General report

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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 1937-38. An appendix to this report, giving detailed information about various phases of the activity at the Institution, will be submitted in the near future.

Personnel — On May 16, 1938, the Institution suffered a great loss by the death of Dr. Fred Baker, honorary curator of mollusks, who had been active in the first organization of the Institution and who had always retained his sincere interest in our activities. It is a honor to take this occasion to pay a tribute to Dr. Baker for his unselfish efforts in furthering the organization and development of the Institution from a modest beginning to its present internationally recognized position.

On September 1, 1937, Dr. F. F. Shepard, Associate Professor of Geology at the University of Illinois, was appointed Research Associate in Oceanography. The arrangement was made to make it possible for Dr. Shepard to obtain the greatest benefit of a research grant of $10,000 which had been made him by the Geological Society of America to conduct studies in submarine geology off the coast of southern California. Otherwise, no changes occurred within the scientific staff of the Institution.

I am pleased to report that Dr. C. E. ZoBell was awarded a fellowship from the Scandinavian-American Foundation, and he was also awarded a Research Post-Doctorate at the University of Wisconsin. He will avail himself of the latter during the academic year 1938-39 when he has a sabbatical leave. I am also pleased to report that Dr. D. L. Fox has been awarded a fellowship from the Rockefeller Foundation which will make it possible for him to visit Cambridge, England, in 1938-39 when he will be absent on sabbatical leave.
Research vessel — The facilities of the Scripps Institution
were greatly increased when Mr. R. P. Scripps, on December 17, 1937,
presented to the Regents the vessel E. W. SCRIPPS, which had been
remodelled and equipped for oceanographic work. The E. W. SCRIPPS has
been in commission since January 1, 1938, and has now made three cruises
in the waters off southern California for studying physical, chemical
and biological conditions, and three cruises for study of submarine
geological features conducted by Dr. Shepard. During these cruises the
vessel has been found entirely satisfactory and the equipment and arrange-
ments on board convenient and practical. The vessel appears to be ideally
suited for the purposes of the Institution since it is large enough to
make possible cruises of any desired extent and not so large that main-
tenance and operation become prohibitively expensive. The results obtained
during the first cruises, to which reference will be made in the appendix
to this report, are very promising and make us look forward with increased
interest towards the continued operation of the vessel.

Laboratories and library — The only major alteration which has
been undertaken within the laboratories consisted in the replacement of
the refrigeration system by more efficient and sturdy units. During the
year 1937-38 the Institution has had so many visitors that all laboratory
space has been in use. In the library the number of bound volumes has
increased from 14910 to 16125. Thanks to the cooperation of the Works
Progress Administration Library Project in San Diego, it has been possible
to bind a large number of volumes the binding of which we could not other-
wise have afforded. Thanks to the same project, a recataloguing of the
library has been commenced, changing from the present system to the
Library of Congress system which is used in the University libraries at
Berkeley and U. C. L. A. This change and other minor changes in handling library matters are making the library more useful to the Institution.

Research activities -- Detailed accounts of the research activity is given in the appendix to this report. In this place it will merely be mentioned that, thanks to the new facilities presented by the E. W. SCRIPPS, a systematic attack has been commenced on the hydrographic and biological problems off the coast of southern California. Repeated cruises show that a certain pattern of water masses is present in all seasons and it is believed that this pattern reflects itself in the distribution of organisms. Some evidence to this effect has already been gathered. A common program is now in progress in which a group of the physicists, chemists, bacteriologists, and marine biologists are participating. Besides these studies, work continues with larger oceanographic problems and with special questions in marine biology.

The research activity has been greatly stimulated by the many visitors to the Institution.

Cooperation with other organizations -- During the past year the Scripps Institution has cooperated with the Bureau of Construction and Repair of the United States Navy in a study of organisms which cause fouling of ships' bottoms. The Bureau of Construction and Repair engaged Mr. F. W. Whedon and paid for his supplies, while the Institution placed laboratory space at his disposal. I am pleased to report that the Bureau finds Mr. Whedon's first results so promising that next year he will obtain an assistant and his budget for supplies will be increased.

Much valuable assistance has been received from the Works Progress Administration project in operation at the Institution.
Publications -- During the year about forty-eight papers have been published by members of the staff and visitors. Beginning with January 1, 1938, all scientific papers approved by the Director will be numbered and published as "Contributions from the Scripps Institution of Oceanography. New Series." In this new series twenty are published or in press, and eight have been accepted for publication.

Instruction -- In the summer session of 1937, an upper-division undergraduate course, Introduction to Oceanography, was offered at the Scripps Institution as part of the summer session program of U.C.L.A. The same course will be offered in the summer of 1938, but since the attendance has been small the course will probably be discontinued and, instead, a course in oceanography may be offered at U.C.L.A. during alternate semesters in cooperation with the Geography Department. A small number of graduate students are working at the Institution, one or two of whom hope to obtain a degree in oceanography, others planning to obtain their degree in some other department of the University with which the Institution cooperates.

Closer coordination with U.C.L.A. has been established since in the first semester of 1937-38 Dr. Johnson conducted a course in "Invertebrate zoology", and in the second semester Dr. ZoBell conducted a course in "Soil bacteriology," and Dr. Sumner a seminar in "Genetics." Dr. ZoBell has also conducted a course in "Clinical bacteriology" for the University Extension division in San Diego.

Lectures and attendance at scientific meetings -- During the year members of the staff have attended scientific meetings on the west coast and presented a number of papers. A considerable number of public lectures have been given for various organizations in southern California, especially by Messrs. Fleming, Fox, Sverdrup, and ZoBell.
Visitors — Reference has repeatedly been made to the many visiting scientists which the Institution has had during the year. Detailed information will be found in the appendix to this report.

The Museum and Aquarium have, in the course of the year, been visited by more than ten thousand persons.

Buildings and grounds — In last year’s report it was mentioned that a gradual abandonment of the housing facilities on the campus had been proposed, since several of the cottages which had been built as temporary structures could no longer be maintained. During last year a new policy has, however, been adopted. The cottages will in the near future be dealt with as a separate part of the University’s property and all rentals from cottages will be applied toward maintenance and improvements. A sum has been allotted by the Regents for immediate improvements and this sum will be repaid over a period of years. The adoption of this plan has caused great satisfaction among the members of the staff and other employees of the Institution, and it is believed that this step will place the housing on a sound economic basis and will mean a permanent betterment of the living quarters.

Attention must again be drawn to the fact that the wooden bulkhead in front of the Institution’s property is rapidly deteriorating. Conditions are now critical, since the soil inside the bulkhead has been washed out and at any great storm large portions of the bulkhead may be torn away. Replacement by a concrete bulkhead is urgently needed. Attention must also be drawn to the dangerous condition which the Institution’s pier approaches. Irreparable damage may result if the restoration of the pier is not made within the next year or two.
Financial outlook — In 1937-38 the Institution had larger funds at its disposal than in any previous year, thanks to the generosity of Mr. R. P. Scripps and the cooperation established with Dr. F. P. Shepard in regard to his studies of submarine geology. Mr. Scripps contributed $9,000 towards the operation of the E.W.SCRIPPS and gave a special contribution of $2,500 for development of a deep-sea coring apparatus. Further funds for keeping the E.W.SCRIPPS in operation throughout the year were obtained through the arrangement with Dr. Shepard who paid the expenses during the time the vessel was at his disposal for his special investigations. In 1938-39 the trustees of the Ellen B. Scripps Foundation which will be created by the will of Mr. R. P. Scripps have promised to contribute half of the operating expenses of the vessel ($9,500) in addition to a contribution of $15,700 to the regular activities of the Institution. The financial outlook for 1938-39 is, therefore, bright provided that the University finds it possible to match these contributions. From July 1, 1939, the above-mentioned contributions from the Scripps family will, however, probably be reduced to less than half ($10,000 - $12,000). After July 1, 1939, the expenses for operation of our vessel can probably be reduced by $8,000 or $9,000, since the interests of the Institution will not make it necessary to have the research vessel in commission throughout the year. This possible reduction of expenses is, however, less than the expected reduction of the contributions from the Scripps family. If the activity of the Institution is not to be seriously handicapped it will, therefore, be necessary to find means of increasing the income either by increased contributions of the University or by obtaining funds from other sources. The latter possibility will be examined as early as possible. It is sincerely hoped that the budget of
the Scripps Institution can be retained at such a level that continued operation of the E.W.SCRIPPS will be possible, since in oceanography work at sea is of the same importance as the work in the laboratories.

Respectfully submitted

[Signature]

H. U. Sverdrup
Director

RR
APPENDIX

I. Research Activity

a. Physical oceanography — Research within physical oceanography has
been conducted by G. F. McEwen, assisted by R. D. Gordon, and by R. H.
Fleming and H. U. Sverdrup, assisted by E. C. Le Fond. Under the super-
vision of G. F. McEwen, averaging and plotting by months and quadrangles
of sea-surface temperatures observed by navigators of various steamers
in the Pacific Ocean have been continued.

Detailed records of the meteorological observations at the
Scripps Institution pier presented in systematic form have been mimeographed
(510 pages per volume). A summary of these results has been prepared for
mimeographing (about 30 pages).

After some interruption work on the topographic map of the ocean
floor and some adjacent land along the eastern Santa Barbara coast was
resumed. The area included is about 30 miles east and west by 20 miles.

During the summer of 1937, R. T. Young, Jr., of Worcester Poly-
technic Institute, made an instrument for measuring the transparency of
sea water, and Mr. Gordon collaborated with him in preparing a paper
reporting results of radiation studies by means of an apparatus previously
prepared by Mr. Young.

The Works Progress Administration Project sponsored in 1935 by
the University of California for evaluating oceanographic data reported
by ships since 1924 and begun in April, 1936, has continued. It is under
the general superintendence of the Director of the Scripps Institution
and supervised by the Officer in charge of the Branch Hydrographic Office
in San Pedro. Arrangement has been made with the United States Hydrographic
Office for the final coding sheets to be kept at the Institution for use in
various studies of ocean surface conditions, in particular for investigating
variations in the Japan Current.

Investigations were continued of trends of air-and sea-surface
temperatures of the southern California area for the purpose of providing
advance temperature indications. Also the investigation of advance indices
of the seasonal rainfall of the Pacific Coast have continued. Our correspon-
dence shows continued interest in both of these projects. To meet a popular
request for general information regarding this work, G. F. McEwen published
a three-page paper entitled, "Seasonal forecasts of California weather," in
the California Monthly for November, 1937.

Mr. Gordon has nearly completed a study of the random errors
committed in the direct computations of surface currents between two points
by means of surface temperatures. The formulas connecting the currents
with surface temperatures were derived by McEwen.

Theoretical studies are under way which it is hoped may throw
light on the mechanism involved in the maintenance of the typical temperature
distributions of the deep waters of mid-ocean.

R. H. Fleming and H. U. Sverdrup, assisted by E. C. La Fond,
technical assistant, have devoted most of their time to the discussion of
the data which were collected during the BLUEFIN cruises in the spring and
summer of 1937, and during the first cruises with the E. W. SCRIPPS. Fleming
took part in two of the latter cruises and Sverdrup in all three of them.
The discussion of the BLUEFIN data has been nearly completed and the necessary tables, charts, and diagrams prepared. Some of the results from the BLUEFIN cruises were presented by Sverdrup in his Faculty Research Lecture on March 23, and others in a short paper on the process of upwelling. The BLUEFIN cruises showed a typical pattern of water masses and currents off southern California. The cruises of the E. W. SCRIPPS in 1936 confirm the existence of such a pattern.

Studies of the oxygen distribution off the coast led Sverdrup to a consideration of the general conditions which govern the distribution of oxygen in the sea and to the preparation of a paper dealing with this question.

Fleming has continued his work with the HANNIBAL material from the Panama area, and has two papers ready for publication. With the assistance of Mr. LaFond he has prepared tables of the U.S.S. HANNIBAL temperature and salinity observations for 1936, which with accompanying text have been submitted to the Hydrographic Office of the United States Navy. With Revelle, Fleming has prepared a paper on physical processes in the ocean for publication in a Symposium on Recent Sediments, edited by Parker D. Trask and published by the American Association of Petroleum Geologists.

In addition to the assistance in the work mentioned above, Mr. LaFond has been engaged in current measurements at the end of the pier, using an electrical current meter. He has also undertaken or supervised studies of beach and bottom profile along the length of the pier, using an easily operated sounding machine by means of which over ten thousand soundings have been made. For the study of the period and height of waves he has developed an instrument which gives a continuous record
during a short period of each day. The relation of mean sea level to the
surface temperature, the solar radiation, the tides, and the movement of
the sand, has been examined, comparisons have been made between varia-
tions of the mean sea level and variations of the distribution of density
off the coast.

W.C. Jacobs, meteorologist of the United States Weather
Bureau, visited the Scripps Institution from June to September, 1937,
during which time he was engaged in a discussion of the meteorological
observations obtained on board the CARNEGIE in 1928-29.

H. R. Seiwell of the Woods Hole Oceanographic Institution
was at the Institution from the middle of January to the end of April.
He took part in the April cruise of the E. W. SCRIPPS, but he was mainly
engaged in discussion of data from the Atlantic Ocean which he had
brought with him in order to have the benefit of the advice from members
of the staff.

Several papers have been presented at scientific meetings and
a number of popular lectures have been given.

Application of statistical methods to biological problems —
Sufficient formulas have been deduced by Mr. Gordon for the numerical
determination of geometric mean estimates of bacterial densities on the
basis of results of successive dilution technique. The formulas are
based on Bayes' principle and are intended to replace tables prepared
by Halvorson and Ziegler which give the corresponding modes and which
have been shown to be unsatisfactory. An essay is under preparation
explaining the adoption of the classic Bayes-Laplace formula as a basis
in preference to the Maximum Likelihood criterion which seems to be in
favor among certain groups of statisticians.
A preliminary problem of probability distribution has been solved by Mr. Gordon and the solution interpreted in terms of visual discrimination. The discrimination data for Brodhun's eye (obtained from a paper by Hecht) were fitted to this interpretation as a test with promising results, taking into consideration the probable chemistry of visual sensitivity. These studies are preliminary to a projected attempt to develop a dynamical theory of the schooling behavior of fish, which it is hoped may prove a valuable aid in estimating relative population densities of schooling species of fish, such as sardines, on the basis of fishing records.

Chemistry -- The studies in marine chemistry have been conducted by E.G. Moberg, assisted by John Lyman. In accordance with a program initiated about fifteen years ago, water samples collected from two depths at the Institution's pier at least twice a week have been analyzed for chloride, titratable base, hydrogen ions, and certain plant nutrients. This year the program was augmented by including routine determinations of organic (Kjeldahl) and ammonia nitrogen. Many of the results of previous pier water analyses have been averaged and plotted with a view to preparing a report on the daily, seasonal and year-to-year variations of certain of the chemical constituents of the water near shore.

In connection with the investigation of the circulation off the southern California coast (see p.2 ) determinations of salinity and of oxygen were made on about 500 serial water samples collected on the last of the three cruises of the California Fish and Game Commission's vessel BLUEFIN and a similar number the first and third cruise of the E. W. SCRIFFS. On the second cruise of the E. W. SCRIFFS, only about
200 samples were obtained because of unfavorable weather conditions. On the latter cruises the samples were analyzed also for phosphate in the hopes that this substance would serve as an additional index of the origin of water masses, as well as an index of the plant nutrient content especially in the upper water layers. Data on temperature, salinity, oxygen, and phosphate obtained at about sixteen depths at each of eleven stations occupied by the U.S.S. LOUISVILLE and MINNEAPOLIS between the California coast and the Hawaiian Islands in November and December, 1936, have been reduced, arranged for publication, and submitted to the United States Hydrographic Office. Practically all of these stations were located at positions where the CARNEGIE made observations in 1929 and the results from the two sets of stations have been compared and found to be in good agreement.

Although nitrate occurs in sea water in exceedingly small quantities and therefore may easily be one of the factors limiting plant growth, relatively little is known concerning its distribution and variation with season, locality, etc. for any part of the sea. This is because a satisfactory method for its determination has been lacking. A few years ago W.R.G. Atkins of the Marine Biological Laboratory of Plymouth proposed a new nitrate method, using diphenylbenzidine as reagent, and with this method Dr. Stina Gripenberg and Mr. John Lyman have recently made a number of experiments in this laboratory. The results so far do not warrant any definite conclusions, but they indicate that with slight modifications the method can be used for accurately rapidly determining the amount of nitrate in sea water.

Mr. Lyman has made further studies of the buffer mechanism of sea water, a subject investigated at this Institution for a number of years. Mr. John Cunningham has prepared a paper on the iodine content
of sea water based on the results of analyses, of both surface and subsurface water, made last year.

**Sediments and sedimentation.** -- During the absence of Roger Revelle until the first of October, the work of the Sediments laboratory was in charge of R. H. Fleming. For most of the year the work carried on has been in collaboration with the project of the Geological Society of America under F. P. Shepard.

Since January, Mr. Howard Niederman has been technical assistant in charge of the making of mechanical analyses on a project of the Geological Society of America. Also, Miss Edna Caney has, since January, been employed as technical assistant.

Messrs. F. M. Varney and Lowell Redwine, research assistants in this laboratory, have been primarily concerned with the development of an instrument to obtain long cores of sediments from the sea bottom in both shallow and deep water, making use of the hydraulic pressure of the water itself.

Dr. Stina Grippenberg, of the Oceanographic Institute of Helsingfors, has been a visitor at the Institution most of the year, as Fellow of the American Association of University Women. Her work has been primarily concerned with sedimentation problems.

Mrs. Eric G. Moberg has been a volunteer worker in this laboratory several months of the year, engaged in studying the relative amounts of pelagic foraminifera in sediment samples from southern California regions.

In addition, the section has employed two skilled WPA workers in the systematic filing and classification of the Institution's collection of sediment samples and in the making of several kinds of routine analyses.
For the past few years the sediments laboratory has been carrying on a comprehensive program of chemical and mechanical analyses of the large collection of recent west coast sediments, mostly from the California coast, in the collections of the Institution. This program has been continued during the past year, and in addition many new samples, collected in collaboration with the project of the Geological Society of America, under the direction of F. F. Shepard, are being studied. A series of core samples from Monterey Bay, obtained by B. W. Galliher, have also been investigated. Nearly three hundred mechanical analyses by the pipette method, over 170 determinations of carbonate content, and 125 nitrogen analyses have been made.

A simplified dry combustion procedure for the determination of organic carbon in sediments and soils is being developed by Dr. Gripenberg. As soon as this method can be standardized it will be applied to the routine determination of organic carbon on the samples previously analyzed for nitrogen and carbonate. The carbonate method employed in this laboratory has also been modified for use in sediments by Dr. Gripenberg.

Experimental and field studies of the mechanism of coagulation of freshwater colloidal suspensions in the sea have been carried on by Drs. Gripenberg, Revelle, and Shepard and their assistants. During the recent Southern California flood, samples of water and mud were collected at the mouths of all the major streams debouching into the sea, at varying distances along the shore and out to sea. From the data so obtained it may be possible to obtain rough estimates of the amount of sedimentation during this period, as well as to gain information about rates of coagulation and settling under the conditions of rapid turbulent diffusion existing in the sea.
A shallow water type of the coring apparatus developed by Varney and Redwine, which utilizes for driving force the hydraulic pressure of the water itself, has been successfully tested. Cores six feet long have been obtained in 100 fathoms of water. A design for an instrument for use in water over 400 fathoms deep is now being developed.

Revelle has prepared two papers for the *Symposium on recent sediments* (see p. ), one on the sediments off the coast of California (with F. P. Shepard) and one on physical processes in the ocean (with R. H. Fleming).

**Investigations in submarine geology** -- Through a grant from the Geological Society of America a cooperative program has been carried on at the Scripps Institution which is bringing in data on a much neglected phase of geology. This work carried on by F. P. Shepard with the active cooperation of Roger Revelle, with the full time assistance of K. O. Emery and Robert Dietz, and with considerable assistance from various others, has consisted primarily of dredging and sounding activities on the E. W. SCRIPPS. An investigation of the rift valley southeast of San Clemente Island has shown that this feature has the same V shape as typical submarine canyons, although its relation to fault scarps and the absence of tributary valleys indicate that it is due to faulting rather than to subaerial erosion as appears to have been the case for the submarine canyons. Large amounts of rock have been dredged from this trough and from the fault scarps at either end. These formations have fossils which have been diagnosed by Manley Natland as Miocene and Pliocene. Fossil bones were recovered in one dredging. These are principally fish bones but also in one case a mammal bone was obtained. Dredgings from
the bank 20 miles southeast of San Clemente Island revealed rocks closely related to those of the Island. Since the physiographic relations of the fault scarps and trough mentioned above suggest a large amount of horizontal offset along this line, the dredgings from the bank tend to give supporting evidence for the same type of movement.

Accurately located soundings have been made along range lines at the heads of Scripps, La Jolla, Newport, and Carmel submarine canyons for the purpose of watching changes which may occur in these canyon heads. Repetitions of these lines have been made several times and are being made every two months in the case of the first three canyons. Decided changes have been discovered. A large slow-moving landslide was charted during its occurrence at the head of La Jolla Canyon. Fill has also been noted in all of the canyons during the winter months.

Sediment traps designed by K. O. Emery have been put down in the local canyons and on the shallow continental shelf off Newport. Despite some loss of these devices results have been obtained in a few cases. Sediment has been washed out at least to 30 fathoms in considerable quantities during the storms and winter floods. It is not yet known whether sediment is carried to the same localities during quiet weather. A device developed by Revelle shows the direction in which the trap rests on the bottom.

Observations of the sediment washed out to sea during floods was made in cooperation with Revelle and Dr. Gripeberg.

In cooperation with E. O. LaFond and W.P.A. assistants, daily measurements of the sand fill under the Scripps Institution pier are being made to determine the relation of cut and fill at various points to different types of waves and currents. The seasonal variation which had been observed previously from weekly soundings is being established
again this year. Also certain relations to the tidal cycles are appearing although these are proving to be somewhat variable. Large waves generally produce large changes, mostly cut near shore and deposition farther out, but this is also variable according to the direction of the current and the nature of the waves.

At intervals of one or two months, soundings are being made out beyond the pier to look for changes in depth. So far, only insignificant changes have been noted, much smaller than along the pier and in the submarine canyons.

Daily measurements are being made along the beach which extends for a mile south of the Scripps Institution. These observations like those along the pier show seasonal changes and have distinct relation to large waves and less distinct relation to the tides.

**Marine microbiology —** The studies of Claude E. ZoBell and associates reveal that bacteria influence the diagenesis of marine sediments in several ways. Analyses of the bacterial populations in several mud cores suggest that aerobes are most active in the topmost 5 to 10 cm. of bottom deposit while anaerobes are active to a depth of 40 to 50 cm. below which they seem to be slowly dying off. Biochemical processes activated by bacterial enzymes which seem to concentrate in the sediments may occur at much greater depths. The reducing activities of bacteria lower the oxidation-reduction potential of many sediments to a level which is unfavorable to nitrification. The physiological reactions of several anaerobes isolated from bottom deposits have been studied using the "oval tube" technique perfected for this purpose.

Continuing the observations of ZoBell and Anderson on the factors which influence the activity of bacteria in sea water, Dr. H. D. Michener has shown that protozoa play a very minor role in restricting
the bacterial population either in the sea or in the laboratory. Apparently the lack of solid surfaces or particulate matter in the open sea is one of the chief factors which accounts for the small numbers of bacteria found there. It is believed that solid surfaces serve as concentration food for the absorption of organic matter and that such surfaces retard the diffusion of exo-enzymes as well as partially digested food away from the bacterial cells.

The specificity of marine bacteria has been found to be partly due to certain micro-nutrients and accessory growth factors found in the sea and partly due to their osmotic pressure requirements. Paradoxically it is difficult to acclimatize young cultures of marine bacteria to grow in fresh-water but senescent ones develop a tolerance for adverse conditions. The young cultures are hypersensitive to heat, some of them being killed by ten minutes exposure to the plating temperature of agar (45°C).

The reliability of the minimum dilution method of enumerating marine bacteria has been tested under different conditions. After statistically analyzing the data, Mr. R. D. Gordon has developed a new mathematical formula for estimating the most probable number of bacteria indicated by the biological results. Judging from preliminary calculations this formula will provide for greater accuracy in quantitative bacteriology.

Assisted by Mrs. C. B. Feltham and in cooperation with Mr. G. E. MacGinitie, it has been shown that bacteria play an important role in the nutrition of marine invertebrates. Specimens of the sand-crab, Emerita analoga, have been maintained for over twenty weeks on an exclusive diet of bacteria during which time they gained in size and weight. The mechanisms by which the mud shrimp, Upogebia psittacina, and the echinoid worm, Urechis caupo, feed on mucus-entrapped bacteria have been studied.

Several kinds of chitinoclastic bacteria which are probably
primarily responsible for the decomposition of chitin in the sea have been described by Mr. S. C. Rittenberg. The "shell-disease" of lobsters which reached epidemic proportions on the west coast last year may be due to such bacteria.

Several improvements have been made in the methods for studying marine bacteria. A collapsible rubber bottle has been developed for collecting bacteriological water samples from great depths in the ocean, micro-electrodes for measuring the pH and ionic strength of marine materials have been perfected. Analytical methods have been improved and standardized.

During the year, eleven papers were presented at scientific meetings and nineteen semi-popular lectures on scientific subjects were presented by Mr. ZoBell all before various educational and civic groups. ZoBell also conducted a three-unit course in Clinical Bacteriology for the University Extension Division in San Diego and a two-unit course in Soil Bacteriology for the University of California at Los Angeles.

**Phytoplankton** — The studies of phytoplankton have been continued by Mr. W. E. Allen and Miss E. Cupp. Most of Mr. Allen's time was devoted during the past year to microscopic study and statistical treatment of the daily collections of inshore phytoplankton which have been accumulating since September 1919. The microscopic examination and the preliminary statistical calculations and tabulations have been completed up to December 31, 1937, a period of slightly more than eighteen years. In addition, considerable progress has been made in writing a report on the seasonal, annual and other periodicity distribution and of related phenomena concerning the dinoflagellate populations represented in these collections.

Daily collecting of plankton samples has been continued
through the year at the Scripps Institution and at Pt. Hueneme (more than one hundred miles further north). Mr. Allen has done the collecting himself at the Institution's pier in order to maintain contact and acquaintance with "field conditions."

The 1937 phytoplankton collections made by the G. Allan Hancock Expedition to the Gulf of California were studied and the enumerations of the populations in different parts of the Gulf were tabulated for use in the joint report with Miss Cupp which is now in press. Miss Cupp wrote the general discussion, the taxonomic discussion, and prepared illustrations of prominent species. Forty-five figures grouped into twelve plates were included in the paper.

The collections of phytoplankton made at seven levels at twenty-seven off-shore stations on the February cruise of the E. W. SCRIPPS have been examined, the numbers at each level at each station estimated, recorded, and tabulated, and preliminary graphs have been prepared to show relative abundances of stations and levels. The collection obtained on the April cruise has been examined and a study begun of the collections obtained on the June cruise.

Miss E. Cupp, during the greater part of the year, has been occupied with a continuation of the preparation of a taxonomic paper on plankton diatoms of the southern California region. Many sketches showing variations in the species have been made. Variations in species characters, seasonal distribution, and abundance are being considered.

Three papers were presented at scientific meetings.

Zooplankton — M. W. Johnson has continued his work in general biological studies which comprised investigations of the zooplankton population, for which samples were taken bi-weekly at the pier
with a view to studying the occurrence and seasonal production of the
more neritic species; a study of the fecundity of *Thysbe*, a common littoral copepod, in experimental cultures; a study of the migratory and
breeding habits of *Limnoria*, the wood gribble in experimental cultures;
analysis of a collection of plankton samples taken at the five and ten
mile stations, with a view to gaining information on the biology of the
local copepods whose life history is now known; studies on a new genus
of copepod transitional between marine and fresh-water forms, and col-
lections for off-shore zooplankton studies made at the regular E. W.
SCRIPPS' oceanographic stations off the California coast in April and
June.

Johnson has also continued his life-history studies of the
developmental stages of the copepods *Pontellopsis* and *Thysbe*. With
Mr. W. Lewis he has studied the developmental stages of *Emerita*, the
common sand-crab, from cultured larvae and plankton collections; and
with Dr. Olga Hartman he has studied the development of local marine
annelids and their pelagic larvae.

Mr. Cecil Monk is continuing a study of the systematics and
distribution of the marine *Harpacticoid* copepods; Miss Hartman has
carried on a survey of the marine Polychaetes to be included in her
monograph of the marine annelids of the Pacific coast.

Several papers have been presented at scientific meetings.

Physiology and Biochemistry -- Investigations into the
biochemistry and physiology of marine organisms have been conducted by
D. L. Fox.

Mr. Bradley Scheer continued his researches, during the Spring
of 1937, on the content of glutathione and ascorbic acid (vitamin C) in
marine invertebrates, giving special attention to age and sex. In the
summer he left to spend a year studying advanced courses in Berkeley,
for work leading toward the Ph.D. degree under the direction of Dr. Fox.

During the summer period of 1937, the following problems
were investigated under the direction of Dr. Fox:

(1) Hydrolysis and oxidative destruction of carotenoid
pigments by marine bacteria, by Henrik L. Blum, graduate
student (Research Assistant from July 1 to August 15).

(2) Electric measurements of membrane potentials between
body fluids of marine animals and sea water, by L. I.
Katzin, graduate student.

(3) Oxygen consumption and carbon dioxide production of
the marine sipunculid worm Dendrostoma Zostercola,
by Dr. William G. Clark, Research Assistant from July 1
to October 1, 1938.

(4) Glycogen content of the California mussel, Mytilus
californianus, with reference to nutrition, sex, spawn-
ing, and age (size), by D. L. Fox and Dr. J. S. Butts,
Assistant Professor of Biochemistry, University of
Southern California Medical School (Research Assistant
from July 1 to September 1, 1938).

Marston C. Sargent, Research Assistant from October 1, has been
studying photosynthesis in and nutrition of certain microscopic and larger
marine plants, and has collaborated with Dr. Fox in studies of production
and variation of chlorophyll and carotenoid pigments in the halophilic
algal flagellate, Dunaliella salina.

Dr. Wesley R. Coe, Professor Emeritus of Biology at Yale
University, visiting investigator in this division of the Scripps Institution since October 1, has continued his studies on the physiology of sex in marine invertebrates.

Mr. Fox has continued, throughout the year, his studies on carotenoid pigments in marine organisms with reference to comparison between species, differences in mature sexes, and the pigments of marine eggs. In addition, he has continued his studies of chemical changes in the tissues of the California mussel (especially body water and tissue chloride), brought about by the keeping of this animal in hypotonic and hypertonic solutions of sea salts. The water - and salt - balance of the animals was studied with respect to the salt concentration of the external environment. Threshold values of tolerance for both hypotonic and hypertonic concentrations of sea salts have been closely approximated. In this work, Mr. Fox has been assisted in the making of biochemical analyses by A.R. Holland, formerly Senior Chemist, W.P.A. Project, until July, 1937; Hiomi Nakamura, Technical Assistant during August and September, 1937, and John P. Cunningham, Senior Chemist, W.P.A. Project, since October 1, 1937.

Mr. Eugene C. LeFond, enrolled for research work with Dr. Fox during the Fall semester of 1937 and the Spring semester of 1938, is continuing an investigation into the role of the California mussel in precipitating sand, mud and other particulate matter, under natural conditions in the sea. He has shown that such filtering organisms as mussels may bring about the precipitation of as much as forty or fifty percent more sand and other detritus than settles to the bottom by gravitation alone. During such activities, mussels contribute to the ocean floor much organic matter, together with sand and other particulate inorganic matter incorporated by mucus into relatively large aggregates.
Mrs. Lois L. Sorkness, enrolled as a part-time graduate student, is carrying out under the direction of Mr. Fox, an investigation of the possible correlation between rate of water propulsion by the California mussel and its rate of oxygen consumption.

Dr. Robert T. Young, visiting scientist at the Scripps Institution, and Mr. Fox published a paper, under joint authorship, concerned with studies of the seminal vesicles of the goby, *Gillichthys mirabilis*, and biochemical and possible physiological properties of the vesicular fluid.

A paper concerned with the carotenoid pigments of a Pacific Coast anemone, *Epiactis prolifera*, is to appear in the June issue of the Proceedings of the National Academy of Sciences, under the authorship of Denis L. Fox and Chesney R. Moe. Mr. Fox has presented four papers at scientific meetings and given nine popular talks.

Fish Biology -- The chief single activity has consisted in carrying to completion an extensive series of experiments by F. B. Sumner and P. Doudoroff upon respiratory metabolism and acclimatization to high and low temperatures. These experiments extended through the greater part of the year, and records were obtained for nearly 3,000 fishes (*Gillichthys*). Many interesting quantitative relations were shown. The results are published in the current number of the Biological Bulletin (June, 1938).

During the latter part of this period, more than one thousand fishes of another species (*Gambusia affinis*) have been subjected to various conditions in respect to background and to incident light, with the object of determining the precise relations between these conditions and the formation of the black pigment
melanin. This material is now being submitted to quantitative treatment.

Mr. Doudoroff has likewise devoted much time to a continuation of his experiments upon temperature selection by fishes, in the gradient tank which was devised by him some two years ago. The influence of acclimatization and other factors upon temperature selection has been investigated by him, and some interesting observations made relative to the behavior and temperature sensations of fishes and the question of the nature of optimal environmental conditions.

During the second semester, Mr. Sumner has taken charge of a seminar comprising graduate students in Zoology at the U.C.L.A. This seminar has been chiefly concerned with some of the problems of adaptation in the living world. The 2-hour sessions have been held twice a month, alternately at U.C.L.A. and at the Scripps Institution.
II. List of Papers Published

- - The collecting of microscopic material. Microscope Record (Watson's, London), no.42, p.20-21, Sept., 1937.
- - Microscope thrills. Microscope Record, no.43, Jan., 1938.


- - The production and distribution of zooplankton in the surface waters of Bering Sea and Bering Strait. In U.S. Coast Guard, Rept. oceanographic cruise U.S. Coast Guard Cutter CHELAN 1934, Pt.2, p.45-82.


- - - The colloidal fractions of Pacific deep-sea clays. Idem, p. 188.


III. Instruction and Students

The following graduate students have been registered at the Scripps Institution during the year:

Peter Doudoroff - two semesters
R.D. Gordon * *
E.R. Monk one *
John Lyman two *
E.C. LaFond * *
Lois Y. Sorkness one *
H.C.A. Gripenberg two *
W. Forest Whedon * *

Leonard I. Katzin, Summer session 1937.

Messrs. Rittenberg and Scheer, who studied at the Institution during 1936-37, spent the academic year 1937-38 at Berkeley where they, in the spring, 1938, passed their preliminary examinations for the doctor's degree in bacteriology and physiology, respectively. Mr. Monk spent the second semester of 1937-38 at U.C.L.A. where he, at the end of the semester, passed his preliminary examination for his doctor's degree in zoology.

Instructions to the graduate students have 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. The seminar has been very helpful in coordinating the different interests represented within the SIO.

Mention has been made in the general report of the upper-division undergraduate course in oceanography offered in the summer
session and of the fact that in the future it will be more desirable to offer a course in oceanography at U.C.L.A. during alternate semesters.
IV. Visitors

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

L. Bostwick - Experiments in culture of pearls from abalone. Throughout the year.

Dr. W. R. Coe, Prof. Biology, Yale University - Studies on sexual phases of marine mollusks. September, 1937, to June, 1938.

Dr. L. R. David, Musée du Congo-Berge, Tervueren, Belgium - Development of fish eggs, studies of pigment. June, 1938.

Robert Dietz, University of Illinois, assistant to Dr. F. P. Shepard, throughout the year.

K. O. Emery, University of Illinois - Assistant to Dr. F. P. Shepard, throughout the year.


Dr. C. E. Moritz, University of Idaho - Embryonic development of some marine mollusks. Summer, 1937.

Dr. E. H. Myers, Compton Junior College - Studies on cytology and reproduction of foraminifera. Summer, 1937.

H. L. Natland, Richfield Oil Company - Conferences on foraminifera. Occasionally throughout the year.

Dr. C. G. Rossby, Massachusetts Institute of Technology - Studies in physical oceanography. March, 1938.

Dr. H. R. Seiwell, Woods Hole Oceanographic Institution - Studies in physical oceanography. February - April, 1938.

Dr. F. P. Shepard, University of Illinois - Studies in submarine geology. July, August, 1937 (From September 1, 1937, Research Associate in Oceanography, SIO.)

Dr. E. M. Thorp, Baylor University - Use of library, studies in geology, Summer, 1937, June, 1938.


Dr. R. T. Young - Experiments with fishes in media other than their natural environment. Throughout the year.

Dr. R. T. Young, Jr., Worcester Polytechnic Institute - Penetration of sunlight into sea water, Summer, 1937, Transparency of sea water, June, 1938.

Other visitors to the Institution include:

President Robert G. Sproul, University of California.

Vice-President E. R. Hedrick, University of California, Los Angeles.

Ursel S. Armstrong, Department of Geology, University of California.

Dr. L. M. Boelter, Department of Mechanical Engineering, University of California.

Dr. Perry B. Clark, U. S. Dept. Agriculture, Food and Drug Administration, San Francisco.

Dr. T. D. A. Cockerell, Prof. Emeritus of Zoology, University of Colorado.

Mr. Clem Copeland, Department of Water and Power, City of Los Angeles.

Dr. A. S. Crafts, University Farm, University of California.

Dr. L. M. Dickerson, U. S. National Parks Service.

Dr. W. F. Durand, Professor Emeritus, Stanford University.

Dr. John A. Fleming, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

Dr. A. J. Goldforb, College of the City of New York.

Dr. Frank Blair Hanson, Rockefeller Foundation, New York.

Dr. van Heyningen, Commonwealth Fellow, Cambridge, England.

Dr. George W. Hunter, II, Claremont Colleges.

Dr. George W. Hunter, III, Wesleyan University, Middletown, Conn.
Dr. Eric Liljencrantz, Stanford University Medical School.
Dr. George D. Louderback, University of California.
Prof. G. E. McGinitie, Marine Biological Station, Corona del Mar.

Dr. R. C. Mullenix, Professor Emeritus, Lawrence College, Appleton, Wisconsin.

Dr. A. J. Nicholson, Commonwealth of Australia, Chief, Division of Entomology,
Council for Scientific and Industrial Research.
Mr. Boyd E. Rakestraw, University of California Extension Division.
Dr. R. D. Reed, Chief geologist, Texas Oil Company.

Dr. Ray Robinson, U. S. Department of Agriculture, University of Idaho.

Dr. Harry S. Smith, University of California, Department of Agriculture.

Gordon Stephenson, Commonwealth Fellow, Liverpool.

Prof. M. A. Stewart, University of California Agricultural Station, Davis.

Mr. E. L. Sumner.

Dr. Harry E. Torrey, Stanford University

Dr. Albert H. Wells, U.S. Department of Agriculture, Food and Drug Administra-
tion, San Francisco.
V. Library

Since August, 1937, almost the full time of Miss Ruth Ragan, assistant secretary, has been given to the library. Simultaneously, thanks to the Works Progress Administration, two other workers have also been available for full time. Since June 1, 1938, a trained cataloguer has been added from the WPA Library Project. Therefore, this has been an opportune time to undertake considerable expansion of the work. Besides the regular routine activities, certain physical improvements have been made. A rearrangement of general reference books in the reading room made it possible to undertake a better looking system in the stacks; better lighting was installed in the reading room, more desk facilities in the stacks. The library is now open four evenings a week with someone on duty.

Cooperation in the preparation of a Union List of Serials of the libraries of southern California furnished information to ourselves as to missing numbers of sets or volumes of periodicals. Many of these were procured to complete sets. Concentrated time and effort was put into the binding of publications. For several years periodicals and other publications had accumulated faster than available time and money for binding. During the past year the binding of most of our current periodicals has been brought up to date. Through the binding project of the WPA in San Diego about five hundred volumes of publications not frequently used but valuable if bound and available for occasional reference, were bound. It is expected that a similar number will be bound during the coming year.

Exchange lists have been revised, with addition of oceanographic and marine laboratories. Series published by the latter have been added to the shelves. Arrangements have been completed for subscription to
periodicals through one dealer, thus saving time and money.

A shelf-list of publications in the library has been begun.

A beginning has also been made of gathering together the available material relating to the Scripps Institution, not only scientific papers published by members of the staff, but all material bearing on the history of the Institution. Several volumes of "Scientific Contributions" have been bound, as also dissertations offered for the doctor's degree on work done at the Institution. In some cases the copies had to be borrowed from the library at Berkeley, as the Institution did not own them.

The most important work undertaken began on June 1 with the arrival of a trained cataloguer, that of recataloguing the library according to the Library of Congress system. For this highly specialized scientific library the old Dewey system in use was fast becoming valueless, since it left off where our needs began. Whether the change was made or not reclassification and recataloguing of many of our books and periodicals was a necessity; also the main University libraries are already using Library of Congress system and our staff is familiar with it. Therefore, it seemed economical of energy and money to make the complete change to the system which does answer the needs of such a special library. Fortunately, the Works Progress Administration Library Project had a librarian who could be assigned to the Institution. The first Library of Congress cards have arrived, and we shall soon have one or two more workers to help revamp the books for which cards have been received.

1313 volumes have been added to the library during the year, 423 of these purchased, 890 bound.
The floor show cases in the Museum which were constructed over twenty years ago for the purpose of exhibiting skates, rays and other flatfishes, were beginning to show signs of deterioration and leakage. As these are but wooden boxes it was to be expected that they would not last indefinitely but as this is a very effective method of exhibiting such specimens the Curator thought it best to try to devise some way by means of which these cases could still be used without going to the trouble and expense of making new cases.

Because of certain technical difficulties it is not possible to mount satisfactorily skins of sharks and rays for permanent exhibition as they shrink, warp out of shape and eventually split. So the next best thing was to make painted plaster casts to replace the preserved specimens. During the past year 11 painted plaster casts of skates, rays and flatfishes have been made for these floor cases. Taking into consideration the fact that the Curator has never had any professional training in this sort of work the casts came out better than he expected. Certainly they are much better than the old faded-out preserved material. As fast as fresh specimens can be obtained for this work it is intended to replace all of the preserved material in these cases with such casts.

While on his recent vacation the Curator had the opportunity and pleasure of spending three days in the taxidermic department of the Field Museum in Chicago, where he gained much information relative to casting fishes for museum exhibition.

During June many exhibits were added to the museum illustrative of oceanographic work of the Institution. This was done especially for the benefit of those attending the meetings of the American Association for the Advancement of Science. But it is hoped by the Curator that
these exhibits may remain in the Museum permanently. Many new labels were made and all of the photographs of the Marine Stations of Europe were remounted and in addition seven photographs of the Institution and of the boats that have been used for its work since 1904.

There were 6823 visitors to the Museum who registered. As only a small proportion of visitors sign the register it is safe to say that there were over 10,000 visitors during the year.

During the past year the Curator has been giving all the material in the biological collections a thorough going over, replacing fluid and corks, sorting over dredge and trawl material and checking records, accessions and indexed material. As these collections represent over 35 years of accumulated material, this is no small task.

Since the S. W. SCRIPPS was put into commission many new specimens have come in, mainly from the work which has been carried on by Dr. F. P. Shepard and his staff of workers.

717 fishes have been collected for the Aquarium and many invertebrates and seaweeds. From an exhibition standpoint the Aquarium has never been in better shape than during the past year. This is due largely to the fact that there is an attendant who not only takes an interest but also pride in keeping the tanks and the specimens in good condition.

Fourteen informal talks on the work of the Institution have been given by the Curator to groups of visiting students and much information on marine life to many persons.

Over 2500 fishes have been furnished for scientific work in the laboratories and aid in collecting material has been given to visiting scientists.
Because of the crowded condition of the laboratories the Curator turned over his main office in the Museum to visiting scientists working at the Institution.
VII. Workshop

The small workshop which was established in July, 1937, has been found very useful. The necessary equipment has been available for making simple pieces of apparatus for use in the work on the pier such as a convenient arrangement for obtaining soundings along the pier, a frame for current meter, and a machine for recording the height and period of waves.

In connection with the work in submarine geology the workshop has been even more useful since it has been necessary to make a number of dredges for rocks and samplers for bottom sediments. None of these items represent standard pieces of equipment and the cost of having them made, especially by some outside organization, would have been prohibitive.

A considerable number of minor repairs have been undertaken and have meant great saving in time since previously work of that nature had to be done either in San Diego or in Los Angeles.

It is not possible to give any estimate of the value of the work which has been completed in the workshop, but it can safely be said that if this work should have been done by outside organizations, the total cost would have amounted to at least $1500, whereas now our direct expenditures for material and additional tools have been less than $200. Even if we count the time which employees at the SIO have spent in the workshop the total expenditure will not exceed $700. It can, therefore, safely be said that the workshop represents a very valuable addition to the facilities of the Institution.
VIII. Other Activities.

In the general report mention has been made of the cooperation between the U.S. Navy Bureau of Construction and Repair and the Scripps Institution. It should be added that in order to facilitate the studies of fouling organisms the U. S. Bureau of Lighthouses has consented to anchor a buoy off the end of the pier in order to make possible suspension of slides for the study of first attachment of organisms in waters which are not so agitated by wave motion as are the waters at the end of the pier.

Cooperation with Dr. F. P. Shepard has continued throughout the year making it possible for him to use to the greatest advantage a grant from the Geological Society of America for studies in submarine geology. Of this grant, $9,000 has been applied towards the operation of the E. W. SCRIPPS and the Institution has given laboratory space to Mr. Shepard and his two assistants. It was hoped that the cooperation would be finished in this academic year, but owing to delays in making the vessel ready Shepard's work at sea could not commence before January. As he was supposed to have the boat at his disposal for six months, he has made arrangements to have his leave of absence from the University of Illinois extended until January, 1939, and will have use of the vessel during three months of the coming half-year. The cooperation with Mr. Shepard has been very valuable to the studies in sedimentation which form part of the Institution's program.

A close cooperation has existed between the Fisheries Laboratories of the California Fish and Game Commission at Terminal Island and the Institution. The Fisheries Laboratories has been kept informed as to the results of the BLUEFIN cruises and, in December, a special conference
was held at Terminal Island during which the BLUEFIN data were discussed. Preliminary results from the cruises on the E. W. SCRIPPS have been communicated to the Fisheries Laboratories which have been kept informed as to dates when cruises would be undertaken so that they might undertake parallel studies at the same time.

Close contact has existed between the local representatives of the Federal Bureau of Fisheries and the Institution, and information of various nature has been given to these representatives.

The local branches of the U.S. Navy have shown great interest in the information which the Institution has obtained as to the character of the currents off the coast and the distribution of temperature and salinity in the upper layers. Unpublished charts and tables have been placed at their disposal. The Institution has also provided the Aeronautical Division of the Navy with charts showing the distribution of surface temperatures. These charts have proved to be of great interest since the distribution of low clouds which present an obstacle to airplane activities shows a definite relationship to the surface temperature of the sea. Further studies of the matter are being conducted by the Aeronautical Division in close contact with the Institution.

The Institution has rendered service to the public in many other ways by giving information of various natures and through public lectures.
IX. 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, and the California Fish and Game Commission. Observations of surface temperature and plankton collections from the surface waters have been obtained from various sources.

Special acknowledgments are expressed to Mr. T. W. Vaughan for his gifts of books and periodicals, and to Mr. R. Revelle for his contribution towards the development of a deep-sea coring apparatus.

Much help has been received from the W.P.A. 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 represent a group of well-trained, able, and industrious persons. The Institution wishes to express its acknowledgment for the valuable services rendered.