purposes. The continual growth of the library and museum mean that in a few years the museum must be crowded out. It is not too early to look forward to the time when new quarters will be needed for the museum.

Supply department.- Sales from the supply department amounted to \$400.16.

Aquarium.- The replacement of the old iron water pipe by lead pipe from the salt-water storage tank to the gravity tank and aquarium, has been of very material benefit to the upkeep of the aquarium and the animals in it. There has been less mortality among the fishes and invertebrates and it has been possible to keep more of the latter than heretofore. Thus, while the total number of animals shown has been decreased, the number of species has been increased.

One of the one hundred and thirty gallon tanks was replaced by a 260 gallon tank, and two of the 260 gallon tanks were replaced by one of 520 gallon capacity, making it possible to exhibit larger fishes. Two of the 50 gallon tanks were lined with rock-work adding much to their attractiveness. The exhibits in the aquarium during the past year have been better than for many years past.

Attention might be called to the fact that the present aquarium, when built, was expected to be only a temporary structure, and not supposed to last nearly so long as it has lasted. It was expected that it would be replaced by a larger and better constructed building. All the

foundations supporting the tanks are of untreated wood laid down on the ground. The effect of moisture on these earth-wood foundations is beginning to show in settling and warping, as well as rotting. This temporary structure has well proved the need of an aquarium for such an institution as this, from the standpoint of public interest and educational and scientific value. The need now is for an aquarium with laboratory facilities where problems relating to marine fish life may be studied experimentally.

During the year 580 fishes representing 42 species, and 140 invertebrates representing 32 species, were shown.

Other activities.- The Curator visited the Steinhart Aquarium in San Francisco for the purpose of studying aquarium construction and maintenance. On the invitation of Capt. Victor Angulo of the Mexican Fisheries Patrol Boat, S. A. F. No. 1, the Curator made a three weeks' collecting cruise down the west coast of Baja California, across to Socorro Island and back to La Paz. Ninety-six water samples and two hundred plankton hauls and temperature records were taken for the Institution. A number of mosquito fish, Gambusia affinis, were taken from the Institution and planted at San Jose del Cabo to assist in the eradication of the malaria-carrying mosquito at that place.

Special acknowledgments -

The Institution has continued to receive generous assistance in its work from the same organizations that have helped it during several years past. This assistance has been rendered by the transports of the United States Navy in the eastern Pacific, the Peruvian Navy, the U. S. Naval Attaché in Chile, the Chilean Meteorological Service, the Grace Steamship Line, the officers of the U. S. Coast and Geodetic Survey in command of vessels operating the Northeast Pacific, the Bureau of Lighthouses, and the Los Angeles Steamship Company. In addition to the organizations mentioned, during the year the Institution has also been helped by the U. S. Hydrographic Office, the U. S. Weather Bureau, and the Canadian Meteorological Service. The San Diego Consolidated Gas and Electric Company has generously done, without charge, a large amount of photostating of records and charts for the Institution.

Gifts and special contributions -

For the year 1930-31 the Institution received gifts as follows: Miss Ellen B. Scripps has continued her generous support of the Institution; Mr. Robert P. Scripps, for general purposes, \$5,000; the Director of the Institution, towards maintenance and improvement of the grounds, \$650.00. The organizations interested in the efforts of the Institution to find a basis for forecasting seasonal rainfall and other meteorological conditions contributed \$10,000 for the continuance and extension of these investiga-

tions during the year 1930-31, and prior to May 1, 1931, they paid to the Regents of the University \$12,000 for the continuance and extension of investigations during the year 1931-32. The Southern California Telephone Company contributed about \$500 worth of apparatus to help in the investigation of the penetration of light into sea water.

During the year the Institution received, as in past year, many gifts of books and specimens. Its library, as the report of the librarian shows, has grown rapidly. Its collection of certain groups of foraminifera has also very considerably increased, so that its collection of the larger forms is now certainly one of the two best in the United States and one of the four or five best in the world.

Concluding remarks -

At the end of each of the annual reports of the Scripps Institution for several years past there has been a statement of some needs for further development of the Institution. The provisions for the Institution for the year which began on July 1, 1931, have already been made. They include the appointment of a successor to Dr. Gee who has been the Institution's bacteriologist for several years but who resigned in November, 1930, and the appointment of an additional member of the staff of the Institution to undertake investigations of the physiology of marine organisms, as has already been stated in the general remarks at the beginning of this report. The number of research assistants on the Institution's staff has been somewhat increased. It is not contemplated to make additions in the immediate future to the members of the staff in charge of definite lines of research, but conditions within the Institution need to be improved in several respects, so as to make the efforts of the different members of the staff more effective. One of these is the provision of additional equipment, the second is the improvement of certain personal service in the different investigations, and a third is an increase in the scientific assistance at the Institution, either by the appointment of a few more research assistants or a few technical assistants who can help with the routine of some of the investigations. It is contemplated to try to take care of some of these needs in the plans for the Institution for the year which begins July 1, 1932.

The provisions for more extended operations at sea have not yet been realized. If the Institution is to play the rôle that it should play in the development of oceanography as a science and the study of the Eastern Pacific Ocean which is logically its principal field of operation, a sea going vessel with an adequate staff and crew is necessary. It scarcely needs to be said that a considerable part of the scientific staff of such a vessel can be taken from the regular staff of the Institution. This matter is now under consideration and it is earnestly hoped that the decision may be favorable to the expansion of the Institution's work at sea.

Although provisions have been made for extensive improvements of the Institution's physical property, after all that is possible has been done with the funds now available, there will remain a number of features that will require attention. Among these may be mentioned the construction of additional roads, the improvement of the landscape gardening, and, as is pointed out in the report on the work of the curator of the biological collections, the Institution should have as soon as can be provided an adequate and permanent Aquarium. There should also be one or more service buildings.

Respectfully submitted

(Signed) T. Wayland Vaughan
Director,
Scripps Institution of Oceanography