

SCRIPPS INSTITUTION FOR BIOLOGICAL
RESEARCH

LA JOLLA, CAL., July 1, 1916.

To the President of the University,

SIR: My report of the year July 1, 1915, to June 30, 1916, is herewith respectfully submitted.

MATERIAL DEVELOPMENT

The last year—like the preceding—has been especially notable for physical development in the life of the Scripps Institution.

Wharf.—The new 1000-foot reinforced concrete wharf was completed in February, 1916. The cost of the complete installation has been:

By original contracts—

Wharf alone	\$26,184.00	
Pump, etc.	2,443.50	
Sedimentation tank	2,715.00	
Sea wall	1,890.00	
		\$33,232.50

By additions—

For extra piling, required by excess depth of water and sand	\$2,850.00	
Change of floor from partial to complete width....	1,120.00	
Inspection and overhead	1,791.50	
		5,761.50

\$39,000.00

Although the installation has been in operation only a few months it has been tried sufficiently to give considerable indication as to its effectiveness and range of utility. The heavy wind which culminated on March 23 gave clues concerning the stability of the structure that are encouraging. The elements on which

we are relying for safety when the real test comes are the strength of the piles, the fact that the penetration of each pile into the solid shale which underlies the shifting sand and gravel is at least five feet, and the fact that the superstructure of the wharf is 23.3 feet above mean low tide, this being sufficient, it is believed, to prevent the seas from ever reaching the upper works. It is felt on all hands that one of the most vulnerable points in the whole structure is the steel casing near the end of the wharf in which the pump is placed. This, together with the pile close to which it stands and which is its main support, presents a rather formidable broadside to waves from the northwest.

Three main utilities were contemplated for the wharf: that of a landing place for boats, of an intake for the salt water system, and of a place for certain kinds of scientific observation and experimentation. The few months of its life have shown incontestably its success in each of these particulars, but the incompleteness of the trials are leading us to see that it has even larger possibilities of usefulness than we had counted on. This is particularly true as to its direct service in scientific work. For example it is already being used for making plankton collections in ways that we had hardly contemplated.

The quality of water obtained, as tested both by the animals kept in the public aquarium and by the requirements of the research aquaria, has more than met our expectation. At times a good deal of iron rust comes in, gathered somewhere in the 1500 feet of iron piping between the sea pump and the pressure tank, but sufficient attention to the discharge gates on starting and stopping the pumps ought to overcome this. But while expressing gratification at the quality of the sea water which has been brought into the buildings so far, it will not do to forget that we have yet to see what happens during the long, heavy winter storms when the sea is most stirred up and carries the greatest amount of foreign matter.

The sea pump, a centrifugal driven by an electric motor of five horsepower, when working at its best delivers about 150 gallons per minute, which is considerably better than the guaranteed performance.

Barring difficulties that must be anticipated from the growth of organisms over the intakes and in the pipes, the new salt water system may be counted as effective as any that could be secured for the expenditure.

Library-Museum Building.—The contract for this, made with Messrs. Winter and Nicholson of San Diego, was signed on January 12, 1916, but owing to the January floods construction did not begin until March 1. The work was so nearly complete by the middle of June that the moving of the library and museum to their new quarters began at that time and was practically complete in time for the Assembly in Science which began on June 26. The building cost:

Building alone	\$17,928.00
Book stacks	2,014.00
Furniture	1,561.00
Window shades, etc.	136.00
Excavating and grading	2,000.00
Architect's fees	800.00
Inspection	400.00
	\$24,839.00

New Cottages and the Commons.—Nine new cottages have been built during the year from the Ellen B. Scripps gift, and three others for Mr. E. W. Scripps from funds of his own. The total cost is \$20,000. Most of them are of considerably better quality than those built in 1912. These cottages increase the housing capacity of the colony by more than fifty persons. The living facilities have also been increased through the erection, at a cost of \$4000, of a "commons" with dining-room space for about forty. It is intended that this building shall serve for a social as well as for a dining hall. A half-basement story of the commons contains four bathrooms. This basement also contains a small laundry.

A corrugated iron garage with stalls for four automobiles has been built at Mr. Scripps' expense in the vicinity of the new cottages.

The portion of the grounds occupied by the new dwellings and commons has been made accessible from the lower grounds

occupied by the main buildings by a well-constructed road, the cost of which, about \$4000, was borne by Mr. Scripps. The opening up of this portion of the Institution's land, and the acquisition by Mr. E. W. Scripps of some forty acres adjacent to the Institution property on the north, also made accessible by the new road, marks the beginning of a new phase in the development of the "biological colony" as distinguished from the Institution. Mr. Scripps has deeded at a nominal cost small pieces of this land to two members of the staff, F. B. Sumner and P. S. Barnhart, with the understanding that these are to be used as home sites. The problem of what relationship to the Institution ownership of these pieces of land shall carry with it is one that is receiving careful consideration.

It is especially satisfactory to be able to report the continued rapid growth of the library during the year. The total of bound volumes is now about 5300. And hardly less gratifying is it to be able to say that the books and other library material are about as well housed, arranged, and catalogued as it is possible for a library to be. The stack-room now occupied has space for more than 25,000 volumes.

THE YEAR'S SCIENTIFIC WORK

The most striking hydrographic studies made during the year were on the effects of the winter floods on the ocean water. It was found shortly after the great rains of January that samples of water taken from the Institution's wharf showed a density sharply below the normal. Systematic observations were begun at once to ascertain the distance from shore, depth, and duration of this effect.

Although the field data have not yet been fully examined it is possible to report that the diminished specific gravity extended to sea at least twenty miles and lasted until June at least, a period of more than five months.

The plankton collections taken during the continuance of these effects of the flood also show peculiarities that suggest that the life of the open sea in the vicinity of the coast was affected by the great influx of fresh water. But more detailed study of the field data will be necessary fully to establish this point.

Also to be mentioned here, though not coming strictly under the head of hydrography, was the destructiveness of the flood water to the invertebrate life of San Diego and False Bays. The usual luxurious growth of sponges, hydroids, ascidians, etc., on piles, floats, buoys and the like was almost entirely destroyed. But hardly less striking than the destruction of this life was the rapidity of its recovery. The study of these phenomena fell largely to Mr. Barnhart.

In interesting contrast with the incidental, rather spectacular observations on the effects of the flood on the sea water and the marine life of the region has been the emergence during the year from the masses of data accumulated of the truth that in this part of the Pacific Ocean the salinity of the water diminishes slightly from the surface downward to a minimum at about twenty-five fathoms, from which depth it increases slightly as the greater depths are reached. This discovery is due to Dr. McEwen alone, and seems to be original, no reference to the phenomenon in writings on the physics of the sea having yet been found. To what extent the truth holds for the ocean at large is still to be determined.

During a considerable part of the present summer, beginning about the middle of June, Dr. McEwen had charge of the hydrographic and plankton work aboard the United States Bureau of Fisheries steamer "Albatross," engaged in investigating the long-finned albacore in the interest of the tuna canning industry. The arrangement between the Bureau of Fisheries and the Scripps Institution for this combination was that the Institution should have all the water samples and plankton collections taken by Dr. McEwen in return for his professional service in directing the hydrographic work, plus the payment of his wardroom expenses to the ship by the Institution.

Although Dr. McEwen has been able to study the data sufficiently between cruises to bring out several items of interest from the fisheries standpoint, he has not had time yet to make much use of them for his own general hydrographic studies.

As usual the hydrographic and plankton work during the year have been so intimately connected that they cannot be sep-

illustrated in a general statement. Messrs. McEwen and Michael have worked closely hand in hand nearly all the time. A good example of this is furnished by the development during the year of a combined plankton net, water bottle, and thermometer. The special advantages of this apparatus are: Duplicate closing net hauls and temperatures and water samples are taken simultaneously at each of a series of depths. The reversal of the thermometer holder closes the water bottle, thus making it impossible for the thermometer to register at one depth and the water sample to be taken at another. Finally, the thermometers cannot register nor the water bottle close except when both plankton nets close. By this contrivance not only is greater trustworthiness attained than hitherto in collecting biologic and environic data, but a valuable means is at hand for determining the approximate depth of closure of the nets and water bottle independently of the depth indicated by the amount of cable out. The importance of this last is emphasized by costly past experiences. The apparatus has been so tested that there is no doubt about its workableness. The general design of the apparatus is due to Messrs. Michael and McEwen and the working out of its mechanical details to Engineer James Ross.

A remarkable piece of information obtained by the new net is that two nets exactly alike placed six inches apart, and operated simultaneously rarely catch anything like the same number of organisms. This is the most conclusive disproof yet obtained of the theory that the minute organisms of the sea are disseminated uniformly through the water.

The co-operative mathematical task by Messrs. Michael and McEwen, mentioned in my last report, of devising a probability method by which it is possible to determine the probability that a difference between the averages of two series of observations is significant; and of determining the probability that the average of a series of observations deviates from the true average by a stated amount, was completed in 1914-15; and during the past year tables for the application of the method have been in course of construction, largely through the assistance of Mr. F. P. Clough as computer. This large task will soon be completed and

the results will furnish an important instrument not only for plankton investigations but for dealing with many problems involving the correlation between biologic and environic data.

Another important mathematical undertaking during the year has been that of devising a statistical method for answering such questions as that of the extent to which ascertained correlations between variations in the distribution of organisms and in temperature, for example, are due to the effects of temperature variations, and to what extent to other coincidently varying factors, as of salinity, light, etc.

While these tasks are being prosecuted primarily in the interest of the Institution's plankton investigations and McEwen and Michael work together on them, that Dr. McEwen is chiefly responsible for the mathematical part of the work is fully recognized, especially by Mr. Michael.

Dr. McEwen has continued his study of the absorption of solar radiation by the ocean; but other more immediate demands upon his attention have made it impossible to bring this to a conclusion.

The hydrographic, plankton and dredging records of the Institution have been brought up to date and published through the partnership work of Michael and McEwen; and still further discussion of methods and results has been given.

The main outcome of all this on the biological side, stated in the most general terms, is that not only *the fact of periodic vertical migration of many marine organisms is made far more definite than ever before, but many details of these movements and several causal factors have been discovered.*

Mr. Michael has practically completed his report for the U. S. Bureau of Fisheries on the chaetognatha collected by the "Albatross" during her Philippine cruise of 1907-1910. He has likewise advanced the investigation of the vertical distribution of *Salpa democratica*; but the completion of this as of other plankton studies still awaits the publication of Dr. McEwen's work on probability.

As the result of laboratory studies carried on during the summer of 1915, Dr. C. O. Esterly has made an important con-

tribution during the year to the obscure problem of the food and feeding habits of pelagic copepods. So large a part do these minute crustaceans play in the general life economy of the ocean that anything like a comprehensive understanding of this vast subject must depend in no small degree on knowledge of the food and feeding of these creatures. The possibility—not to say probability—indicated by these studies that the food of the animals consists largely of extremely minute—superminute—shellless organisms, is most interesting and suggests several sorts of future inquiry in this field.

Dr. Esterly has continued his statistical studies of the distribution of copepods; but by the natural process of division of labor this aspect of the Institution's programme of investigations is moving toward Mr. Michael and it is not impossible that to him will fall the main responsibility for all that is done in this direction. For example, Dr. Esterly's beginnings, just mentioned, on the problem of the food of copepods, and his full occupation for the coming year with laboratory experiments on the movement of pelagic animals may be taken to indicate still further the tendency toward differentiation of labor in research.

On the initiative of the Institution Dr. Esterly has been granted a leave of absence from Occidental College to reside at the Institution during 1916-17 and devote himself to experimental studies on the movements of pelagic animals, the aim being to establish more definitely than has yet been done the relation between the statistical evidence for the movements of the organisms in nature, and the laboratory evidence on the reaction of such organisms to external influences.

Work on the Dinoflagellates of the San Diego region, upon which Professor Kofoid has been long engaged has been pushed forward during the year through the employment by the Institution of Dr. Olive Swezy on three-fourths time and Miss Ebbra Brease on one-fourth time as research assistants to Professor Kofoid. The entire time of these assistants was passed in Berkeley.

The taxonomic work on this group being once completed, it is obvious that some arrangement will have to be made whereby

a specialist on the group can work at the Institution a considerable part of the time if the marine programme is to be fully carried out. The importance of resident investigators for each of the main groups of pelagic organisms is more obvious than ever now that the wharf provides a means for keeping the living organisms under almost continuous observation.

Dr. Berry's home work, prosecuted under the auspices of the Institution, on the chitons of the California coast has been continued during the year and is nearing completion, as is Professor Daniel's book on the Elasmobranch fishes, to the preparation of which the Institution has continued to contribute.

Miss Ruth A. Forsythe, a high school teacher of science and graduate student, spent most of the year at the Institution studying, in collaboration with the Scientific Director, the littoral ascidians of the coast of Southern California. The result of this work is a paper, nearly ready for the printer, which will be a considerable advance toward that taxonomic fullness of knowledge of this group of animals of the Pacific Coast of North America which has been the Director's ambition for twenty-five years.

A wide range of activities has characterized Dr. Sumner's work on environmental influence and heredity as exemplified by his special studies on the genus of mice, *Peromyscus*.

In accordance with the conditions of the research a considerable portion of these activities has been in the field, partly for the purpose of getting more stock for the experiments and partly for gaining fuller knowledge of the various races of the mice relative to the natural conditions under which they live. Thus from April 25 to June 19, 1916, the following new localities were visited: The volcanic region of Inyo County, for studying the color peculiarities said to be possessed by the mice living among the dark volcanic rocks; the redwood region of the Big Basin and adjacent territory, for determining definitely whether the northern race *P. m. rubidus* occurs in the redwoods of this locality; and several new localities in Humboldt County. The most noteworthy result of this work was the confirmation of an instance in the Humboldt region, hitherto not fully established,

of the importance of isolation for the differentiation of races. Considerable trapping was done in these and other localities, some of the "stock" being transferred alive to the breeding houses at La Jolla, while study series were made of another portion of the collections. The breeding experiment at Berkeley has been discontinued, the individuals of the third cage-born generation having been killed and prepared for detailed study. The total number of living mice of all races now in confinement at the Institution is about one thousand. A portion of these are kept in a pen of concrete, wood, and wire-screen covering an area of 25 × 50 feet and divided into two compartments, this having been constructed during the year. The floor of this pen is the native soil, in which are growing the commoner wild plants of the region. The purpose of this contrivance is to make the conditions under which the captive animals of both local and alien race are kept, as near as possible like those under which the former live in nature. During June, 1916, Mr. F. H. Holden was again employed for the preparation of another five hundred skeletons for quantitative study. In March Mr. Corwin Seitz succeeded Mr. Stuart Taber as caretaker of the murarium.

Two new experiments have been begun during the year; one to test the inheritance of differences due to differences of functional activities resulting from certain injuries to the hind limbs; the other to test the effects of different sorts of food on the mice. This last experiment is undertaken partly for the purpose of overcoming certain untoward effects of confinement of the mice.

The hybridization experiments between *rubidus*, the darkest race, and *somoriensis*, the lightest, have been continued. F_1 and F_2 generations have come to maturity and back-crosses between the F_1 mice and both of the parent races have been secured.

Two serious difficulties have been encountered in the experiments. One of these is the infertility and otherwise abnormal condition of many of the cage bred mice. The other is the existence in each of the races of color differences which are due to causes almost wholly unknown. Mr. H. H. Collins, a candidate for the doctor's degree at the University of California, who had assisted Dr. Sumner in his mouse work at Berkeley, has become

a member of the research staff for the ensuing year, his research work having largely to do with the difficulties above indicated.

An interesting "by-product" of the mouse experiments, reported upon by Dr. Sumner during the year, is the pregnancy of occasional females under circumstances which make it certain that it could not be due to intercourse with the males in the usual order. Dr. Sumner concludes that the cases are the result of superfetation and deferred fertilization.

The major scientific work of the Director during the year has continued to be the general problem of biologic integration, on which progress has been made.

With the starting up in San Diego of two large establishments, one by the Hercules Powder Company and the other by Swift and Company for the commercial utilization of kelp, problems in this quarter have entered upon a new and important phase during the year; and, acting as a collaborator for the United States Government, Mr. Crandall has continued to keep informed on what is being done and to report from time to time to officials at Washington.

The continued rapid growth of the tuna canning industry during the year has emphasized more strongly than ever the importance of the scientific study not only of the long-finned albacore as a fish, but also the whole subject of the conditions of life of this and the other pelagic fishes of the region likely to become economically important. As previously mentioned, Dr. McEwen has had charge of the hydrographic investigation aboard the "Albatross" in her present summer's work on the albacore problem. Initial steps were taken during the year looking to the co-operation of the Institution and the canners in urging upon the attention of both the National and State governments the extreme importance of putting the pelagic fisheries of the region on a scientific basis.

In my last annual report I said, relative to the importance of government action in behalf of scientific investigation of fisheries matters arising in this locality: "The wisdom of meeting such questions in their incipiency rather than waiting till, by a drifting policy, complications have arisen that might be avoided

would seem obvious enough." Strong as were the reasons for this remark a year ago, they are doubly so now.

The facilities of the Institution were made use of by thirteen visiting naturalists during the year, the aggregate of service rendered in this way by the Institution being greater probably than in any previous year.

GENERAL EDUCATIONAL WORK

The new public aquarium began running about May 1, 1916. The excellent quality of the sea water brought in; the comparatively small trouble involved in keeping the tanks stocked; and the obvious interest of the many visitors make this one of the most satisfactory of the new acquisitions. Nor is its usefulness by any means limited to its general educative function. Probably few investigators who spend a considerable time at the Institution will fail to see much of interest to them in some of the aquarium animals.

The building contains three tanks of 96 gallons capacity; fourteen tanks of 145 gallons; and two tanks of 228 gallons. Mr. Barnhart reports that up to the present time thirty-five species of fish have been exhibited, besides a large number of crustaceans, mollusks, worms, echinoderms, and coelenterates.

Although museum specimens are, rightly, always less interesting to the general public than are living, active creatures in aquaria, yet in some ways a well selected and arranged museum is more instructive than the aquarium. This is especially true where, as with the museum we are developing, the aim is to exhibit as large a part as possible of the local fauna, and this only.

As long as Mr. Barnhart is obliged to do so much of the work of both the aquarium and museum, the building up of the zoological display collections must go on rather slowly. But we feel that the beginning made is rather creditable, and that the room for expansion provided by the new building assures continued growth. Something has also been done now toward the creation of an oceanographic department to the museum. The possi-

ilities in this direction are very alluring; and Dr. McEwen's interest in the project assures its success if only funds can be secured for the purpose.

Although no advertising has been done for the "supply department" of biological material, a dozen institutions and persons have been, according to Mr. Barnhart, supplied with material during the year. Considerable stores of such supplies are being accumulated as occasion offers, and there are clear indications that a useful department can be built up—useful not only as a source of revenue to the Institution but as a means of extending acquaintance with the life of this portion of the Pacific. And this acquaintance should be greatly facilitated by the handbook of the marine animals of our shores upon which Mr. A. M. Snook and Dr. Myrtle E. Johnson have been engaged for some time, and which enterprise the Institution is very glad to aid in every way possible.

All the members of the staff attended the scientific meetings in San Francisco and vicinity in August, 1915, as representatives of the Institution in one capacity or another, the Institution contributing part of the expenses. Under present circumstances there can be no doubt about the wisdom of the small expenditures incurred in this way, though this statement implies nothing as to what this or any other institution's general policy ought to be in such matters.

The rather extensive preparation for the "Assembly in Science" at the Institution from June 26 to August 5, 1916, produced disappointing results as far as concerns one of the main objects at which the plan aimed; namely, that of bringing to the Institution science teachers in the secondary schools. On the other hand the response by the general local community was gratifying. Query as to why so few teachers and students availed themselves of what we had to offer has not yet elicited any very satisfactory answer. It is probable, however, that our unwillingness to shape the courses offered in accordance with ordinary college instruction, and to give credits toward a college degree or for other purposes, were influential factors. This "Assembly" was looked upon by the staff from the outset as an experiment, and

whether or not experimenting shall be carried further will have to be decided at an early date.

A week's celebration of the Shakespeare tercentenary was held at the University of Texas in April, 1916. A unique feature of the celebration was the idea of including in it an address on the discovery of the circulation of the blood by Wm. Harvey, the first announcement of which occurred almost simultaneously with Shakespeare's death. The Scientific Director was invited to give this address, the subject chosen being "Know Thyself as Interpreted by Socrates, Shakespeare, Harvey, and Men of Today." While in Austin he also read a paper before the Texas chapter of Sigma Xi on "Are we obliged to assume that life ever arose 'spontaneously'?"

Respectfully submitted,

WM. E. RITTER,
Director.