

SCRIPPS INSTITUTION OF OCEANOGRAPHY,

ANNUAL REPORT

TO THE

PRESIDENT OF THE UNIVERSITY

July 1, 1940

	page
<b>General Report</b>	
I. General report for the year July 1, 1939 to June 30, 1940.	1
II. Review of activity of the Scripps Institution during the last biennium and outlook for the future.	8
<b>Appendices</b>	
I. Research activity	14
Work at sea - - - - -	14
Physical oceanography	17
Chemistry - - - - -	21
Sediments and sedimentation	23
Marine microbiology	26
Phytoplankton - - - - -	28
Zooplankton	29
Physiology - - - - -	31
Biology of fishes	33
Fouling of submerged surfaces	36
II. Library and publication of papers	37
Library	37
List of papers published	38
Papers in press - - - - -	40
Papers submitted for publication	42
III. Instruction and students	43
IV. Visitors	44
V. Museum and aquarium	45
Museum - - - - -	45
Aquarium	46
Other activities	46
VI. Workshop	47

Scripps Institution of Oceanography

La Jolla, California, July 1, 1940

To the President of the University

Sir:

I have the honor herewith to transmit the general report of the Scripps Institution of Oceanography for the year 1939-40 and a review of activities during the last biennium and outlook for the future. An appendix to this report gives detailed information about the various phases of the activity at the Institution.

I

GENERAL REPORT FOR THE YEAR JULY 1, 1939 TO JUNE 30, 1940

Personnel -- No changes in the permanent scientific staff have taken place during the year. D.L.Fox, Assistant Professor of Marine Biochemistry, returned from sabbatical leave in September, 1939, after having spent a year at Cambridge, England with a fellowship from the Rockefeller Foundation. C.E.ZoBell, Assistant Professor of Marine Microbiology and Assistant to the Director, returned from sabbatical leave in September, 1939, after having spent the preceding winter at the University of Wisconsin where he held a post-doctorate fellowship, and the summer at Woods Hole Oceanographic Institution on a research fellowship.

Administration -- The secretary of the Institution, Miss Tillie Genter, has efficiently conducted the general office work which has been steadily increasing, owing to the addition of the research vessel to the facilities of the Institution, to the expansion of the U.S.Navy project for the investigation of fouling growth, and to the increasing number of long-period visitors. The restoration of the cottages brought a large amount of extra book-keeping.

During the year H. U. Sverdrup was a member of the Graduate Council of the Southern Section of the University, and he with other members of the staff served on several committees at U. C. L. A.

Laboratories -- In order to provide for further laboratory space which was needed owing to the increasing number of visitors at the Institution, a new laboratory room was partitioned off in the basement of Ritter Hall, and by other alterations one room which had been used as a dark room was made available for use as a laboratory. Two rooms in Scripps Hall have been at the exclusive disposition of the investigation on fouling growth which is conducted at the Institution by the United States Navy Bureau of Construction and Repair.

Library -- In the library the number of bound volumes has increased by 640 volumes to 18,205. Besides the bound volumes, in the neighborhood of 600 serials have been received by purchase and exchange. Further details are given in the appendix.

Research Vessel -- From September 1, 1939 to February 29, 1940, the "E.W.Scripps" was laid up at San Diego during which period a number of alterations were made, as explained in the appendix.

Research Activities in the Laboratory and in the Field -- Detailed accounts of the research activities in the laboratory and of the work at sea are given in the appendix to this report. The outstanding features are discussed in the second part of this general report, which deals with the activity of the Institution during the past biennium.

Cooperation with other Organizations -- The cooperation with the Bureau of Construction and Repair of the United States Navy in the study of organisms which cause fouling growth on ships' bottoms has been continued and extended.

The cooperation in work at sea on board the "E.W.Scripps" with the Federal Bureau of Fisheries which was initiated in the spring of 1939 was brought to a conclusion on July 11, 1939. A new cooperative project started at the beginning of March, 1940 and was brought to a successful conclusion on June 8, 1940.

During the past year the Scripps Institution has been in close contact with the Destroyer Division at San Diego which was engaged in sonic work at sea. Numerous unpublished data from the sea off the coast of California have been placed at the disposal of the Commander's Office and several conferences have been held.

Unpublished data have been submitted to the California State Fish and Game Commission.

The studies of methods for long-range weather forecasting have been supported by the Los Angeles Department of Water and Power. Data as to sea-surface temperatures have been supplied to several organizations.

Chemical and mechanical analyses of samples of sediments have been continued by means of a grant from the Geological Society of America.

During the year much assistance has again been received from the Works Progress Administration Project in operation at the Scripps Institution and it is a pleasure to acknowledge the unfailing cooperation of the employees of that project.

Publication -- During the year thirty-four papers have been published by members of the staff, twenty-five papers are in press, and seven others are submitted for publication. A complete list of these papers is given in the appendix. Papers published by members of the staff and visitors working at the Institution during the calendar year of 1939 were paper-bound as the second volume of the new series of "Contributions from the Scripps Institution of Oceanography," and were distributed to

exchanges.

A new publication, the first issue of which will appear in the fall of 1940, was established under the title, "Records of Observations." This publication will be printed by the offset method in an 8 1/2 x 11 inch size. The earlier non-technical series, Bulletin of the Scripps Institution of Oceanography, no number of which has appeared since 1930, was formally discontinued, and the name "technical series" was dropped from the current Bulletin series.

Instruction -- During the year twelve graduate students have been working for longer or shorter periods at the Institution. At the end of the second semester of 1939-40 Mrs. L. Sorkness obtained the M.S. degree and Mr. B. T. Scheer the Ph.D. degree at Berkeley. Mr. C.C. Davis obtained his Ph.D. degree at the University of Washington, and Mr. Walter Munk his M. S. degree at California Institute of Technology, on the basis of theses which were prepared here.

During the second semester of 1939-40 Mr. Roger Revelle gave a two-unit course in physical oceanography on the Los Angeles campus, and Mr. Claude E. ZoBell conducted a two-unit course in bacteriology at U.C.L.A. and a three-unit course in bacteriology for the University Extension Division in San Diego.

Lectures and Attendance at Scientific Meetings -- Considerable emphasis has been placed on attendance at scientific meetings by members of the staff because the isolated location of the Scripps Institution makes it desirable for the staff to retain contacts with other workers in the field and to establish new contacts. The attendance at meetings has for this reason been out of proportion as compared with such attendance by faculty members on other campuses of the University, but it is

believed that the travel involved is of special value to the work of the Scripps Institution. The interest of the staff members in these meetings is so great that many have attended meetings without asking for travel funds.

During the year members of the staff have attended and presented a number of papers at scientific meetings on the west coast. In July, 1939, the Scripps Institution was especially well represented at the Sixth Pacific Science Congress (7 members) and at the A.A.A.S. meetings in Seattle, June, 1940 (7 members). In September, 1939, the Seventh Assembly of the International Union of Geodesy and Geophysics in Washington, D.C., was attended by Messrs. Fleming, McEwen, Revelle, and Sverdrup, who all presented papers at the meeting. Mr. Revelle attended the meeting of the Geological Society of America in Minneapolis in December, 1939 and read a paper. Mr. ZoBell was a delegate to and presented a paper at the Third International Congress of Microbiology in New York in September, 1939. On invitation Mr. Sverdrup gave a lecture at the annual meeting of the Sigma Xi - Phi Beta Kappa at the University of Washington on May 23, 1940.

During the year efforts have been made to meet the numerous requests for popular lectures in order to maintain contact between the Institution and the surrounding communities. About fifty popular lectures and semi-popular talks have been given by different members of the staff, besides two interviews over the radio.

Visitors -- Detailed information about visiting scientists and other visitors will be found in the appendix to this report. The number of visitors who have signed the register in the museum was nearly the same as in 1938-39, namely, about 7,000, and the total number of visitors to the museum can therefore safely be estimated at more than 10,000 persons.

Buildings and Grounds -- During last year no steps were taken towards repairing the old wooden bulkhead which since a storm in January, 1939, has been standing like an open fence in front of the sloping ground, because the soil inside of the bulkhead was washed away. Fortunately, during last winter no high waves coincided with high tides, but great damage may be done if such coincidence should occur during the next winter and replacement of the bulkhead is therefore urgently needed.

It is again emphasized that irreparable damage may result to the pier if restoration is not made within the very near future. During the past year the pier has been used more and more for scientific studies in which, particularly, the U. S. Coast and Geodetic Survey and the U. S. Beach Erosion Board are interested, and permanent damage to the pier will disrupt the promising studies which are now being conducted.

The restoration of the cottages of the campus was made this last spring by means of funds which had been placed at the disposal of the Institution by the University and which will be repaid by income from rentals over a period of years. In order to prepare an adequate program for the maintenance of the cottages the tenants have, on request, named a committee of three which will submit plans and will deal with all requests for repairs. Through this measure it is hoped to obtain the active cooperation of the tenants in the housing program and to develop a civic pride leading to general improvement in the appearance of the campus.

Financial Outlook -- There are good prospects that the Scripps Institution during the next years will continue to receive an annual contribution from the Ellen B. Scripps Foundation amounting to about \$10,000, although the Foundation is unable to make any commitment. Advantage should be taken of any possibilities which might present themselves for obtaining support from other sources. If such support cannot

be obtained I hope, nevertheless, that the budget of the Institution can be retained at such a level that the activity in laboratories and the work at sea can be continued as at present.

During the past two years the Federal Bureau of Fisheries has contributed \$2,000 a year in order to have the privilege of conducting their special investigations on our cruises. It is possible that this cooperation will continue in the coming biennium. A grant from the Geological Society of America, amounting to \$2,500, will be applied towards a second cruise to the Gulf of California and further funds may be forthcoming for continued studies of the sediments and processes of sedimentation in the Gulf. These cooperations have greatly increased our possibilities for work at sea because the regular allotment for this work is so low that the greater part has to be applied to insurance and routine expenses which have to be met regardless of whether the vessel lies in port or is at sea. Therefore the regular allotment does not actually provide for taking the vessel out of port for more than about one month of the year, whereas an addition of \$2,000 makes it possible to have the vessel in commission for three more months.

Acknowledgments -- The Scripps Institution gratefully acknowledges assistance in its scientific work received from the U. S. Navy, the U. S. Coast and Geodetic Survey, U. S. Bureau of Lighthouses, the Department of Water and Power, City of Los Angeles, the California Fish and Game Commission, the U. S. Bureau of Fisheries, the Geological Society of America, and from various other organizations which, particularly, have provided surface temperature observations and plankton collections from the surface waters. The financial support received from the Ellen Browning Scripps Foundation is greatly appreciated.



Special acknowledgment is expressed to Messrs. T. Wayland Vaughan and Roger Revelle for their gifts of books and periodicals and also to Mr. Revelle and Mrs. J. G. Johanson for their contributions which have made possible the employment of additional assistants in the Sediments Laboratory.

Great help has been received from the Works Progress Administration Project which has continued at the Institution during the past year. W. P. A. employees have been active in nearly every division of the Institution, serving as stenographers, typists, computers, draftsmen, photographers, translators, librarians, and general laboratory assistants. The efficiency of the work at the Institution has been greatly increased, thanks to the large amount of assistance received in this manner, since the W. P. A. employees represented a group of well-trained, able, and industrious persons. The Scripps Institution wishes to express its acknowledgment for the valuable services rendered.

## II.

### REVIEW OF ACTIVITY OF THE SCRIPPS INSTITUTION DURING THE LAST BIENNIUM AND OUTLOOK FOR THE FUTURE

Since my first contact with the Scripps Institution it has been my hope to establish a closer cooperation between the different specialists on the staff and gradually to develop a research program for the Institution as such. The possibility for development of an Institution program presented itself when the late Mr. R. P. Scripps in December, 1937, donated the research vessel, "E.W.Scripps," to the University. With an adequate research vessel the work at sea could be planned according to problems as we see them, whereas work at sea based only on cooperation with other organizations could never become satisfactory because other wishes than

ours would enter when planning cruises.

The new vessel which made its first cruise early in 1938 could be used either for exploratory cruises extending over some of the large unknown areas of the Pacific Ocean or for intensive work in a smaller region. The latter alternative was selected because in an intensive study of a small area observations within physical and chemical oceanography and collections of biological material could be conducted on the same cruise, thus making possible the accumulation of data from many different fields which, together, would give a relatively complete picture and would make possible the cooperation of different specialists. In 1938 and 1939 the work at sea was of a preliminary nature. By making cruises off the coast of southern California in alternate months of 1938 and by completing in 1939 a long cruise extending from the Oregon border to Cedros Island off Lower California we obtained a fair knowledge of the character of the waters, the type of currents, the dominating populations, and the more outstanding annual changes within the sea off these coasts. In the fall of 1939 it was felt that we had sufficient preliminary information to plan more intensive cruises. Accordingly, during the spring of 1940, between March 6 and June 8 we completed in rapid succession six cruises, each covering an area between San Diego and the Channel Islands and extending to a distance of about 140 miles from the coast. We have procured a series of consecutive pictures of the currents and water masses within the area which had been selected and also of the characteristic populations of microscopic plants and smaller animals. By comparing these pictures we shall be able to follow the changes which took place from one cruise to another.

The study of these data requires the complete cooperation of specialists in physical and chemical oceanography and of those working with phytoplankton and zooplankton. It is as yet too early to express an opinion as to the results which may be obtained from the consecutive cruises of this spring, but the preliminary work has already resulted in certain gratifying results which illustrate the value of the cooperation. These are presented in two published articles, Contributions numbers 69 and 79.

During the past biennium definite progress has been made in the concerted attack on well-defined oceanographic problems and it is hoped that further developments will follow similar lines. Part of the work which has been mentioned so far has been done in close cooperation with the Federal Bureau of Fisheries and I can safely state that without the active cooperation of the Scripps Institution the Federal Bureau of Fisheries would not have been able to approach problems related to the sardine fisheries off the California coast in the efficient manner that has been made possible. Through our cooperation the Branch Office of the Bureau at Stanford University has been able to carry out, with the limited funds at its disposal, a program which without our cooperation would have involved five to ten times as great expense.

The activity of the Scripps Institution has not been limited, however, to the investigations which have been so far discussed. Several staff members have continued projects which have been in progress over a period of years, some of which are independent in their nature, others of which deal with questions which sooner or later will find their place in the common program. Of the latter I wish particularly to mention Mr. ZoBell's studies in bacteriology which have fundamental bearing on the entire question of the cycle of organic matter in the sea, and

Mr. Fox's studies in the biochemistry of marine organisms. Among the former I mention Mr. Sumner's work on the physiology of fishes, Mr. McEwen's studies of the interrelation between the ocean and the atmosphere and possible application to long-range weather forecasting problems, Mr. Revelle's work in the field of sedimentation and submarine geology, and the studies planned and supervised by F. P. Shepard of the University of Illinois dealing with sand movement along the beaches and the influence of waves and currents on such movements. In the study of distribution of sediments and processes of sedimentation results in physical and chemical oceanography have found application and valuable cooperation with the division of bacteriology has taken place. These lines of research will be continued, but at the same time it is hoped that closer contacts between the different specialists will continue to develop.

In these more special fields there has been much cooperation with other organizations. The study of fouling growth which is being conducted at the Institution by three scientists employed by the U.S. Navy has been actively furthered by Mr. ZoBell and his assistants. Mr. McEwen's work on the problem of long-range weather forecasting has been supported by the Department of Water and Power, City of Los Angeles, and a considerable public interest is shown in his work, as evident from the many inquiries received. In his report of last year's activities Mr. McEwen does point out, however, that a service of this nature should preferably be taken up by the U. S. Weather Bureau. The work of Mr. Revelle has been supported by grants from the Geological Society of America and their interest in the work is evidenced by a new grant in the amount of \$2500 which has been given for work planned by Mr. Revelle in the Gulf of California. The study of sand movement along the beaches has attracted the attention of the U.S. Beach Erosion Board which has placed currents meters at our disposal.

The instruction at the Scripps Institution has been limited to graduate instruction of students who have been working for higher degrees and who have been employed in some capacity at the Institution, thus participating in the general work. I record with pleasure the enthusiasm shown by these young men for the work at sea, the greater burden of which they have carried. In this connection it may be mentioned that during the *past one and a half years Messrs. Fleming, Johnson, and Sverdrup have* given much time to the preparation of a textbook, "The Oceans, their physics, chemistry and general biology." It is hoped that this book will appear at the end of 1940 or early in 1941 and will fill a longfelt need for an adequate textbook in oceanography.

During the biennium four members of the staff of the Institution, Messrs. Johnson, Revelle, Sumner, and ZoBell, have given courses on the Los Angeles campus. This work has been voluntary on the part of our staff members, but they have been encouraged to take over the duties in order to establish and maintain a closer contact with the Los Angeles campus. Their contribution appears to have been greatly appreciated by the departments in which they have given instruction.

In regard to the future I shall confine myself to a few statements concerning the Institution. In my opinion, the task of this Institution is primarily to promote the understanding of the events which occur in the ocean and to place whatever advances of our knowledge are made at the disposal of those who wish an answer to questions which have interested them or of those who can use the added information to facilitate any kind of enterprise of practical importance. From this point of view the research program of the Scripps Institution should be developed along the lines which have been followed/prior to and during the last biennium, and continued cooperation

between the specialists in the different branches should be encouraged. It is essential, however, that what advances in knowledge we can make shall reach the general public and those who are directly concerned with practical questions related to the sea. We shall therefore continue our efforts to interest the public by popular and semi-popular lectures, articles or addresses over the radio, hoping that in this manner we can build up an understanding of what we are attempting to do and can satisfy a general wish for exact information as to the oceans. We shall also continue our efforts to remain in contact with the organizations with which we now cooperate and shall be pleased to place at their disposal or the disposal of others what information we have available.

It is possible that the facilities of the Scripps Institution can be made more useful for teaching purposes than they are at the present time. It should particularly be examined if courses could be arranged for students who plan to enter the service of Federal or State investigation of fisheries, because the Institution has very adequate resources for offering <sup>special</sup> such instruction and for making students familiar with practical work at sea.

In concluding my report I wish to say that the Scripps Institution is fully aware of the fact that the disturbed world conditions may influence our future. Whenever called upon we hope to be able to submit proposals as to the best manner in which our facilities can be used if the efforts of research establishments have to be directed towards participation in a program of national preparedness and rational utilization of natural resources.

Respectfully submitted

H. U. Sverdrup  
Director

## APPENDICES

## I. RESEARCH ACTIVITY

Work at Sea -- The research vessel, the "E.W.Scripps," was laid up from September 1, 1939 to February 29, 1940 during which time the following major alterations were completed:

1. The bowsprit was cut off and the forward rail was built up approximately eighteen inches higher at the stem, tapering back to 6 1/2 inches higher at the forerigging.

2. In order to improve the ventilation of the hull the overhead panelling was removed from the aft below-decks accommodations. The beams were smoothed, corners taken off, and all interior was painted.

3. The storage batteries were completely rebuilt using the old cases and jars. The batteries were reinstalled with an eight-year guarantee for satisfactory service.

4. The fore gaff was removed and the foresail was cut to a leg-o'-mutton sail in order to provide for safer and easier handling.

The first two items were completed by the captain and one deck hand who were retained on board during the lay-up period.

At the beginning of the year 1939-40 cruise VIII which was made in cooperation with the Federal Bureau of Fisheries was completed. During this cruise the "E.W.Scripps" covered in all 5450 miles between May 10 and July 11, 1939. A total of 77 hydrographic stations were occupied along the coast between the Columbia River and Cedros Island, Lower California, and on six lines extending about 350 miles off the coast. In the northern portion of the area the program had to be curtailed because of bad weather. Hydrographic observations were taken to 600 meters where depths permitted and to 1200 meters at alternate stations. At four locations samples were

taken down to 3500 meters. In addition to routine observations for temperature, salinity, and dissolved oxygen, qualitative samples for phytoplankton were collected at 7 depths at each station, and net hauls made by the Bureau of Fisheries, after examination for sardine eggs and larvae, were turned over to the Scripps Institution for study of the zooplankton. On the part of the <sup>cruise</sup> to the south of San Diego, comprising 24 stations, Messrs. Roger Revelle and Sydney Rittenberg accompanied the vessel and made detailed depth profiles and obtained a number of sediment samples for chemical, bacteriological, and geological studies.

Cruise IX, August 5-18, 1939 was made in the southern California area under the direction of Mr. Revelle. The purpose of the trip was primarily to obtain bottom samples and to make current observations near the sea bottom with a new type of tripod current meter constructed at the Scripps Institution. A distance of 667 miles was covered and 45 bottom samples collected. At one station in a basin water samples and temperatures were taken down to the bottom at 1900 meters. Current observations were made at 7 stations for periods of from 6 to 36 hours.

During the spring and early summer of 1940 a cooperative investigation with the Federal Bureau of Fisheries was made in the southern California region. A close network of 40 stations was laid out and it was planned to make six cruises at as close intervals as possible in order to study the relatively short time-changes which might occur in the distribution of the currents, physical and chemical properties, phytoplankton, zooplankton, and sardine eggs and larvae. Various data pertaining to the cruises are given in the table. Temperatures and water samples for salinity and dissolved oxygen were taken at all stations and, in addition, samples for phosphate and phytoplankton, and net hauls were made at nearly all stations. Temperatures and water samples were always taken at



15 levels down to 600 meters, and in some cases observations were extended to greater depths. Phytoplankton samples were taken at 7 levels and usually two oblique net hauls were made. Samples for the study of nitrite-producing bacteria and determinations of the dissolved nitrite content of the water were made at selected stations on most cruises. The scientific party comprised two or three scientists from the Scripps Institution and three from the Bureau of Fisheries.

The captain of the "E.W.Scripps," Mr. Earle D. Hammond, deserves great credit for the successful completion of the different cruises, particularly the cruises in the spring of 1940, which were carried out on schedule in spite of weather conditions and an inexperienced crew.

Some data regarding Cruises VIII to XV are given in table 1.

TABLE 1

Cruises of the "E.W.Scripps" between May 10, 1939 - June 8, 1940

Cruise No.	Between dates	Distance covered. Nautical miles	No. hydro-graphic stations	No. bottom samples	No. stations with current measurements
	1939				
VIII	May 10 - July 11	5450	77	11	7
IX	Aug. 5 - Aug. 18	667	1	45	7
	1940				
X	March 5 - March 16	1165	37		
XI	March 20 - March 29	1057	32		
XII	April 4 - April 15	1191	39		
XIII	April 22 - May 4	1271	41		
XIV	May 10 - May 22	1148	42		
XV	May 27 - June 8	1163	39		
		<u>13102</u>	<u>308</u>	<u>56</u>	<u>7</u>

Physical Oceanography -- Research in physical oceanography and related fields has been conducted during the past year by G. F. McEwen and S. W. Chambers, assisted by R. D. Gordon, and by H. U. Sverdrup and R. H. Fleming, assisted by E. C. La Fond and Richard Tibby. Messrs. W. Gorczynski, W. C. Jacobs, L. Lek, and R. T. Young, Jr., have spent part of the year at the Institution engaged in different researches. In the summer of 1939 Mr. Walter Munk, a graduate student from California Institute of Technology, worked with H. U. Sverdrup. W. P. A. employees have rendered valuable assistance as computers, typists, and draftsmen, and have made possible rapid working up of field data so that these could at an early date be at the disposal of interested organizations.

Because of continued interest evidenced by correspondence with many individuals and representatives of various organizations Mr. McEwen continued the work of providing advance indications of air and sea temperatures and seasonal precipitation of Pacific coastal areas. As usual, advance indications were mimeographed in October for our mailing list and for the Press. Mr. Gordon made some progress in revising his preliminary approach to problems of rainfall cycles. The improvement involves random variations in phases, which for predicting has the advantage over the ordinary Fourier development that the quantities are given directly in terms of observations up to the time of prediction. In response to the general demand the U. S. Weather Bureau has continued for several years a critical examination of various long-range forecasting methods in use and has carried on special investigations of the forecasting problem. Quite properly, this Government agency should ultimately provide such forecasts. Long-range forecasts, even approximating to the high standards being realized in those for short periods, necessarily involve world-wide

observations and solutions of various complicated meteorological problems. This realization requires an extensive cooperative undertaking and no agency is better equipped for this than the Weather Bureau. Meanwhile, even the very meager service now being rendered by other agencies will likely continue in response to immediate requirements.

Since November, 1939 when the Polish climatologist, Dr. W. Gorczynski, began working at the Scripps Institution on his studies of comparative climates of California and other western states with sunny regions of Europe and Africa, most of the time and facilities of Mr. McEwen's division have been devoted to these climatic studies. This has involved a large amount of compilation and computing and preparation of many charts at a time of great reduction in clerical and other help. Mr. McEwen has collaborated in these climatic studies and has worked out certain technical problems of a statistical nature whose solution was needed. In particular, these have been concerned with errors and standardization of the precipitation ratio. It remains to prepare the results of these studies for publication. Among various proposed publications based upon Dr. Gorczynski's climatic investigations is a somewhat popular 200-page handbook on "California's sunny climates." The chapter outline already prepared has occasioned a good deal of interest in this project.

In order to facilitate numerical applications of statistical methods that he has devised and published for estimating the densities of bacterial populations in solutions, Mr. Gordon has prepared a five-page mimeographed paper entitled, "A shorter method of computation of the estimate of the mean and variance," which will serve until appropriate tables have been computed.

A problem arising in Mr. McEwen's formula for computing surface currents from temperature, referred to in the 1939 report, of estimating the error of a quotient has been worked out by Mr. Gordon. Extensive applications of the formula have been made to North Pacific observations, and the results are being assembled for publication.

Computations of turbulence and vertical velocity have been made from numerous sets of serial temperatures and salinity observations within ten miles of La Jolla and at various months within a ten-year period. Methods of computation developed earlier were used. Mr. Gordon has made progress in developing a more fundamental attack on the turbulence problem. His results do not seem too complicated for numerical application to ocean observations.

Methods developed earlier have been applied to various type problems involving the dispersion in three dimensions of suspended material concentrated near shores and settling at a constant rate.

Messrs. Fleming and Sverdrup have devoted the greater part of their time to the preparation of a textbook in oceanography. In connection with this work certain minor problems have been made the subject of studies the results of which are incorporated in published articles appearing in the list of Contributions from the Scripps Institution. A considerable amount of the routine study of data collected at sea and the observations of waves, currents and sand movements at the Institution pier have been carried out under the general direction of Mr. Fleming.

Mr. La Fond has assisted in the plotting, calculating, and compiling of hydrographic data from the different cruises and has, in connection with this work, prepared a set of simplified tables for the calculation of specific volume anomalies and has improved other tables used in routine computations. He has had the daily supervision of a

wave machine and a current meter at the end of the pier and has obtained daily records whenever weather conditions permitted. At the Institution pier, the Del Mar pier, and at Crystal Pier, he has taken a total of about 10,000 soundings for the study of sand movement on the beaches. Some of the results of the latter work are incorporated in papers which have been published or are in press.

Mr. Tibby, who has been employed as a part-time assistant, has analyzed the data from the "E.W. Scripps" Cruise VIII. In the spring of 1940 he took part in all six cruises and was in charge of the work of several of the cruises. Mr. Sverdrup participated in the first cruise of 1940 and Mr. Fleming and Mr. La Fond took part in portions of other cruises.

Mr. Woodrow C. Jacobs of the U. S. Weather Bureau worked for several months on problems in marine meteorology. Under the direction of Mr. Sverdrup he completed a study of the relation between the distribution of atmospheric pressure over the North Pacific Ocean and temperatures and sea level on the California coast (Contribution no. 78). He also prepared an article on the factors governing the distribution of microorganisms in the atmosphere (Contribution no. 76).

Mr. L. Lek from Holland who studied oceanography at the University of Berlin where he obtained his doctor's degree has been a visitor at the Scripps Institution since December, 1939. At the suggestion of Mr. Sverdrup he has started a study of the current through Drake Passage separating South America from the Antarctic Continent, with particular reference to the effect of the bottom topography on the course of the current. It is hoped to continue these studies in order to examine whether a steady flow can exist when a current flows over a submarine ridge, or whether eddies must develop. The problem is of fundamental importance because similar conditions are met with in many other parts of the ocean.

Mr. Walter Munk spent the summer of 1939 at the Scripps Institution and under the supervision of Mr. Sverdrup began a theoretical examination of the possible standing internal waves in a rectangular bay with sloping bottom. This problem had been suggested by the observations which were made in the Gulf of California in the spring of 1939 and which indicated the existence of such a standing wave of a period length of between 6.3 and 7.6 days (see Sverdrup, Contribution no. 109). The question was whether this period corresponded to one of the possible free periods of oscillations of the character indicated by the observations. Mr. Munk returned to California Institute of Technology, retaining his contact with Mr. Sverdrup, completed his study during the year and obtained his master's degree on the basis of a thesis dealing with this problem. By means of a numerical integration of his equations he was able to show that the free period of the observed oscillation was approximately seven days, in good agreement with the preliminary results.

Mr. R. T. Young, Jr., worked during the summer of 1939 designing and assembling an instrument for laboratory studies of absorption of light in samples of sea water. During the past year he has conducted a number of experiments with this instrument at Worcester Institute of Technology and he expects to return to the Scripps Institution in the coming summer to continue his work here.

Chemistry -- The work in the division of Chemistry has been in charge of E. G. Moberg assisted by John Lyman during the entire year and by Lynn Simpson and Karl Heusner during parts of the year. Miss Thelma Johnson has acted as secretary and has had, under the supervision of Mr. Moberg, charge of the great amount of clerical work related to the Works Progress Administration Project at the Scripps Institution.

Much of the work of this division has been routine required in connection with the investigations carried out by the "E.W.Scripps," that is, preparation of the necessary reagents for the determination of oxygen and supervision of the determination of salinity of the samples collected. Mr. Moberg took part in two of the spring cruises, and John Lyman in four. In connection with the above determinations about eighty pounds of silver nitrate have been prepared by John Cunningham of the W.P.A. from silver residues saved during the last two or three years.

Mr. Lyman has made further investigations of the buffer mechanism of sea water using the glass electrode for determining the hydrogen-ion concentration. This method had not previously been used in investigating this particular problem. The results obtained so far indicate that this method will lead to more accurate values of both the first and second apparent dissociation constants of carbonic acid in sea water. Together with R. H. Fleming he has completed a discussion of the composition of sea water (Contribution no. 93).

Analyses of the calcium content have been made of all the water samples collected by the "E.W.Scripps" in the Gulf of California and by the U.S.S. "Bushnell" between San Diego and Panama, and on a representative number of samples collected by the "E.W.Scripps" on the 1939 U.S. Bureau of Fisheries cruise. The results indicate that the Ca/Cl ratio is constant in all the regions investigated although we had suspected there might be a deviation in the upper part of the Gulf of California because of the chemicals carried down by the Colorado River.

Mr. Heusner has determined the organic nitrogen in practically all the bottom samples obtained on the "E.W.Scripps" cruises to the Gulf of California. The results indicate a very interesting correlation between nitrogen content and depth.

Evidence obtained some years ago indicated that the phosphate content of sea water might be used as a means of identifying water masses or water movements in the ocean. Evidence subsequently obtained locally and in the Gulf of California furnished additional information regarding phosphate as an indicator of the physico-chemical properties of the water, at least below the photosynthetic zone. Consequently, phosphate determinations were made on practically all of the water samples collected on the six cruises made by the "E.W.Scripps" during the spring of 1940. Although there has not yet been an opportunity to examine in detail the results from all of the cruises it can be said that below the photosynthetic zone the phosphate content can be used as an auxiliary, or even independent, indicator of water movements.

Sediments and Sedimentation -- The work of the division of Marine Sediments has been under the general charge of Mr. Roger Revelle. In addition to several W.P.A. workers, Messrs. H. Niederman, K. Herreschoff, K.W.Heusner and L.J.Anderson have acted as technical assistants in the laboratory during at least part of the year. Messrs. F.P.Shepard, K. O. Emery, and M. L. Natland have continued their respective studies of (1) shoreline processes, (2) the theory and practice of bottom core-collecting and of sediment-trap construction, and (3) of foraminiferal remains found in the sediments of the Scripps Institution collections. Messrs. *La Fond, Eittenberg*, and Anderson, and Mrs. L. Sorkness have carried on as graduate students various special research problems.

*As previously*, a large part of the work of the sediments laboratory has been the making of mechanical and partial chemical analyses of sediment samples in the collections of the Scripps Institution. In approximately 50 cores collected on the 1939 cruise of the "E.W.Scripps" to the Gulf of California the particle-size distribution, contents of



calcium carbonate, organic nitrogen, water and chloride have been determined at a series of ten or more depths within each core. Likewise, representative portions of the sediment samples collected in 1938 under the direction of Mr. Shepard have been analyzed, together with cores collected during the present year off the Lower California coast and in southern California waters by Mr. Revelle. The analytical work has been supported in part by a grant from the Geological Society of America, in part by other funds from outside sources, while the making of such a large number of analyses has been possible only because of technical assistance supplied by the Works Progress Administration.

Besides the above studies of the relationships between certain sedimentary characteristics and environments of deposition, considerable attention has been directed during the past year to investigation of sedimentary processes, particularly to problems of transportation of debris in the sea, and to physical and biochemical processes in sediments after deposition.

Problems of sediment transportation may be conveniently divided into two categories: the nature of transporting agencies, and the character of transported materials. In collaboration with Mr. Carl Johnson a tripod has been developed containing three Ekman-type current meters arranged one above the other, by which it has proved possible to measure the vertical distribution of velocity within a meter of the sea bottom in waters of considerable depth, without anchoring the ship. Six series of measurements for periods greater than twelve hours have been made in a variety of environments, including offshore banks, the mainland shelf, and the deep Santa Monica and Santa Cruz basins (see Contribution no.53). An unexpected feature of the results was the observation of velocities up to 15cm/sec at the bottom of the Santa Cruz basin, in waters 1900 meters deep and

nearly 1000 meters below the sill depth of the basin. With the aid of a grant of funds by the American Association of Petroleum Geologists, studies of the character of transported materials are being carried out by means of sediment traps placed near the bottom. The relative efficiency of different types of traps in capturing the sedimentary load of moving waters is being investigated as a fundamental part of this work, which is being carried on in collaboration with Messrs. Shepard and Emery. In the laboratory, studies of the process of coagulation of colloidal suspended materials by salts in sea water have been carried out in cooperation with Mrs. Sorkness. It has been found that the degree of coagulation varies directly with the concentration of suspended material, as well as with the concentration of dissolved salts.

Problems of physico-chemical and biological equilibria in marine muds have likewise been approached from several different aspects. Investigations of the distribution and activities of aerobic and anaerobic bacteria in cores have been carried out by Mr. Rittenberg who has also measured by means of a glass electrode the vertical distribution of pH in freshly collected cores of various types. Relatively high pH values, well over 9.3, have been observed in calcareous cores at depths of 100 cm or more beneath the surface, while values as low as 7.4 have been found in highly organic sediments. An attempt has been made to determine the amounts of iron sulfide in muds of different environments, but in only a few cases have determinable quantities been detected, even where  $H_2S$  was obviously present. In connection with studies of the sulfur cycle in marine muds a conductimetric titration method for the determination of sulfate, chloride and other dissolved salts in sea water and in interstitial waters of marine sediments has been developed, chiefly by L. J. Anderson.

Marine Microbiology -- Studies on the occurrence and importance in the sea of bacteria and other closely related microorganisms have been conducted by C. E. ZoBell assisted by Sydney C. Rittenberg and a number of W.P.A. workers. Mr. Rittenberg participated in the work of two of the cruises of the "E.W.Scripps" during July and August, 1939 and two during April and May, 1940. Mr. ZoBell worked on a cooperative microbiological project at the Woods Hole Oceanographic Institution during July and August, 1939 and visited several marine stations on the Atlantic Coast from Maine to Mississippi before returning to La Jolla in September.

It has been shown that there is a direct relationship between the amount of oxygen consumed by respiring bacteria and the amount of organic matter which is oxidized in sea water. There are enough bacteria in the sea to consume from 0.0013 to more than 2.4 cc of oxygen per liter per year, bacterial respiration being limited primarily by a lack of organic matter and solid surfaces. Bacterial respiration is increased by approximately 2.1 times for each 10-degree increase in temperature throughout the range of 0° to 30° Centigrade. The rate of oxygen consumption is independent of the oxygen tension until the latter is reduced to less than 0.3 cc per liter. Four papers summarizing these observations have been published and the investigations are being continued in an effort to elucidate further the cycle of organic matter and distribution of oxygen in the sea.

Continuing the studies on the factors which influence the occurrence and activity of nitrifiers, about 1000 water samples obtained from various "E.W.Scripps" stations are being analyzed for nitrifying bacteria and nitrite. A synthetic medium containing <sup>20</sup>/mg per liter of  $\text{NH}_4\text{Cl}$  has proved to be superior to the medium which others have recommended

for demonstrating nitrifiers. Low concentrations of organic matter do not inhibit nitrification and bacterial nitrification does not seem to be stimulated by light, contrary to the hypotheses of others.

A paper published on the microbiology of marine air (Contribution no.77) points out that the atmosphere contains some microorganisms wherever samples are analyzed, regardless of the distance from land or the prevailing direction of the wind. The characteristics of the microorganisms found appear to depend on the history of the air mass sampled. The data suggest the possibility of using microorganisms in the air as a meteorological tool for tracing air movements.

The analysis of several samples of sediments collected off the coast of Lower California and in the Channel Island region shows that the vertical distribution of both aerobic and anaerobic bacteria varies greatly (see papers submitted). The relation of the chemical and physico-chemical properties of the sediments to bacteriological activity has been investigated in cooperation with the sediments department. A range of pH 7.4 to pH 9.4 has been observed in freshly collected cores, sediments of large medium-particle-size being more basic in reaction in general than those of small particle-size. The influence of the salt concentration and the interstitial water content has also received attention. The effect of temperature, pH, oxygen tension, and salt concentration on the morphology and physiology of marine sulphate-reducing bacteria is under investigation. Variation of these factors has not resulted in spore-formation although heat-tolerance tests on raw cultures indicate that Vibrio desulphuricans may form spores in nature. The cultivation of these organisms in peptone media has shown that organic sulphur compounds may be utilized as hydrogen-acceptors in the absence of sulphate ions.

Methods for the collection and bacteriological analysis of water and sediments samples have been improved during the year. Mrs. Feltham has made comparative tests on nearly 200 different combinations of nutrients and one has been found which provides for the growth of forty per cent more bacteria than any previously used.

Phytoplankton -- The studies of phytoplankton have been conducted by W. E. Allen who has analyzed field data and by M. C. Sargent who has conducted laboratory experiments on the physiology of phytoplankton.

For the first time in twenty years Mr. Allen has been without the aid of a technical assistant or a direct associate. Nearly all of his time has been devoted to laboratory studies of the phytoplankton material collected by the "E.W.Scripps" on Cruise VIII of 1939 and those of 1940, also from pier catches of 1939. Aside from that he has given considerable time to survey of the records for twenty years of the catches of dinoflagellates (made daily except Sundays and holidays) at the Scripps Institution pier and at the Pt. Hueneme pier. Some progress was made in efforts to prepare a report on this pier material (Contribution no. 102).

For a considerable part of the year Mr. Allen has had good clerical assistance from a W.P.A. worker. This has been sufficient to keep the current routine almost up to date, but there is still an enormous amount of clerical work to do in condensing older records and distributing them in tabulations necessary for good understanding of their meaning. Preliminary stages of the clerical work were completed on about 1500 catches of phytoplankton.

During the past year Mr. Sargent's experiments of previous years on methods of cultivating and isolating phytoplankton organisms have begun to bear fruit. Three typical species of plankton diatoms have been brought into cultivation during the year. Observations on these and other

diatoms already in cultivation show that the productive capacity of a sample of sea water is different depending on which species of diatom it is seeded with, and that samples of sea water collected at different times or places, even when enriched with nitrate, phosphate, silicate, and iron, have different productive capacities. Whether these differences are due to the relative abundance of trace elements or of organic accessory growth factors, or to other factors is now the subject of investigation.

Last summer, with Ralph W. McCoy, and this spring the question has been investigated whether a reported inhibition of the photosynthesis of diatoms by bright sunlight was real or the result of some defect in the experimental technique. Although the nature of the defect is still in doubt the probability of its existence is enhanced by the successful experiment of cultivating diatoms in full sunlight where it is found that they grow with immense vigor. The importance of this result in oceanography is that it disposes of the possibility that the diatoms in the upper layers of the sea are constantly exposed to an extremely unfavorable, almost lethal factor.

With F. B. Sumner Mr. Sargent took part in a field trip to eastern Nevada in October to study the respiratory metabolism of warm spring fishes. He also participated in two of the hydrographic cruises in the spring of 1940 with the special purpose of estimating phytoplankton populations in terms of plant pigment units.

Zooplankton -- Regular members of the zooplankton division include Martin W. Johnson and a half-time research assistant, Mr. Charles Davis. Mrs. Sally Davis has been a regular research student in the division throughout the year, and on May 27 Miss Beatrice La Rue joined the division and is working on a research problem. Dr. W. R. Coe, an

independent investigator on marine invertebrates has shared space in the culture room, as has also Mrs. Bernadine Tschudy who is working on marine algae.

An additional laboratory room has become available by rearrangement of the dark room and it is being equipped with glassware, tables, etcetera.

The major work of the division has been concerned with a study of the zooplankton, its relation to external ecological conditions, and the life histories, taxonomy, and racial development of its members.

The field work for the year has consisted of participation in the spring cruises, Mr. Johnson taking part in the major portion of one, and Mr. Davis in one complete cruise and a portion of another. Much of the extensive plankton material collected by the Institution and in cooperation with the U. S. Bureau of Fisheries remains to be analyzed even as to special groups of organisms. The extensive material from the 1939 Cruise VIII has been partly analyzed as to copepods, and Miss La Rue is now assisting in examination of the Chaetognaths of this material.

From our own collections, supplemented by small samples obtained from Japanese workers on the Asiatic coast, a survey is being made with a view to learning the probable influence of the great clockwise current system of the North Pacific on the distribution and racial development of certain copepods (Contribution No. 79). Mr. Davis has completed a taxonomic report on marine copepods of the Northeast Pacific for his doctorate dissertation. Mrs. Sally Davis has continued her work on the life histories of local crabs and crab larvae collected off Lower California by the California Fish and Game Commission.

In addition, Mr. C. Monk and Mr. S. Brode, though not registered students, have been working on problems intended to lead to the doctorate degree under Mr. Johnson's direction. The first section of Mr. Monk's thesis is now in press.

A large part of Mr. Johnson's time has been devoted to preparation of the biological portion of a textbook in oceanography which is being written jointly with Messrs. Sverdrup and Fleming.

Physiology -- Upon his return in September from a year's sabbatical leave spent at Cambridge, England, D. L. Fox resumed charge of the division which had been temporarily under the supervision of M. C. Sargent. Beginning with March, 1940 Mr. Sargent, appointed to an instructorship with the opening of the academic year, took charge of a separate laboratory for studies of the physiology of phytoplankton. During the year Bradley T. Scheer was employed as a research assistant and Mrs. Lois Sorkness completed her work for the degree of M. S. under Mr. Fox's supervision. Mr. Scheer brought to a conclusion his studies pursued during the past two years on the nature, probable origin, and metabolism of carotinoid pigments in the California mussel. His report on this work constituted his dissertation for the Ph. D. degree which he obtained at Berkeley on May 25, 1940. He has modified and condensed the full treatment in preparation for publication. Mrs. Sorkness' thesis for the master's degree dealt with correlative studies of the rate of oxygen consumption by the mussel and the rate of its ciliary propulsion of water through the gill chamber (indicated by the rate of filtration of the diatom *Nitzschia* from the water) as both processes are influenced by temperature. A maximum rate of each process was evident at about 20°C, with decreases at higher and lower temperatures. A rather smooth parabolic relationship between rate of oxygen consumption and rate of water propulsion is evident between temperatures of 12°C and 30°C.



The following have conducted research work in the laboratories: W. R. Coe, Professor Emeritus of Zoology at Yale University, was in residence until April 1; Victor Schechter, Instructor in Biology, College of the City of New York, two weeks in the summer of 1939; H. J. Van Cleave, Professor of Zoology, University of Illinois, visited the Institution for six weeks in April and May, 1940.

Various members of the W.P.A. personnel provided valuable aid both to the resident staff and to visiting investigators in the performance of work of routine nature, such as typing, drafting, photography, translating, laboratory assistance, and the collecting and care of biological material.

Mr. Fox has made a separate detailed report to the President of the University and the Director of the Scripps Institution of his research while at Cambridge. Since his return he has done much writing for final publication concerning studies on the identity, relative quantities, and distribution of carotinoids, melanins and purines in sea anemones, jointly with Dr. C.F.A. Pantin at Cambridge; his work at Cambridge with Dr. Ralph Emerson, on both sexual differences and reproductive aspects of carotinoids in certain species of water fungi has recently been published in the Proceedings of the Royal Society of London (Contribution No. 87). In addition, a few experiments of a series begun in Cambridge in collaboration with J. F. Danielli were completed by Mr. Fox after his return to La Jolla. These concerned the chemical nature and surface-behavior of certain carotinoids at interfaces between immiscible fluids.

Currently Messrs. Fox and Scheer are investigating the kinds and quantities of carotinoid pigments occurring in a considerable number of classes, genera and species of local echinoderms to determine the possible existence of biochemical relationships between groups, as well as any correlations with environmental factors such as light, temperature, food.

Jointly with W.R.Coe and with assistance from Messrs. Scheer and Cunningham of the WPA, Mr. Fox is conducting growth-rate studies on the California mussel. Several hundred individuals representing separate size-groups are suspended in a wood and wire crate in the open sea at the end of a cable operated by a winch at the end of the pier. Monthly measurements of shell-length are made upon each individual. Observations since January, 1940 indicate a fairly rapid growth in the younger animals, slowing down in larger groups. Correlations will be made with temperature and phytoplankton data to be provided by other divisions, and calcium analyses of flesh and shell will, it is hoped, reveal any existing differences in calcium metabolism, related to the growth of shell on a quantitative basis.

Mr. Coe continued his studies on the biology of sex with special reference to sex reversal in certain worms and mollusks. He also completed his work on the revision of the nemertean fauna on the Pacific coasts of North, Central, and northern South America (Contribution No. 85). Mr. Schechter made some preliminary laboratory studies of regeneration in the mud-flat coelenterate, *Corymorpha*. Professor Van Cleave examined about 150 fishes representing some 30 or 40 local species, collecting, identifying and preserving worm-parasites from the gastro-intestinal tract and liver.

Biology of Fishes -- The laboratories were utilized continuously by F. B. Sumner and Peter Doudoroff. Mr. Sargent was engaged in work there for several weeks during the spring semester, and several members of other divisions made occasional use of the facilities. R. T. Young made extensive use of laboratory space and equipment throughout the year.

Several months during the summer and fall were consumed by Mr. Sumner in completing an extended study of the relation between the shade of the background and the development of black pigment cells in fishes.

Shortly thereafter he prepared, by invitation, a historical review of the subject, "Quantitative changes in pigmentation resulting from visual stimuli" (Contribution No. 98) for publication in the English journal, *Biological Reviews*.

In October Messrs. Sumner and Sargent made a second field trip of about two weeks in continuation of their studies of the physiology of warm-spring fishes. Two springs in eastern Nevada were selected for a study of acclimatization and metabolic rate in relation to temperature. These springs had temperatures of 37°C and 21°C, respectively. One species of fish of the "top-minnow" group was present in abundance in both of the springs. It was found that the metabolic rate, as measured by survival time in cyanide, was far higher in individuals inhabiting the warmer water than in ones inhabiting the cooler. This was in agreement with results obtained by the authors with fishes of another genus in western Nevada earlier in the year. It seems probable, therefore, that in nature fishes inhabiting warmer waters have a normally higher rate of oxygen consumption than ones of the same species inhabiting cooler waters. This is a point regarding which there was little previous information, although it was known that differences in the same direction could be produced in the course of short-time experiments in the laboratory.

Warm-spring fishes, after two days in cool water, could be returned with impunity to the warm water, whereas those native to the cool water died rapidly as a result of such transfer. Other evidence was encountered that these physiological adaptations of the fishes to different temperatures were to some extent fixed and were not effaced by brief exchanges of environment. The degree of fixity could not be ascertained, however, in the brief periods available for the experiments.

In view of previously known facts concerning the effects of temperature differences upon the formation of fats and oils by animals and plants, considerable numbers of fishes from the warm and cold springs were preserved and brought back to La Jolla for future studies of these substances. The problems here involved relate to such important aspects of physiological adaptation that a somewhat extensive excursion into this field seemed warranted. Accordingly, much time was devoted by Messrs. Sumner and Sargent during the second semester to work upon the fats, both from the fishes of the Nevada springs and from local marine fishes which had been subjected to temperature differences in the laboratory. It was the endeavor to extract and measure the total lipid content of each lot of fishes, and to determine the "iodine value" (indicative of degree of saturation) of these lipoids.

Thus far, most of the time has been employed in overcoming the rather great difficulties of biochemical technique, so that few definite results have yet been obtained bearing upon the effects of temperature. Some further improvements of technique will be necessary when these studies are resumed upon Mr. Sumner's return from his sabbatical leave.

The work of Mr. Doudoroff was concerned chiefly with some of the temperature relations of marine fishes. Two lines of investigation were undertaken. The more productive of these was a study of the tolerance of fishes for exceptionally high and low temperatures, and the changes of tolerance produced by acclimatization. Special attention was paid to cold tolerance and acclimatization to cold, subjects which have received very little attention from earlier investigators. Experiments on two species which are common in this locality (*Girella nigricans* and *Atherinops* sp.) have shown that these fishes are very sensitive to cold and are at least

as tolerant to high temperatures, or even more tolerant to them, than to low temperatures. This conclusion is in contradiction to that of earlier investigators, apparently because of the inadequate technique employed and the misinterpretation of available data by the earlier workers. Large changes of cold tolerance produced by acclimatization to high and low temperatures were demonstrated by Mr. Doudoroff, and were measured by accurate quantitative technique. Very interesting relationships between acclimatization temperature and time of death at various lethal low temperatures were discovered.

A second line of investigation to which considerable time was devoted but with less definite results related to the effects of temperature changes (as distinct from uniform temperatures) upon oxygen consumption.

Fouling of Submerged Surfaces -- During the year this investigation has been in charge of W. Forest Whedon assisted by R. T. Tschudy and J. C. Hindman. Studies concerned with the formation and development of film on submerged surfaces which were begun three years ago have been continued and expanded. On July 1, 1939 R. T. Tschudy was added to the staff of investigators and assigned to studies relating to the bacteriological and physiological phases of the problem. These studies have resulted in the collection of much data of great importance to a clear understanding of the manner in which submerged surfaces accumulate fouling growths. They have in addition supplied much valuable information pertaining to the factors underlying the functioning of toxic surfaces.

A series of chemical investigations have been conducted by Mr. Hindman to supplement the physiological studies and to obtain information concerning the composition of the films. The results have aided materially in the interpretation of the physiological and general biological findings.

Periodic examinations of a series of test panels and film samples from them were conducted throughout the first half of the year.

## II

## LIBRARY AND PUBLICATION OF PAPERS

The library has continued to be in charge of Miss Ruth Ragan who has also acted as secretary to the Director. Owing to shortage of personnel the work done in the library during the past year was considerably slowed down. The much appreciated assistance of Mrs. Bresler, librarian, and Miss Vertefeuille, typist, from the W.P.A. Project, ended with August, 1939. A new person with library experience, Mrs. Forester, was added on May 5, 1940, and she promises to be of much help in the future. For three months Institution funds provided for the half-time work of Miss Riva Bresler, a recent graduate of the University Library School.

The most important help Miss Bresler has given consists of (1) checking up the reclassification and recataloguing that has been done in the past two years; (2) preparation of a list of serial holdings for inclusion in the new edition of the Union List of Serials soon to be published and in which the Scripps Institution library has not previously appeared; (3) preparation of a similar list of bibliographies for publication by the Southern California Library Association. Progress in recataloguing was made by the completion of such publications as those of the International Council for the Exploration of the sea, the Great Barrier Reef and Discovery Expeditions, etcetera. Several thousand cards were filed which had been either previously made or recently checked. With Miss Bresler's help a scheme was devised for classifying general works in oceanography which will amplify the Library of Congress outline. Miss Bresler did an enormous amount of valuable work for the month and a half she spent in the library.

During the year the series, "Contributions of the Scripps Institution," was completed and thirty-five volumes represent the publications

from the beginning of the Marine Biological Station, 1893 to the end of 1937. Two volumes of the new series, 1938 and 1939, are also bound. Two hundred copies of the "Contributions" for 1939 were bound in paper covers for distribution among exchange organizations. A few volumes have been stored for institutions in warring countries. The collected papers of individual members of the staff have been bound to the end of 1939.

During the year about 640 volumes were accessioned with an approximate value of \$2650, two hundred fifty of these valued at \$790 being gifts and exchanges. Besides the bound volumes, in the neighborhood of six hundred serials were received by purchase and exchange.

List of Papers Published -- The following papers, "Contributions of the Scripps Institution," have been published since July 1, 1939;

	<u>No.</u>
Allen, W.E., Growth of a marine observatory. Intern. Revue d. ges. Hydrobiol. u. Hydrogr., Bd. 39, S. 464-471, 1939-	51
" - - Cut-throat competition in the sea. Scientific Mon., v. 49, pp. 111-19, 1939	58
" - - "Phosphorescence" in the sea. Nautical Gazette, 2 pp., Aug. 26.	74
" - - Life in a drop of sea-water. Turtox News, March, 1940, 3 pp.	86
Coe, W.R., Notes on the morphology and sexuality of the terrestrial Nemertean <i>Geonemertes palaensis</i> . Bishop Museum, Occasional Papers, pp. 205-11, 1940	80
" - - Revision of the Nemertean fauna of the Pacific coasts of North, Central and northern South America. Allan Hancock Exped., v. 2, pp. 247-323, Feb., 1940	85
Fleming, R.H., The control of diatom populations by grazing. Conseil Perm. Intern., Jour. du Conseil, v. 14, p. 210-27, 1939.	65
" - - , and Roger Revelle, Physical processes in the ocean. In: Recent Marine Sediments, A symposium, pp. 48-141, A.A.P.G., Tulsa, Oklahoma, 1939.	70
Fox, D.L., and C.F.A. Pantin, The biochemical basis of the colors of the plumose <i>Anemone metridium senile</i> . Anat. Record, v. 75, Suppl., pp. 135-36, 1939	51-A

	<u>No.</u>
Fox, D. L., and Ralph Emerson, Gamma-carotene in the sexual phase of the aquatic fungus <i>Allomyces</i> . Roy. Soc. London, Proc., Ser.B., no.852, v.128, pp.275-293, Feb., 1939.	87
Gordon, R.D., Estimating bacterial populations by the dilution method. <i>Biometrika</i> , pp.167-180, 1939. - - -	60
Jacobs, W.C., A discussion of physical factors governing the distribution of microorganisms in the atmosphere. <i>Jour. Marine Research</i> , v.2, pp.218-24, 1939. - -	76
- - Sea-level departures on the California coast as related to the dynamics of the atmosphere over the North Pacific Ocean. <i>Jour. Marine Research</i> , v.2, pp.181-94, 1939. - - - - - - -	78
Johnson, M. W., <i>Pseudodiaptomus</i> ( <i>Pseudodiaptallous</i> ) <i>euryhalinus</i> . A new subgenus and species of Copepoda, with preliminary notes on its ecology. <i>Amer. Microsc. Soc., Trans.</i> , v.58, pp.349-55, 1939. - - - - -	64
- - The correlation of water movements and dispersal of pelagic larval stages of certain littoral animals, especially the sand crab, <i>Emerita</i> . <i>Jour. Marine Research</i> , v.2, pp.236-45, 1939. - - - -	79
La Fond, E.C., and F. P. Shepard, Sand movements along the Scripps Institution pier. <i>Amer. Jour. Sci.</i> , v.238, pp.272-85, 1940. - - - - -	83
Revelle, Roger, and F. P. Shepard, Sediments off the California coast. In: <i>Recent Marine Sediments, A symposium</i> , pp.247-82, A.A.P.G., Tulsa, Oklahoma, 1939. - - - -	71
Rittenberg, Sydney, Investigations on the microbiology of marine air. <i>Jour. Marine Research</i> , v.2, pp.208-17, 1939. - -	77
Scheer, B. T., The development of the concept of tissue respiration. <i>Annals of Science</i> , v.4, pp.295-305, 1939. - -	62
- - "Homing instinct" in salmon. <i>Quart. Rev. Biol.</i> , v.14, pp.408-30, 1939. - - - - -	73
Sumner, F.B., Human psychology and some things that fishes do. <i>Scientific Mon.</i> , v.49, pp.245-55, 1939. - - -	50
- - and M.C.Sargent, Some observations on the physiology of warm spring fishes. <i>Ecology</i> , v.21, pp.45-54, 1940. -	81
- - Further experiments on the relations between optic stimuli and the increase or decrease of pigment in fishes. <i>Jour. Exper. Zool.</i> , v.83, pp.327-43, 1940 -	82



	<u>No.</u>
Sverdrup, H.U., Research within physical oceanography and submarine geology at the Scripps Institution of Oceanography during April 1938 to April 1939. Amer. Geophys. Un., Trans., pp.422-27, 1939. - - - -	63
- - Response of the medallist (Presentation of the Agassiz Medal to Harald Ulrik Sverdrup). Science, v.90, pp.26-27, 1939. - - - -	66
- - and W.E.Allen, Distribution of diatoms in relation to the character of the water masses and currents off southern California. Jour. Marine Research, v.2, pp.131-44, 1939. - - - -	69
- - Lateral mixing in the deep water of the South Atlantic Ocean. Jour. Marine Research, v.2, pp.195-207, 1939.	75
- - The currents of the Pacific Ocean and their bearing on the climates of the oceans. Science, v.91, pp.273-82, 1940. - - - -	84
- - Hydrology, Section 2, Discussion. B.A.N.Z. Antarctic Research Expedition 1921-31, Reports, Ser.A., v.3, Oceanography, part 2, pp.88-126, 1940. - -	91
Young, R.T., Jr., and R.D.Gordon, Report on the penetration of light in the Pacific Ocean off the coast of southern California. Scripps Institution Bull., tech.ser., v.4, pp.197-218, 1939. - - - -	61
- - , Measurements on the transparency of sea-water off the coast of southern California. Jour. Marine Research, v.2, pp.117-125, 1939. - - - -	68
ZoBell, C.E., Primary film formation by bacteria and fouling. Collecting Net, v.14, 2 pp., 1939. - - - -	67
- - Occurrence and activity of bacteria in marine sediments. In: Recent Marine Sediments, A symposium, pp.416-27, 1939. - - - -	72
- - , and Janice Stadler, The effect of oxygen tension on the oxygen uptake of lake bacteria. Jour. Bacteriology, v.39, pp.207-22, 1940. - - - -	88

Papers in Press -- The following papers by members of the staff are expected to appear in the near future:

Allen, W.E., Ocean pasturage in California waters. Scientific Mon.	89
- - "Indicator" values of phytoplankton at the Scripps Institution. Sixth Pacific Sci.Cong., Proc.	100

	<u>NO.</u>
Allen, W.E., Methods of collecting phytoplankton, of microscopic study, of assembling and filing data, and of preparation for reports at the Scripps Institution of Oceanography. Sixth Pacific Science Congress, Proc.	101
- - Summary outline of results of more than twenty years of research on marine phytoplankton at the Scripps Institution of Oceanography. Idem - - -	102
Fleming, R.H., Character of the currents off southern California. Idem - - - - -	103
- - Composition of plankton and units for reporting populations and production. Idem - - -	104
- - A contribution to the oceanography of the Central American region. Idem - - - - -	105
Fox, D.L., and C.F.A.Pantin, The colours of the plumose anemone, Metridium senile. Roy. Soc. London, Ser.B., Proc. -	95
Johnson, M.W., The study of species formation in certain Eucalanus copepods in the North Pacific. Sixth Pacific Science Congress, Proc. - - - - -	106
La Fond, E.C., Sand movements near the beach in relation to tides and waves. Idem - - - - -	107
Lyman, John, and R.H.Fleming, Composition of sea water. Jour. Marine Research, v.2 - - - - -	93
McEwen, G. F., Observations on temperature, hydrogen-ion concentration, and periods of stagnation and overturning in lakes and reservoirs of San Diego County, California. Scripps Institution Bulletin, technical series -	---
Monk, Cecil R., Marine Harpacticoid copepods from California. Amer. Microscopical Society, Trans. - - - - -	---
Sargent, M.C., A theoretical definition of productivity. Sixth Pacific Science Congress, Proc. - - - - -	108
Sumner, F.B., The naturalist as a social phenomenon. American Naturalist. - - - - -	97
- - Quantitative changes in pigmentation, resulting from visual stimuli. Biological Reviews. - - -	98
Sverdrup, H.U., On the annual and diurnal variation of the evaporation from the oceans. Jour. Marine Research, v.2	90
- - Research within physical oceanography and submarine geology at the Scripps Institution of Oceanography during April 1939 to April 1940. Amer. Geoph.Un.,Trans.	94

	<u>No.</u>
Sverdrup, H.U., The Gulf of California. Preliminary discussion of the cruise of the "E.W.Scripps" in February and March, 1939. Sixth Pacific Science Congress, Proc.	109
- - The Scripps Institution of Oceanography from 1933 to 1938. Idem - - - - -	110
- - and R. H. Fleming, The waters off the coast of southern California, March to July, 1937. Scripps Institution, Bulletin, tech. ser. - - -	---
- - and Staff, Oceanographic observations on the "E.W.Scripps" cruises of 1938. Scripps Institution, Records of Observations, no.1 - - -	---
ZoBell, C.E., and Jean Conn, Studies on the thermal sensitivity of marine bacteria. Jour. Bacteriology, - -	92
- - Some factors which influence oxygen consumption by bacteria in lake water. Biol. Bull. - - -	---
- - and Janice Stadler, The oxidation of lignin by lake bacteria. Archiv für Hydrobiologie - - -	---

Papers Submitted for Publication -- The following have been

submitted for publication:

- Emery, K.O., and R.S.Dietz, A new marine coring instrument and a discussion of the mechanism of sediment coring.
- Gordon, R.D., The maximum likelihood criterion of Fisher versus the Bayes-Laplace formula of inverse probability.
- Rittenberg, Sydney, Bacteriological analysis of some long cores of marine sediments.
- Scheer, B. T., Some features of the metabolism of the carotinoid pigments in the California sea mussel (*Mytilus californianus*).
- Shepard, F.P., Non-deposition environments off the California coast.
- Sverdrup, H.U., Research in oceanography.
- ZoBell, C.E., The effect of oxygen tension on the rate of oxidation of organic matter in sea water by bacteria.

## III

## INSTRUCTION AND STUDENTS

The following graduate students have been registered during the year:

		<u>Degrees Conferred</u>
C. C. Davis	throughout the year	Ph.D., University of Washington
Sallie May Davis	throughout the year	
Peter Doudoroff	throughout the year	
R. D. Gordon	summer, 1939, first semester	
E. C. La Fond	two semesters	
Beatrice La Rue	May 26 - June 30, 1940	
John Lyman	throughout the year	
Walter Munk	summer, 1939, June 11-30, 1940	M.S., California Institute of Technology
Sydney Rittenberg	throughout the year	
Bradley Scheer	throughout the year	Ph.D., University of California
Lois Sorkness	first semester	M.S., University of California
R. B. Tibby	throughout the year	

Instruction to the graduate students has been given in the form of conferences and reading assignments and, in addition, a weekly seminar has been conducted during which members of the various divisions in rotation have presented results of their work or reviewed literature pertaining to their special field.

## IV

## VISITORS

Visiting investigators during the year, with the subjects upon which they worked, were as follows:

- Dr. J. Bjerknes, Geophysical Institute, Bergen, Norway - Lectures and conferences in meteorology. December, 1939, January, 1940.
- L. Bostwick - Experiments in culture of pearls from abalone. Throughout the year.
- Dr. L. F. Byars, University of Colorado - Library studies. Oct. 16 - Dec. 15, 1939.
- Dr. W. R. Coe, Dept. Biology, Yale University - Studies on sexual phases of marine mollusks. July 1, 1939 - May 1, 1940.
- Dr. Roy W. Drier, Michigan College of Mining and Technology - Library studies. Summer, 1939.
- K. Emery, Dept. Geology, University of Illinois - Assistant to Dr. F.P. Shepard. Summer, 1939, Feb. 6 - June 30, 1940.
- Dr. W. Gorczynsky, Government Climatologist, Poland - Comparative studies of climate of California and other western states with sunny regions of Europe and Africa. November, 1939, to June 30, 1940.
- W. C. Jacobs, U. S. Weather Bureau - Marine meteorology. July 1 - Oct. 10, 1939, June 26-30, 1940.
- Dr. J. P. Jacobsen, Service Hydrographique, Charlottenlund, Denmark - Conferences on chemistry of sea water, 1939.
- Dr. L. Lek, Netherlands - Investigations in physical oceanography. Dec. 7, 1939, to June 30, 1940.
- Dr. Ralph McCoy, University of Idaho - Photosynthesis of diatoms. July 1, 1939 to Aug. 15, 1939.
- M. L. Natland, Richfield Oil Company - Studies on foraminifera found in Scripps Institution collections. Various times through the year.
- Dr. Victor Schechter, College of the City of New York - Regeneration in Corymorpha. July 7 - 29, 1939.
- Dr. O. E. Sette, U. S. Bureau of Fisheries - Conferences on cooperation with the Scripps Institution. Various times through the year.

- Dr. F. P. Shepard, Dept. Geology, University of Illinois - Studies in submarine geology. July 5 - Aug. 10, 1939, March 10 - June 30, 1940.
- Dr. E. M. Thorp, U. S. Soil Conservation Service - Studies of calcareous remains in shallow-water sediments collected in the Gulf of California. July 1 - August 31, 1939.
- Mrs. Bernadine Tschudy, La Jolla - Marine algae. Throughout the year.
- Dr. H. J. Van Cleave, University of Illinois - Worm parasites in fishes. April 16 - June 1, 1940.
- Dr. L. A. Walford, U. S. Bureau of Fisheries - Conferences on cooperation with the Scripps Institution. Various times through the year.
- Dr. R. T. Young - Investigations in marine biology. Throughout the year.
- Dr. R. T. Young, Jr., Worcester Polytechnic Institute - Absorption of light in sea water. July 1 - Aug. 15, 1939.

## V

## MUSEUM AND AQUARIUM

Museum -- The matter of legible labels for the museum specimens has always been somewhat of a problem. To overcome this the Curator procured a hand-printing press and several fonts of type. During the year the task of replacing all the old typewritten labels with type-printed labels was almost finished. Several impressions were made of each label so that discolored cards may be replaced when necessary.

In order that visitors may know the type of scientific work carried on at the Institution a permanent exhibit has been installed in one of the large showcases of the museum. This exhibit illustrates the work by means of subject cards, published papers, photographs, graphs, etcetera.

An additional showcase, three feet by eight, was installed with mounted specimens of three large fishes: A yellowtail (*Seriola dorsalis*), a runner (*Elegatis bipinnulatus*), and a luvar (*Luvarus imperialis*), a very rare fish recently caught in these waters. Several other large fish specimens were prepared and will be placed on exhibit in the near future.

There were 6,822 visitors to the Museum who signed the register.

Aquarium -- The large tide-pool tank was entirely rebuilt and lined with rock-work. The old tank was one of those purchased on contract fifteen years ago, and which cracked soon after installation. In order to get some use out of it and as an experiment, it was used as a tide-pool aquarium with simulated wave action, and it proved to be one of the most interesting tanks in the aquarium. In replacing it, it was thought best to continue the tide-pool effect. However, in construction it was so built that it may be used as a large aquarium if necessary.

The skylights of the aquarium were in a dilapidated condition, broken frames and glass, all of which had to be replaced. The material and part of the labor was paid for from the Aquarium budget and some of the labor came from the W.P.A.

The interior appearance of the aquarium was made much better by the placing of nineteen frames with glass fronts, one above each tank, to hold the descriptive labels, all of which had to be reprinted.

During the year there were over 2035 fishes exhibited in the aquarium, representing about 45 species, also many invertebrates and seaweeds.

Other Activities -- Over 800 fishes and marine invertebrates were furnished for scientific work. A much-needed large heavy casting

table and a machine-tool bench were made for the casting room. A large amount of time was spent on the shell, seaweed and other research collections of the Institution.

## VI

### WORKSHOP

In 1937 facilities and certain tools were provided out of the scientific budget of the Scripps Institution for the establishment of a metal-and woodworking shop. Since that time an appropriation of \$100 per year has been provided for the purchase of smaller tools and expendable material, and in addition special allotments have been made to obtain more expensive pieces of equipment. Mr. Carl Johnson has been in charge of the shop under the general supervision of R. H. Fleming.

The original purposes of the workshop were to construct apparatus and instruments from designs prepared by members of the scientific staff and to remodel and repair research equipment of various kinds. These ends have been attained and the workshop has proved to be a tremendous benefit to the Institution. Not only can the work be done at a considerable saving, but it is a great convenience to have it done on the campus where there can be close supervision and cooperation in design and construction.

A record of the time spent by Mr. Johnson on the work requested by the scientific staff has been kept for the past three years. This averages about 560 hours per year or approximately 25% of his time.

The success of the project is in no small part due to the skill and inventiveness of Mr. Johnson who uses the available tools and materials to the greatest possible advantage. He has constructed many complicated and original pieces of equipment that are unobtainable on the open market and, in addition, many instruments have been remodeled to make



them more appropriate for the work of the Institution. The establishment of the workshop has provided facilities for the better care of the permanent equipment of the buildings and grounds. Furthermore, a carpenter assigned to the W.P.A. Project for assistance in constructing laboratory and office equipment has been able to do more and better work because of the available woodworking tools.

It is impossible to list the numerous pieces of equipment built by Mr. Johnson and the time spent in the remodelling and maintenance of scientific equipment. However, the total time, namely, about 560 hours per year, which has been devoted to this work indicates its importance and it should be pointed out that the work could not have been done on the campus without the facilities provided in the workshop.