ACTIVITIES OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIFORNIA

By H. U. Sverdrup

On November 13, 1936, the Institution's boat, Scripps, which in 1934–35 had been completely overhauled and reequipped, was lost by explosion and fire. On April 5, 1937, Mr. R. P. Scripps bought the 104-foot schooner Serena, which, after remodeling, he gave to the Institution. In its transfer, its name was changed to E. W. Scripps. In addition to the crew, the E. W. Scripps can accommodate a scientific party of six, contains adequate laboratory space both on deck and below deck, and carries two winches for oceanographic work, one provided with 2000 feet of 3/8-inch wire rope and one provided with 2000 feet of 5/32-inch wire rope. The normal cruising radius under power is 2000 miles, but this can be extended by taking fuel on deck and by using the sails.

Expeditions and oceanographic data.—From June, 1935, until November, 1936, the Scripps occupied a number of oceanographic stations in the waters near the coast of southern California between San Diego and Santa Barbara. In 1937, when the Institution had no vessel at its disposal, three cruises were made in cooperation with the California State Fisheries Laboratory, using their vessel, the Bluefin. Nearly thirty stations were occupied on each cruise along four lines running at right angles to the coast. The lines were 70 miles apart and 160–180 miles long, the northern beginning off Port San Luis and the southern off San Diego. In 1938 all these stations were occupied by the E. W. Scripps on six cruises in alternate months from February to December, except when, in April and October, bad weather prevented the completion of the work. On the Bluefin cruise, observations were made at standard intervals down to as low as 2000 meters, but on the E. W. Scripps cruises the work was confined to a depth of 600 meters. On the latter cruises quantitative catches of phytoplankton were made at seven depths at all stations, and vertical hauls of zooplankton were conducted on all cruises except the first one. In 1933, 1934, and 1935 the U. S. S. Hannibal occupied a large number of oceanographic stations in the Gulf of Panama and off the coast of Panama and Costa Rica. In 1933 R. H. Fleming of the Institution's staff spent about three months aboard the Hannibal as special observer. In 1934 the U. S. S. Bushnell occupied 18 stations between Adak in the Aleutian Islands and Pearl Harbor in the Hawaiian Islands. Roger Revelle of the Institution's staff accompanied the Bushnell. In November, 1936, 10 stations were occupied by the U. S. S. Louisville between San Pedro and Pearl Harbor. This work was under the charge of E. G. Moberg of the Institution's staff.

In addition, the Institution has received subsurface data from various stations close to the American coast occupied by vessels of the United States Coast and Geodetic Survey. About forty subsurface data were obtained by the Valero III in 1934–35 from the area off the coast of Peru in about latitude 10° S. A large number of surface data have been submitted to the Scripps Institution.

Physical oceanography.—The above-mentioned data have all been discussed and published or prepared for publication except those of 1938, which are under preparation. The Bluefin observations in 1937 and the observations of the Bushnell in 1934 have shown that off the coast of California a big eddy appears to be present during the greater part of the year. This eddy is especially well developed during the period of upwelling when the offshore branch of the eddy carries cold upwelled water toward the south, whereas the inshore branch carries water of higher temperature toward the coast, but this inshore branch reaches only to the Channel Islands.
Researc hes on smaller bodies of water, lakes or storage reservoirs, where relevant conditions are more completely observed, and processes are less complex than in the sea, are helpful in attacking problems of the sea. A paper presenting an extensive series of such observations and their interpretation in San Diego County was prepared by McEwen.

Daily observations of surface temperature and salinity have been continued at the following six stations:

- Scripps Institution Pier .................................................................................. Latitude 32° 59' N
- Hueneme .............................................. Latitude 34° 9' N
- Pacific Grove .......................................... Latitude 36° 38' N
- North Farallon Island .............................. Latitude 37° 45' N
- Blunt's Reef ........................................... Latitude 40° 37' N
- Balboa ................................................... Latitude 33° 36' N

A study of the energy relations between the sea surface and the atmosphere has been completed, and by means of local observations of the vertical temperature gradient in the sea, together with the distribution of solar radiation and the amount of radiation penetrating the sea surface, the resulting evaporation from the sea has been computed. Methods for use in summarizing numerical field data have been critically examined.

Estimation of ocean currents from surface temperature distribution has been made. McEwen has devised formulas, based on considerations of surface energy relations, for estimating surface ocean currents from the distribution of temperatures. One such formula consists of a quotient of two quantities which in practice are subject to rather serious random errors which (ideally) are normally distributed in both numerator and denominator. Under the hypothesis of normal distribution, the probability distribution of values of the quotient has no standard deviation and its arithmetic mean is indeterminate, so that it has no “law of large numbers.” A statistical estimate of the “true value” of such a quotient has been obtained which possesses a definite mean and satisfies a “law of large numbers” (half of the size determined), although this estimate also has no standard deviation. These characteristics of an estimate are of importance for “least squares” treatment of data, and, for example, for estimating total transports of water over a period of time; it is hoped that this estimate will be found satisfactory.

Several applications of statistical methods to biological problems have been developed by McEwen and Gordon. Mr. Gordon has developed a new method for computing “most probable” bacterial populations from the results of successive tenfold dilutions of the sample. It is believed that tables based on the new formula will give better agreement with experimental results than Halvorson and Ziegler’s tables, which are now in use.

Dr. C. E. ZoBell compared plate counts and successive dilution estimates taken from tables by Halvorson and Ziegler on the same material, with unsatisfactory results. The unsatisfactoriness is attributable to varying skewness of certain probability distributions, of which Halvorson and Ziegler’s tables give the modes. Formulas have been devised for obtaining geometric means of these distributions, together with logarithmic standard deviations. It is expected that much better agreement with plate counts will thus be attained. Computation of tables to replace those of Halvorson and Ziegler will be necessary before this can be actually tested, also for practical use. It is hoped that funds will become available to enable this to be done. Further material is yet to be published.

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has continued his work on bacteria in sea water and in bottom deposits. Five new species have been isolated which produce ammonia from low concentrations of urea in sea water. Observations on the influence of temperature, organic matter, pH, redox potentials, and salinity on the activities of nitrifying and denitrifying bacteria indicate that in the sea the redox potential is perhaps the most important factor. Multiplication, proteolysis, carbohydrate fermentation, ammonification, and nitification in marine bacteria have been observed at 0° to −2° C, which indicates that bacteria are functional at the low temperatures encountered in the deep sea.

With the assistance of D. Q. Anderson the vertical distribution and relative abundance of bacteria in marine sediments which activate a number of different physiological processes of oceanographic significance have been estimated. It has been shown that bacteria have a great capacity to affect in marine bottom deposits the O/R potentials which are of bacteriological, geological, and chemical significance. Mrs. C. C. Cupp, a microstegos calomel half-cell has been prepared for measuring the O/R potentials of anaerobes in oval tubes. The device makes it possible to study the influence of bacteria upon the O/R potential and also to study the influence of O/R potentials upon the activity of the bacteria.

Chitin-digesting bacteria have been found to be quite widely distributed in sea water and bottom deposits. They were found in abundance in the digestive organs of squid, thereby indicating that they may aid marine animals in the digestion of the resistant chitin which constitute the exoskeletons of most crustacean bacteria which liberate high fatty acids from lipins and utilize the glycerol have been demonstrated in marine materials. Those, together with those which create extremely reducing conditions, may account for the formation of long-chain hydrocarbons found in petroleum.

Mrs. C. B. Feltham has continued the experiments on the bacterial nutrition of marine organisms. Mussels have thrived for 14 months in the dark on a diet consisting exclusively of bacteria.

The importance of the presence of solid surfaces to which bacteria can attach themselves has been examined. It is believed that the low number of bacteria per unit volume in the ocean is associated with lack of surfaces per attachment. For further studies of the abundance of bacteria an improved bacteriological water sampling bottle has been perfected.

**Phytoplankton.**—W. E. Allen has continued the daily collections of phytoplankton from piers at Scripps Institution and Point Hueneme more than 100 miles farther north. The microscopic work and preliminary calculations have been completed up to 1937 and cover now a period of 18 years. A large number of surface plankton collections have been obtained from various vessels, the collections have all been examined and the results published. The surface and sub-surface collections of phytoplankton which were made on the 1938 cruise of the E. W. Scripps have been studied and show especially that the abundance of diatoms may be as great at a distance of 180 miles from the coast as close to the coast.

Miss Easter E. Cupp has analyzed a number of phytoplankton collections by means of the centrifuge method and has spent the greater part of her time in preparing a taxonomic paper on plankton diatoms of the southern California region.

**Foraminifera.**—T. W. Vaughan has published a number of papers on fossil foraminifera. E. H. Myers has succeeded in working out the life history of a local species of foraminifera known as *Patelina corrugata*, and has extended his studies to another form in which the cycle in all respects conforms to that of *Patelina*. M. L. Natland has continued his studies of the ecological relations of the foraminifera in the Gulf of Catalina.

**Zooplankton.**—Martin W. Johnson has been engaged partly in the study of the life history of certain copepods and partly in studies of the geographic distribution of copepods and other forms of zooplankton. Among others, the development stages of the oceanic copepods *Eucalanus elongatus* has been completely worked out and a report has been published on the distribution in the Pacific of the varieties of this form. The large accumulation of collections which were made by the E. W. Scripps in 1938 is being examined with the assistance of C. C. Davis, C. R. Monk has continued a systematic and distributional survey of the harpacticoid copepods of the Pacific coast.

**Physiology of marine organisms.**—D. L. Fox, in collaboration with G. W. Marks and others, has concluded a study on the habitat and food of the California sea mussel. Further work on the mussel has been made possible by assistance from the Works Progress Administration. Experiments dealing with the physiological effects of hypo- and hyper-tonic solutions upon tissues have been conducted. It has been established that the mussel propels water through the gill chamber at an average rate of 2.5 l/hr. One of the chief lines of research has been the study of various carotenoid pigments in marine materials and marine animals, with special reference to nutrition. Part of this study, that dealing with carotenoid pigments in marine fishes, has been undertaken in cooperation with F. B. Sumner. The characteristic absorption curves of different pigments have been established spectroscopically.

**Biology of Fishes.**—F. B. Sumner has continued his studies of the protective value of color changes in fishes, and has experimentally established that fish-eating birds catch a much greater proportion of these fishes which do not harmonize with the background. The work of F. B. Sumner and his collaborators has, however, mainly dealt with the quantitative determination of the amount of pigments formed in fishes which have been subjected to different conditions with respect both to color of background and to incident light. It was found that the amount of melanin extracted from a given lot of fishes bears an inverse relation to the albedo of the background, probably varying inversely as the logarithm of the albedo. Intensity of incident light also played a part in determining the production or loss of melanin, but under the degree of illumination employed so far, the influence of this factor was small in comparison with that of the albedo of the background. A series of experiments have been commenced with a view to discovering some of the physiological differences between fishes which have been acclimatized to widely different temperatures.

P. S. Barnhart has completed a monograph, *Marine Fishes of Southern California*, illustrated by 292 figures.

**Studies on “fouling growth.”**—In 1937 cooperation was established between the United States Navy Bureau of Construction and Repair and the Scripps Institution in order to study the fouling growth on ships' bottoms. These studies form a continuation of work which was conducted at the Institution over a long period of years but which had to be discontinued because of other pressing demands. Mr. W. F. Whedon, who has been engaged by the Bureau of Construction and Repair to carry on these studies, has been engaged mainly in examinations of the primary film formed on submerged surfaces.

**Publications.**—In the years 1933–1938, 265 papers have been published. A partial list follows, which includes only those papers which deal with general aspects of oceanographic problems or with conditions in the Pacific Ocean.
REVELLE, R.


NATLAND, MANLEY L.


REVELLE, HOGS.


SUMNER, F. B.


SVERDRUP, H. U.


THORP, E. M.


VAUGHAN, T. W.


WELLS, NELSON A.