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Scripps Institution of Oceanography

La Jolla, California, July 1, 1946

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UNIVERSITY OF CALIFORNIA

To the President of the University of California

Sir:

I have the honor to transmit the general report of the Scripps Institution of Oceanography for the biennium July 1, 1944 to June 30, 1946. An appendix to this report gives detailed information about the various phases of the activity at the Institution.

REPORT ON THE ACTIVITY OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY,
BIENNIUM 1944-1946

I. Instruction, Research, and Public Service

Instruction

General Instruction. - Graduate students working towards a higher degree in oceanography or in one of the marine sciences:

1944-45.	Summer term	6
	Fall term	3
	Spring term	3
1945-46.	Summer term	6
	Fall term	4
	Spring term	6

Degrees granted:

William D. Rosenfeld. (Microbiology) Ph. D. June, 1945.

Josephine Beckwith Senn. (Microbiology) Ph. D. June, 1946.

War Instruction.- Eleven courses in sea, swell, and surf forecasting attended by 151 aerological officers of the Navy and 2 officers of the Army Air Forces were given (Contracts N123s-10181-8 and N123s-10181-D1377a). Three courses in oceanography were given to meteorology classes

at the University of California, Southern Section. Since 1943 fifteen such courses have been given and a total of 162 Navy officers and 39 officers of the Army Air Forces have received instruction.

Research.

General Research.-- The general research activity has been greatly curtailed because many of the staff members were on leave with the armed forces or on leave in civilian work.

The topics of research comprise:

Analysis and discussion of phytoplankton collections from the "E.W.Scripps" cruises in 1938, 1940, and 1941 (Mr. W. E. Allen).

Structural colors and pigments of animals, fouling problems, biology of the California sea mussel (Mr. D.L. Fox).

Behavior, distribution, ecology, development, systematics, variations and evolution of fishes (Mr. C.L. Hubbs).

Review of problems in physical oceanography; preparation and extension of auxiliary mathematical tables (Mr. G.F. McEwen).

Agar resources of the west coast, nutrition requirements, respiration, and photosynthetic activity of the seaweeds from which agar is obtained (Mr. C.K. Tseng).

Distribution and physiological activities of marine bacteria in marine sediments, with particular reference to the role of bacteria in the formation and transformation of oil. Research supported by grant from the American Petroleum Institute (Mr. C. E. ZoBell).

War Research.--

Oceanography of the surface layers of the western Pacific with special reference to problems in submarine warfare (Contracts NOd 3427 and 3470) and NObs 2074).

Problems related to forecasting sea, swell, and surf, particularly surf conditions in relation to bottom topography and beach slope (Contracts NObs 16290 and NObs 2490).

Regarding the results of the latter study, Captain H.T. Orville, of the Division of Aerology, Office Chief of Naval Operations, has stated that in his war experience there has been no case in which such a small investment paid such large dividends.

Public Service

General Service.-

Cooperation with the California State Division of Fish and Game in problems related to distribution of fishes (Mr. Hubbs).

Cooperation with the "American Coordinating Committee on Corrosion" in problems related to fouling and corrosion of submerged surfaces (Messrs. Fox, ZoBell).

Advice and assistance to commercial firms engaged in production of agar (Mr. Tseng).

Development of methods for using activity of bacteria in secondary recovery of oil. These methods are now being investigated in the field (Mr. ZoBell).

Assistance to the San Francisco Sardine Association in planning work on experimental fishing cruise (Mr. Sverdrup).

Public lectures to a number of civic groups (Messrs. Fox, Sverdrup, Tseng, ZoBell).

The museum and aquarium open to several thousand visitors.

War Service.-

General supervision of war projects at the Scripps Institution at which on an average thirty persons were employed and to which six to eleven officers were assigned (Mr. Sverdrup).

On leave for duty in the armed forces:

Mr. Roger R. Revelle, Assistant Professor of Oceanography, on active duty with the Navy since July, 1941, now Commander, USNR, attached to Bureau of Ships and the Hydrographic Office. Since 1942 Mr. Revelle has primarily been engaged in the application of oceanographic knowledge to Navy problems. He deserves great credit for having demonstrated to Navy units the value of oceanographic information and for arousing interest leading to the establishment of a Division of Oceanography in the Hydrographic Office, and for the plans for Navy support of oceanographic research. Mr. Revelle has prepared the plans for oceanographic

work in connection with operation CROSSROADS and will be directly in charge of all such work to be undertaken following the test.

Mr. Marston C. Sargent, Instructor in Oceanography, has been on active duty with the Navy since the fall of 1942 and is now Lt. Commander attached to the Bureau of Ships. Mr. Sargent has worked closely with Mr. Revelle and has materially assisted him in his efforts. Mr. Sargent is in charge of the biological surveys prior to and following operation CROSSROADS.

Besides Revelle and Sargent, who were permanent members of the staff, two men, Messrs. John Lyman and Richard B. Tibby who had recently received their training in oceanography at the Scripps Institution, have been in the armed forces and have contributed to the application of oceanography to war problems.

On leave for Civilian War work.-

Mr. Martin W. Johnson, Associate Professor of Marine Biology, on leave since the fall of 1942 and attached to the University of California Division of War Research. Mr. Johnson has primarily been concerned with "biological noises" which disturb reception of under-water sound. He has examined the shrimp noises and a variety of fish noises. He is now attached to operation CROSSROADS where he is in charge of the examination of the zooplankton. The important work to which he has rendered substantial contributions has recently received wide publicity.

Mr. Richard H. Fleming, Assistant Professor of Oceanography, has been on leave since July, 1941, and attached to the University of California Division of War Research, where he has served as Assistant Director during the past two years. On May 1, 1946, Mr. Fleming assumed

the position as head of the new Division of Oceanography in the Hydrographic Office, which can be developed into the most important oceanographic position in the country.

Mr. H. U. Sverdrup has served as special consultant to the Norwegian Government in connection with a contemplated winter invasion of Norway in January - March, 1943; as consultant to the Army Air Forces; consultant to the Army Service Forces; and consultant to the National Defense Research Council, Division 6 (underwater sound). In these capacities he has studied a number of special problems and rendered advice regarding a variety of questions.

In addition to the above, Messrs. K.O. Emery, E. C. La Fond, H. Mann, and W. H. Munk who had received training in oceanography at the Scripps Institution have been engaged in civilian work pertaining to the application of oceanography in the war.

II. Plans for the Biennium 1946-48

Staff

At the beginning of the biennium there will be three vacancies on the staff. Mr. Revelle is expected to remain on leave with the armed forces in 1946-47 attached to the Office of Research and Invention and to return to the Scripps Institution in the summer of 1947.

Mr. Fleming, as stated previously, has accepted the position as head of the new Division of Oceanography, Hydrographic Office, and will not return.

Mr. W. E. Allen who retired in 1943 but has been retained on half time will retire completely on June 30, 1946.

The vacancy left by Mr. E. G. Moberg has been filled by Mr. Norris W. Rakestraw. The filling of the vacancies left by Messrs. Allen and Fleming will be carefully considered, taking into account the fact that research in physical oceanography will be amply supported by Navy funds and that the University funds can be best used in the biological fields. Request for filling these vacancies will not be made prior to January 1, 1947, and possibly not prior to July 1, 1947. When the vacancies are filled the staff will be as large as the facilities of the Institution permit, taking into account that much space is needed for research supported by outside resources.

Instruction

As a result of the greatly increased interest in oceanography a special three-semester course of study has been planned to begin September, 1946. It is expected that about 15 graduate students will enroll in this course. Furthermore, it is expected that about 15 graduate students will be working at the Institution towards a doctor's degree in oceanography or one of the marine sciences. Among these there will be students from Canada, Holland, South Africa, and Egypt.

It appears that during the next few years the Scripps Institution will be a center for training in oceanography because it is at present the only University institution in the United States at which work towards a higher degree in oceanography is offered.

Research

The general research program of the Scripps Institution will remain somewhat curtailed until the above-mentioned vacancies have been filled. It is expected that the American Petroleum Institute research project under Mr. ZoBell will be continued. This project could be greatly expanded if more laboratory space were available.

It is expected that ample funds for research in physical oceanography, submarine geology, and beach problems will be available through contracts with federal agencies. At present the following contracts and amounts are under discussion:

General oceanographic research (Hydrographic Office)	\$100,000
Oceanographic instruments (Bureau of Ships)	16,000
Problems in forecasting coastal fog (Office of Research and Invention)	10,000
Problems in beach erosion (Beach Erosion Board)	10,000 - 20,000

The personnel for carrying out research under contracts as listed above is available, mainly because a number of well trained young men, who served as officers and were assigned to participate in the war research at the Scripps Institution, have decided to remain in this work. These men are capable of dealing with special problems and will take advantage of the instruction offered at the Institution to broaden their background and qualify themselves for studies of wider scope.

Public Service

It can confidently be expected that there will be an increasing demand on the staff of the Institution for assistance in practical problems. The expanded research in physical oceanography and problems

of beach erosion will probably lead to closer contacts with fishery problems and problems of beach structure.

It is hoped that the new museum-aquarium will be very attractive to the public and will give us an opportunity to demonstrate the character and scope of the activity of the Scripps Institution in a much better manner than has been possible to date.

Facilities

The outlook for the Scripps Institution is bright as far as capable staff and adequate funds are concerned, but the problem of space represents a dark picture. Two temporary buildings have been obtained from Camp Callan which will add about 3500 sq.ft. of usable space. An instrument shop is planned in one of these but an amount of about \$25,000 is needed for equipment. With the number of students increase from 6 or 7 to about 30, and the number of employees increased from a pre-war level of about 25 to between 50 and 60, our present buildings will be filled to overflowing. There is no indicate that this is a temporary situation. The worst features are (1) lack of adequate space for carrying on satisfactory instruction of students, (2) lack of space for any expansion in the fields of fish biology to which Mr. Hubbs has attracted a number of able students, (3) lack of space for expansion of bacteriological research for which ample support can be obtained from outside sources, (4) complete lack of space for visiting scientists, (5) lack of an adequate auditorim, (6) lack of space for an adequate instrument shop, and (7) lack of space for handling the increased administration.

The cramped conditions which will make work difficult during the next year and will prevent any further development can only be alleviated by the addition of one large and well-equipped building. Unfortunately, the development of the last year could not be foreseen when the general plans for the post-war building program of the University were prepared. The needs which have arisen here are, however, so acute that I wish to urge the president's office to request a special appropriation for a new laboratory-office building on the La Jolla campus in order that the University may retain a leading position in oceanographic research and instruction. The cost of such a building can roughly be estimated at about \$300,000.

General.-- By means of the adequate funds which have been allotted for the repair of the pier, extension of the sea wall, improvement of the grounds, new museum-aquarium building, changes in the library building, and construction of a service building, the general plant of the Scripps Institution can be expected to be developed in a very satisfactory manner. However, only by adding one large building can full advantage be taken of all the other improvements.

Acknowledgments.-- The resumption in 1946-47 of contribution toward the activities of the Institution by the Ellen Browning Scripps Foundation is gratefully acknowledged. This contribution is more valuable than ever because with federal funds available for research in physical oceanography it is of great importance that the activity in the biological aspects of oceanography be not curtailed. Thanks to the contribution from the Ellen Browning Scripps Foundation, it may even be possible to attain a much desired expansion.

Respectfully submitted

H. U. Sverdrup
Director

APPENDIX

I. RESEARCH ACTIVITY

Physical Oceanography -- Opportunity is taken to review briefly the oceanographic studies under the general direction of Mr. H.U. Sverdrup during the years of the war. These studies fall mainly within four subjects: Examination of the surface layers of the ocean in connection with the submarine warfare; studies of the boundary layer atmosphere-ocean; studies of sea, swell, and surf; and studies of beaches in relation to wave action.

The work on the surface layers of the Western Pacific was primarily directed towards compilations of existing information for the use of submarines or anti-submarine vessels. In preparing these compilations it was often necessary to carry out interpolations and extrapolations because of the few available data, but on the whole the work was of such a nature that it did not lead to any new contributions to our understanding of the regions. During the past year it has been possible, however, to undertake detailed studies of the oceanographic conditions around the islands of Japan, making use of the numerous observations which had been taken by Japanese organizations prior to 1939. As an example of these studies J.C. Armstrong's paper on "The Oceanography of the Kii Suido" is mentioned. In this and other cases the published studies by Japanese oceanographers were inadequate but it was possible to derive considerably more information from their observations than they had extracted. Other areas have been examined in a similar manner and the results will probably be published later.

The examination of the boundary layer problems has dealt with conditions in the atmosphere and in the ocean. When dealing with the atmosphere it has been established that the coefficients of eddy conductivity and eddy diffusivity which apply at indifferent equilibrium are also applicable under unstable conditions, that is, when the air is much colder than the water. Furthermore, it has been found that simple laws are applicable at wind velocities exceeding six meters per second. These conclusions have been used by C.J. Burke for a discussion of the transformation of polar continental to polar maritime air and for the preparation of graphs by means of which the air temperature near the sea surface at different distances from the coast can be forecast if the lapse rate in the outflowing polar air is known. Comparison with observed values has given satisfactory results.

When dealing with the boundary layer in the ocean, J.C. Armstrong has examined the characteristics of the surface layer when cold air flows over the water and has shown that under these conditions static instability is maintained in the sea with temperature slightly increasing and salinity slightly decreasing with depth. In order to account for the observed conditions it was necessary to introduce a coefficient of eddy diffusivity (of salt) much smaller than the coefficient of eddy conductivity (of heat).

A systematic study has been started of the distribution of temperature in the surface layers under different meteorological conditions, making use of bathythermograph observations from weather ships. As yet, only preliminary reports on the findings have been prepared.

In all of these studies monthly charts of sea-surface temperatures and currents have been helpful. These were prepared in 1942 to 1944. At present, an investigation is in progress dealing with the proper inter-

pretation of vector averages used in presentation of currents.

In the summer of 1943 H.U. Sverdrup and W.H. Munk carried out a theoretical study of the growth of waves under the influence of the wind. This study has been revised in the spring of 1946 and has been submitted to the Hydrographic Office for publication. Definite relations are established between wind, fetch, and duration on the one hand, and wave characteristics on the other hand, which have been used extensively during the war for forecasting sea and swell on the basis of weather maps from ocean areas. During the war about two hundred weather officers of the Army and Navy obtained special training at the Scripps Institution in the use of these methods.

A great deal of work was devoted to the study of the transformation of waves as they travel from deep to shallow water and to the relation between swell and surf. The studies covered such subjects as the velocity of progress in shallow water, the effect of shoaling bottom in the bending of waves (refraction), height of breaker in relation to height of swell, and relation between height of breaker and depth of breaking. An example of these studies is contained in a paper by R.S. Arthur on refraction around a circular island. It is expected that several other studies will be published in the near future. A number of the results as to waves in shallow water obtained at Woods Hole, the Department of Mechanical Engineering at the University of California at Berkeley, and at the Scripps Institution were applied to the problem of depth determination by means of aerial photographs of waves and to other problems in amphibious warfare.

A number of systematic measurements of beach profiles and studies of sand movement have been undertaken in localities where the characteristics of the surf have been studied simultaneously. Results have been incorporated in reports with bearing on problems encountered in landing operations, but as yet no scientific papers have been published.

As an activity carried out in connection with war research, during the spring of 1946 the Utility Squadron 7 of Fleet Air West Coast took a series of photographs of dye bombs in order to examine the rapidity with which the colored area spreads as a result of processes of diffusion. The experiments show that these processes are extremely irregular, but they also indicate that the "diffusion coefficient" which can be introduced is proportional to the dimensions of the diffusing area. These studies led to some of the theoretical work reported by G. F. McEwen.

During the biennium critical reviews were made by Mr. McEwen of the results of earlier researches involving oceanic circulation, the distribution of temperature and salinity, and the accompanying processes of turbulent diffusion and evaporation. Also, additional translations and abstracts of literature pertaining to these subjects were made. Moreover, certain aspects of these earlier researches, including a variety of separate problems, were of a preliminary nature and required revision. In particular, several earlier basic mathematical tables have been prepared as required. These computations involved a number of special problems and required a good deal of time. The effort devoted to all of the various fundamental aspects of the general research program is justified, however, because it is intended to form a basis for working on various specific problems involving a large amount of observational

material and requiring table space, the integrator, and other facilities that will soon be available again.

While Mr. McEwen was carrying on the program outlined above, assistance in the mathematical aspects of various problems was given as requested by workers on the war projects. Fortunately, the experience gained while conducting these fundamental investigations were very helpful in carrying on the supplementary work of the war project.

A paper now in press on "The reality of regularities indicated in sequences of observations" was presented by Mr. McEwen at the Symposium on Mathematical Statistics and Probability held in the University of California at Berkeley during August 13-18, 1945.

The usual observations of temperature, salinity, and weather at our shore stations have continued, but the supplementary observations from the United States Lighthouse tender were terminated in December, 1944. There were about 1800 salinity observations, 1800 temperature observations, and 1500 wind observations. Barograph and pyrheliometer records and daily observations of humidity and temperature were continued as before. Results of the 1941 cruises of the "E.W.Scripps" are being prepared for publication.

Chemistry -- The facilities in the Chemistry Division have been used primarily by workers from other divisions or projects. The office and one room have been occupied by Mr. McEwen whose accomplishments in the field of physical oceanography are reported above. One laboratory, the constant temperature room, and the Division facilities in general have been used in the research work of V.J. Senn and C.K. Tseng, reported below. Another laboratory has been used by A.P.I. Research Project 43A workers under the supervision of C.E. ZoBell.

During the time he was in residence in 1944-45, E.G. Moberg devoted his time to arranging, plotting, and analyzing certain previously accumulated data, with particular reference to the calcium and phosphate content of sea water. The hydrogen-ion concentration and the buffer mechanism of sea water also received attention. Mr. Moberg has been on leave of absence during the year 1945-46.

Agar Research -- During the biennium Mr. C.K. Tseng continued his field investigation of agar resources, laboratory culture of the two principal agarophytes, Gelidium cartilagineum and Gracilaria confervoides, and research on the inorganic nutrition and photosynthetic activity of these plants. Mr. V.J. Senn of the U.S. Fish and Wildlife Service cooperated with Mr. Tseng on the analysis of the agar content of about 150 samples of seaweeds from various sources. Mr. Senn also continued his technological investigations on the improvement of the methods of agar extraction. Dr. Beatrice M. Sweeney continued as visiting investigator, working with Mr. Tseng on photosynthesis of seaweeds.

Mr. Tseng had been in close contact with the agar concerns in California, North Carolina, and Florida, which have received much help and advice from the Scripps Institution and, in turn, these concerns have provided valuable information regarding the manufacture and production of agar. This cooperation has enabled Mr. Tseng to prepare a series of articles on "America's agar industry." There has been similar cooperation with processors of Irish moss (carrageen) and kelp (algin).

Prerequisite for the development of the seaweed industry in California, considerable quantitative work has been done in the field on the seaweed resources of the State and data have also been obtained from the State Division of Fish and Game and other reliable sources. This information has been compiled for publication. A complete bibliography on seaweed utilization and chemical technology of seaweed products has also been prepared.

It has been found that the apical growth rate of ~~the~~ Gelidium, the seaweed from which agar is obtained, is very slow, being about 1 to 3 cm per month. There are always more tetrasporic plants than the sexual ones, the ratio being approximately 4:1. Gelidium has the ability rapidly to regenerate the stem tips which are commonly eaten by animals or torn away by wave action. Laboratory experiments indicated that complete generation of new tips may take place within two or three days. Plants resulting from the germination of Gelidium spores have been maintained in the laboratory for about two months. Because of certain unknown factors, however, growth stops at the end of this period. Experiments are being carried on in order to find out the governing factors involved. A rather complete picture of the life history of the first two months after spore germination has been obtained. By agitating the water, older specimens of Gelidium have been maintained in the laboratory for several months.

Gracilaria is an agarophyte which grows in environments quite different from those in which Gelidium grows. Gracilaria is found near estuaries and in sheltered bays. Unlike Gelidium, Gracilaria grows fast and seasonally. It begins to appear in April or May and in one

month may grow three or four feet in length. The water in which Gracilaria is growing rapidly has been found to be 200 per cent saturated with oxygen. Ammonium is quite toxic to Gracilaria but not to Gelidium. While ammonium bicarbonate has been used with success to supply the needed carbon dioxide for the cultivation of Gelidium, this compound can not be used for the cultivation of Gracilaria because the introduction of only 0.0005M ammonium bicarbonate is lethal. On the other hand, Gracilaria can tolerate high pH and thus can grow in culture solutions enriched with sodium bicarbonate, while Gelidium cannot. Experiments are being conducted on the effects of salinity and different cations on these plants. Maximum photosynthetic activity of Gelidium occurs in nutrient solutions containing about 0.0015M bicarbonate; the maximum for Gracilaria exceeds 0.003M bicarbonate. Some work has also been done on the extraction of the chlorophyll from these seaweeds and on the rate of photosynthesis under different light rays and intensity.

Biochemistry and Physiology -- During 1944-45 Mr. D.L. Fox served on the doctoral committees of several graduate students but conducted no formal courses and had no regularly assigned research assistants, two such men being on war leave. Research on antifouling measures for marine instruments and other submerged surfaces was brought to a close. Explorations into various environmental factors which influence the growth rate and reproductive cycles of sedentary invertebrates were continued. The survey of structural colors and pigments of animals was resumed. During 1945-46, Mr. Fox has been on sabbatical leave from University duties while preparing a monograph on animal biochromes, for which work he has held a Guggenheim Memorial Fellowship.

Working in Mr. Fox's division during the biennium were Messrs. Fox, W.R. Coe, and W.D. Rosenfeld, and Mrs. Josephine Beckwith Senn. Mr. Rosenfeld and Mrs. Senn, while occupying laboratory space in this division, were both pursuing problems in API Research Project 43A under the direction of Mr. ZoBell who has reported on the character of their researches. Dr. F.M. McFarland, Professor Emeritus of Histology at Stanford University, gathered specimens and information in furtherance of his monography on the nudibranch mollusks of the Pacific Coast while at the Institution from March 8-29, 1946. Dr. C.E. Moritz of the U.S. Naval Ordnance Laboratory spent two weeks in the division in the spring of 1945.

Mr. Coe, Professor Emeritus of zoology, Yale University, has continued his studies on the nutrition, growth, distribution, and resurgent populations of marine invertebrates and has added much to our knowledge of the bathypelagic nemertean worms of the Bermuda area and their means of dispersal. He has named a subspecies of marine mussel, Mytilus edulis diegensis, which established itself suddenly in 1943, multiplying rapidly to vast numbers in the ocean and bay waters of this vicinity, and at one season crowding out the sea mussel, Mytilus californianus from its established position on the pier pilings of the Scripps Institution. He has made a study of the nutrition and growth rate of the newly named subspecies, parallel to the earlier investigations conducted jointly with Mr. Fox on the sea mussel. Mr. Coe has contributed important evidence to our conclusions regarding the subsistence of Mytilus and similar pelecypod mollusks primarily upon marine detritus. He has observed that large numbers of dinoflagellates, s.g., Prorocentrum

micans, a common species in these waters, pass through the gut of such mollusks undigested. He has furthermore actually recovered and cultured living dinoflagellates and diatoms from fecal masses taken from the rectal segment of such animals.

Returning students who will resume research work towards the doctoral degree in this division are Mr. David M. Updegraff, who served as a commissioned officer in the U.S. Navy from August 1942 until December, 1945, and Mr. Sheldon C. Crane, who was engaged in war research at the California Institute of Technology from January, 1943 until June, 1946. Dr. Henry Kritzler will arrive as a National Research Fellow in Zoology to pursue research concerned with the biochemistry of pigments in marine animals.

During the biennium Mr. Fox held the following offices: Biochemist on the Research and Hospital Committee, San Diego Zoological Society; treasurer, San Diego Scientific Library Association; member of the Council, AAAS; biochemical consultant to A.P.I. Project no. 43A, assigned to the Scripps Institution; member of the board of directors, La Jolla Visiting Nurse Association (chairman of Headquarters Committee).

Marine Microbiology -- The research program under the direction of Mr. C.E. ZoBell has continued to emphasize a study of the distribution and physiological activities of bacteria in marine sediments, with special reference to the role of bacteria in the formation and transformation of oil. This work has been aided by generous grants from the American Petroleum Institute and by the close cooperation of an Advisory Committee of technically trained men appointed by the A.P.I. Also participating on A.P.I. Research Project 43 are biochemists at Penn

State College and geophysicists at M.I.T. Certain practical problems which developed from the fundamental investigations in progress at the Scripps Institution are being exploited for the benefit of the public by the Pennsylvania Crude Oil Association.

The synthesis of hydrocarbons by marine bacteria has been confirmed. Sulfate reducers were found by Mr. G.J. Jankowski to be endowed with the ability to assimilate fatty acids with the formation of petroleum-like substances. The oily or waxy substances formed by bacteria are produced intracellularly, probably as a component of bacterial cells.

Lipolytic anaerobes have been shown by Mr. W.D. Rosenfeld to attack a large variety of fats and other lipids in the absence of oxygen. A gradual increase in the ratio of unsaponifiable to saponifiable material in a mass of decomposing marine algae indicated that lipolytic anaerobes were deoxygenating the fatty acids. The unsaponifiable material was an oily or waxy ether-soluble substance which consisted almost exclusively of hydrogen and carbon. The reduction or hydrogenation of unsaturated compounds by lipolytic anaerobes has been indicated by decreases in the iodine number. Much useful information has been obtained on the mechanisms whereby bacteria catalyze the removal of oxygen from organic compounds and how hydrogen is introduced into molecules. Repeated efforts have failed to demonstrate the direct decarboxylation of fatty acids, but certain amino acids are decarboxylated by bacteria found in marine sediments.

Mrs. Margaret Hawksley, working under the supervision of Mr. Rosenfeld, investigated the metabolism of lipids by 31 cultures of sulfate reducers. Many of the latter were found to be able to

hydrolyze various kinds of fats under conditions designed to simulate the natural environment of marine bottom deposits.

Bacteria which produce free hydrogen from the fermentation of organic matter have been shown by Mrs. Josephine Senn to be rather widely distributed in both recent and ancient marine sediments. Polyhydroxy compounds have proved to be the best substrates for the bacterial liberation of hydrogen. Methane results from the bacterial reduction of carbon dioxide by hydrogen, and there is indirect evidence which suggests that bacteria may catalyze the hydrogenation of unsaturated compounds, thereby forming compounds which are more petroleum-like.

Since joining the microbiology group in January 1946, Miss Helen Hölston has been working on the factors which influence the rate at which crude oil is modified or destroyed by bacteria. It is not uncommon to find in marine sediments bacteria which readily attack crude oil. The activities of such bacteria may help to account for the absence of oil from certain subterranean deposits where geological and paleontological evidence indicates oil should be found. Such bacteria also may have played a role in modifying crude oil throughout the geological ages.

In continuing the observations on the oxidation of hydrocarbons by sulfate reducers, Miss Jean E. Switzer has found that several aliphatic hydrocarbons of greater chain length than decane are oxidized under anaerobic conditions. Aromatic and naphthenic hydrocarbons appear to be more resistant to attack by anaerobes than aliphatic compounds. Relatively small concentration of cyclic compounds inhibited the growth of sulfate reducers. Emulsifying liquid and solid hydrocarbons in culture media with a Waring blender and hand-operated homogenizer has rendered the hydrocarbons more susceptible to attack by bacteria. A 90-page monograph on the bacterial utilization of hydrocarbons has been

prepared by Mr. ZoBell.

Mr. W.E. Hutton has been perfecting techniques for the cultivation of methane-oxidizing bacteria. The objective of these experiments is to gain information on the ecology, taxonomy, and physiology of methane oxidizers, with special reference to their role in petroleum formation and soil fertility.

Mr. ZoBell's studies indicate that bacteria are the principal dynamic agents which influence the redox potential of marine bottom deposits. The redox potential in turn appears to influence the formation and preservation of petroleum hydrocarbons in marine sediments. Although the redox potential of samples of recent marine sediments has been found to become more negative by an average approximating the theoretical value of 60 millivolts for each unit increase in pH at 30°C, the E_h/pH slope for individual mud samples ranged from 54 to 117 millivolts. The E_h of mud samples varied capriciously with temperature changes.

Dr. Jay V. Beck and Dr. J.C. Ireland, who were employed by the Penn Grade Crude Oil Association to work on the bacterial release of oil from petroliferous sediments, each spent a month with Mr. ZoBell at the Scripps Institution studying thigmotactic bacteria. This work is an outgrowth of the discoveries of Institution microbiologists that certain types of bacteria found in the sea promote the release of oil from solids. The possibilities of employing such bacteria in the secondary recovery of oil are being investigated in the field and laboratory at Bradford, Pa., where unique geological formations and water-flooding procedures are favorable for such experiments.

Assisted by Miss Barbara F. Brown, transplants of the sixty new species of marine bacteria described by Messrs. ZoBell and Upham

were prepared for the American Type Culture Collection. Transplants of these bacteria have also been sent to several other laboratories.

Phytoplankton -- Except for brief attention to dinoflagellate abundances in pier collections in order to obtain some supplementary data for Mr. W.R. Coe and some details in the occurrence of "red water" of 1945, Mr. W.E. Allen has devoted most of his time to the preparation and completion of the general report on the Cruises of the "E.W. Scripps" in 1941. However, this preparation involved assemblage of many data in tables and charts which could be used also for more specialized study of such items as distribution of diatom species, depth relationships in different localities and sections, seasonal differences in the influences of bottom topography (especially ridges and basins), and several problems of zonation which invite more attention than it was possible to give them in the primary report. This primary report required so much time for its completion that there has been no opportunity to make further progress toward the more comprehensive supplementary report.

Daily collection of phytoplankton material has been continuous at the Scripps Institution pier and near the lighthouse near Pt. Hueneme since 1919, but the local collections have not been worked over for the full year since 1943, for Pt. Hueneme not since 1942. However, enough attention has been given to them to obtain special information about "red water" occurrences and to show that each year has its own peculiarities of seasonal distribution of phytoplankton.

Although he retired in 1943, Mr. Allen has been retained on a half-time basis. He will retire from further active service at the end of the present fiscal year. The vacancy left by his retirement will probably be filled during 1947 in order to provide for a continuation of the work on phytoplankton.

Biology of Fishes -- Mr. F.B. Sumner retired in 1945 and his place as head of the division was taken on October 1 by Mr. C.L. Hubbs, who is now giving greater emphasis to systematics, speciation, zoogeographical and ecological research, with particular reference to marine fishes. Mr. Sumner continued his work on animal coloration and the response of fishes to light until his death on September 6th.

Mr. Hubbs has devoted some time to the completion of research projects started at the University of Michigan, but new field and laboratory studies on Pacific Coast fishes were actively prosecuted. Numerous additions were made to the lists of species known from southern California and from northern Baja California. The occurrence of northern fish types in local areas of upwelling cold water was established by the first field work in Lower California. At least one new species was discovered, three unnamed forms were verified as distinct, five others were resurrected from synonymy, and several very rare species were collected. Much variational data was accumulated on various coastal fishes and large series were collected and preserved for racial analyses in certain genera, including Atherinops and Syngnathus. A manuscript on variability in the deviation of the Pacific lamprey was completed.

Work on the nature of the colors in Rimicola, aided by advice from Mr. Fox, was carried far enough to demonstrate that new types of pigments are present and that the hitherto confounded species in this genus have distinct pigment systems. Experiments indicated that the color phases of the kelp blenny Heterostichus change with altered environment. Many detailed observations, with some experiments, were made on the remarkably well defined territory-holding habits of certain

blennies (Hypsoblennius and Gibbonsia), and the breeding habits of Hypsoblennius were observed and described.

Hitherto unrecorded habitat niches were recognized for several species and further analyses were made of the fish faunas of certain communities, particularly in bays and in the littoral zone of the open coast. With the cooperation of Philip R. Park, Inc., and the Kelco Company a study was begun of the neglected fish fauna of the kelp beds. This work, along with racial studies on fish species of commercial importance, a study of the fauna of the little exploited moderate depths off the coast, and some advisory consultation, has lent a degree of economic significance to the work of the division. Cooperation in such research has been established with the California Division of Fish and Game and other agencies.

Other researches on fishes included detailed correlation of the spawning of the grunion with the phase of the moon and with the tide, early stages and relationships of the California flying fish, analysis of sexual dimorphism in meristic numbers in two viviparous perches, and ecotypic differentiation in marine fishes.

Two species of whales new to the known fauna of western United States (one new for the North Pacific) were found by Mr. Hubbs and reported upon for publication. Studies were made of synchronous diving behavior of grebes and other birds.

Researches on the biology of sex in fishes were continued under a grant from the National Research Council. Stocks of Molliensia, including the unique kind that invariably produces only female offspring, with strictly maternal inheritance, have been established in a room

equipped for freshwater aquaria. The Committee for Research in Problems of Sex of the National Research Council has renewed the grant for the following year, to allow a continuation of the experimental work for Mollensia and to aid in analyses on the sexual variations, established in early embryonic life, in the variation in the number of fin rays and of vertebrae in certain viviparous fishes.

A general report was completed on the correlation between fish distribution and past hydrography in the Great Basin. Mr. Hubbs spent three months during 1946 on research in eastern museums and universities.

In the research work of the division effective assistance was given by Miss Elizabeth Kampa, principal laboratory technician, serving under the joint auspices of the University and the National Research Council; Mrs. Laura C. Hubbs, who worked nearly full time as volunteer assistant and collaborator; and Fred H. Stoye of New York, who assisted in the field and laboratory work for several weeks and who gave other personal and financial assistance.

Boyd W. Walker enrolled as a graduate student and spent 1946 at the Institution on his doctoral research (speciation in California atherine fishes). He is also studying the timing of the grunion spawning runs in reference to lunar and tidal cycles. George F. Weisel, Jr., also enrolled as a graduate student and did some research at the Institution on his doctoral problem (effects of hormones on reproduction and color of fishes). He also worked on the breeding habits and early stages of the long-jawed goby. During the second semester he took courses at U.C.L.A.

Through the year Mr. Hubbs continued to serve as review editor of the American Naturalist and as associate editor of the Wildlife Society. He also served as a director of the San Diego Society of Natural History. In April, 1946, he was elected president of the American Society of Ichthyologists and Herpetologists, and he inaugurated a revolving research fund in this society. He participated in several scientific meetings.

No specific war projects or government assignments were undertaken but considerable time was devoted to cooperation with the State Division of Fish and Game. On several occasions assistance and advice was given on war-research projects. As usual, many requests for information from the public were attended to. Assistance was given the Steinhart Aquarium in collecting fish for display. Many specimens were collected for museums in California and the east.

II. LIBRARY AND PUBLICATION OF PAPERS

The library has continued to be in charge of Miss Ruth Ragan who has had clerical assistance for short periods from Mrs. Ruth Novelli and Mrs. Martin Johnson, and part-time assistance from Mrs. Barbara Peterson for more than a year. The library is in great need of a full-time assistant, especially with the expected expansion of the Institution and greater use of the library's facilities.

The number of bound volumes in the library has increased to 21,065 with the addition since July 1, 1944, of 753 volumes of which 210 were gifts and exchanges. Special attention has been paid to increasing the abstracting and bibliographical helps in the reference room. Some valuable oceanographic material from Germany and Japan has been received through the Hydrographic Office of the U.S. Navy.

During the war the publications of the Institution intended for exchange with institutions in foreign countries were allowed to accumulate. Since the end of the war all material has been distributed except to those countries in which mail is not yet accepted. The 1945 volume of the "Contributions" of the Institution is ready for distribution.

The library has continued to serve several war projects, furnishing books and charts, as well as lists of material available on special subjects. The interlibrary loan service has greatly expanded, both in borrowing and lending material.

Miss Ragan, as a member of the interlibrary Library Council of the University, appointed by the President, attended the first meeting of the Council at Santa Barbara in April, 1946.

List of Papers Published -- The following papers, "Contributions of the Scripps Institution of Oceanography," have been published between April 15, 1944 and June 15, 1946 by members of the staff and visiting scientists:

	<u>Contribution</u> <u>No.</u>
Allen, W.E. Occurrence and abundance of marine plankton diatoms offshore in southern California. Amer. Microsc. Soc., Trans., v.64, p.21-24, January, 1945. - - -	249
- - Seasonal occurrence of marine plankton diatoms off southern California in 1938. Scripps Inst. Oceanogr., Bull., v.5, p.293-334, March, 1945. - - -	245
- - Significance of "red water" in the sea. Turtox News, v.24, 2pp. Feb., 1946. - - - - -	287
- - Vernal distribution of marine plankton diatoms offshore in southern California in 1940. Scripps Inst. Oceanogr., Bull., v.5, p.335-370, 1945. - -	258
Arthur, Robert S. Refraction of water waves by islands and shoals with circular bottom contours. Amer. Geophys. Un., Trans., v.27, p.168-77, April, 1946. - - - -	282
Burke, Cletus J. Transformation of polar continental air to polar maritime air. Jour. Meteorology, v.2, p. 94-112, June, 1945. - - - - -	275
Coe, Wesley R. Development of the reproductive system and variations in sexuality in Pecten and other pelecypod mollusks. Conn. Acad. Arts and Sci., Trans., v.36, p.673-700, 1945. - - - - -	255
- - Francis Bertody Sumner, Science, v.102, p.344-46, Oct.5, 1945. - - - - -	264
- - Geographical distribution of the nemertean of the Pacific coast of North America, with descriptions of two new species. Washington Acad. Sci., Jour., v.34, p.27-32, 1944. - - - - -	216
- - <u>Malacobdella minuta</u> , a new commensal nemertean. Washington Acad. Sci., Jour., v.35, p.65-67, Feb., 1945.	243
- - The nemertean Gorgonorhynchus and the fluctuations of populations. Amer. Naturalist, v.78, p.94-96, 1944.	218

	<u>Contribution</u>
	<u>No.</u>
Coe, Wesley R. Nemerteans from the northwest coast of Greenland and other Arctic seas. Washington Acad. Sci., Jour., v.34, p.59-61, 1944. - - - - -	217
- - A new species of hoplonemertean (<u>Paranemertes biocellatus</u>) from the Gulf of Mexico. Washington Acad. Sci., Jour., v.35, p.407-09, 1944. - - - - -	241
- - Nutrition and growth of the California bay-mussel (<u>Mytilus edulis diegensis</u>). Jour. Exper. Zool., v.99, p.1-14, 1945, - - - - -	248
- - Plankton of the Bermuda oceanographic expeditions. XI. Bathypelagic nemerteans... - - - - -	261
- - A resurgent population of the California bay-mussel (<u>Mytilus edulis diegensis</u>). Jour. Morphology, v.78, p.85-103, 1946. - - - - -	284
- - Sexual differentiation in mollusks. II. Gastropoda, Amphineurans, Scaphopods, and Cephalopods. Quart. Review of Biol., v.19, p.85-97, 1944. - - - - -	224
Coe, Wesley R., and Denis L. Fox. Biology of the California sea-mussel (<u>Mytilus californianus</u>).III. Environmental conditions and rate of growth. Biol. Bull., v.87, p.59-72, 1944. - - - - -	233
Doudoroff, Peter. The resistance and acclimatization of marine fishes to temperature changes. II. Experiments with Fundulus and Atherinops. Biol. Bull., v.88, p.194-206, 1945. - - - - -	253
Emery, K. O. Beach markings made by sand pipers. Jour. Sedimentary Petrology, v.14, p.26-28, 1944. - - - - -	220
- - Entrapment of air in beach sand. Jour. Sedimentary Petrology, v. 15, p.39-49, 1945. - - - - -	260
- - Transportation of marine beach sand by flotation. Jour. Sedimentary Petrology, v.15, p.84-87, 1945. - - - - -	268
Emery, K. O., and F. P. Shepard. Lithology of the sea floor off southern California. Geol. Soc. Amer., Bull., v.56, p.431-478, 1945. - - - - -	251
Fox, D. L. Biochemical fossils. Science, v.100, p.111-13, 1944. - - - - -	232
- - Blochromes. Science, v.100, p.470-71, 1944. - - - - -	240
- - Fossil pigments. Scientific Monthly, v.59, p.394-96, 1944. - - - - -	239

	<u>Contribution</u>
	<u>No.</u>
Fox, D.L., and C.F.A. Pantin. Pigments in the Coelenterata. Biol. Reviews, Cambridge Philos. Soc., v.19, p.121-34, 1944	237
Fox, D.L., D.M. Updegraff, and G.D. Novelli. Carotenoid pigments in the ocean floor. Archives of Biochemistry, v.5, p.1-23, 1944. - - - - -	236
Graham, H.W., and E.G. Moberg. Chemical results of the last cruise of the "Carnegie." Carnegie Exped., Cruise VII, Scientific Results, Chemistry, I, p.1-58, 1944.	238
Hubbs, Carl L. California searobin (<i>Prionotus stephanophrys</i>), a fish new for the fauna of southern California. Calif. Fish and Game, v.31, p.195-200, 1945. - - -	267
- - Francis B. Sumner, 1874-1945. Copeia, p.183-84, 1945. - - - - -	263
- - Record of a fish, <i>Scorpaena mystes</i> , from California; A comedy of errors. Copeia, p.129-33, 1945.	262
- - Wandering of pink salmon and other salmonid fishes into southern California. Calif. Fish and Game, v.32, p.81-86, 1946. - - - - -	278
Hubbs, C.L., and P.N. Clark. Occurrence of the bramble shark (<i>Echinorhinus brucus</i>) in California. Calif. Fish and Game, v.31, p.64-67, 1945. - - - -	250
Revelle, R.R. Marine bottom samples collected in the Pacific Ocean by the "Carnegie" on its seventh cruise. Carnegie exped., Cruise VII, Scientific results, Oceanography, II, p.1-180, 1944. - - - - -	242
Senn, J.B. A simple device for the addition or removal of solutions or gases to a closed system. Science, v.101, p.392, 1945. - - - - -	254
Sumner, F.B. The cause must have had eyes. Scientific Monthly, v.60, p.181-86, 1945. - - - - -	246
- - Pigment and biochrome. Science, v.101, p.114, 1945.	244
- - Vision and guanine production. Nat. Acad. Sci., Proc., v.30, p.285-94, 1944. - - - - -	235
- - William Emerson Ritter: Naturalist and philosopher. Science, v.99, p.335-38, 1944. - - - -	223

	<u>Contribution</u>
	<u>No.</u>
Sverdrup, H.U. The California Current. Pages 97-111 in Science in the University. Univ. Calif. Press, 1944.	227
- - - Oceanography. Pages 1032-56 in <u>Handbook of Meteorology</u> , McGraw-Hill, 1945.	269
Sverdrup, H.U., and Staff. Oceanographic observations on the "E.W.Scripps" cruises of 1940. Scripps Inst. Oceanogr., Records of Observations, v.1, no.3, p.161-248, 1944.	225
- - - Research within physical oceanography and submarine geology at the Scripps Institution of Oceanography during April, 1943, to April, 1944. Amer. Geophys. Un., Trans., v.25, p.605, 1945.	257
- - - Research within physical oceanography and submarine geology at the Scripps Institution of Oceanography during April, 1944, to April, 1945. Amer. Geophys. Un., Trans., v.26, p.127-28, 1945.	270
Tseng, C.K. Agar: A valuable seaweed product. Scientific Monthly, v.58, p.24-32, 1944.	215
- - - America's agar industry. Food Industries, v.17 (in nos.1-3), 1945.	247
- - - Colloids from kelp. Chem. and metallurg. engineering, 4 pp., June, 1945.	256
- - - Notes on terminology of seaweed colloids. Science, v.101, p.597-602, 1945.	259
- - - Phyocolloids; usefull seaweed polysaccharides. Pages 629-734 in v.6 of Jerome Alexander's <u>Colloid Chemistry</u> , Reinhold, 1946.	252
- - - A seaweed goes to war. California Monthly, 4 pp., 1944.	221
- - - Seaweed products and their uses. N.Y. Botan. Garden, v.47, 39p., Jan., Feb., 1946.	276
- - - The terminology of seaweed colloids. Science, v.101, p.597-602, 1945.	259
- - - Utilization of seaweeds. Scientific Monthly, v.59, p.37-46, 1944.	229
Worley, L.G. Studies of the vitally stained Golgi apparatus. II. Yolk formation and pigment concentration in the mussel <i>Mytilus californianus</i> Conrad. Jour. Morph., p.77-95, 1944.	222
- - - Idem. III. The methylene blue technique and some of its implications. Jour. Morph., v.75, p.261-89, 1944.	234

	<u>Contribution</u>
	<u>No.</u>
ZoBell, C.E. Functions of bacteria in the formation and accumulation of petroleum. Oil Weekly, 8 p., Feb. 18, 1946	277
- - Marine microbiology: A monography on hydrobacteriology. 240p., Chronica Botanica, 1946. - - -	280
- - The role of bacteria in the formation and transformation of petroleum hydrocarbons. Science, v.102, p.364-69, 1945. - - - - -	265
- - Transformation of organic material into petroleum - bacteriological and sedimentation phases. p.103-04 in <u>Fundamental Research on Occurrence and Recovery of Petroleum for 1943</u> . Baltimore Press. 1944. - -	266
- - The study of the sea and its relation to man. Pages 231-245 in <u>Science in the University</u> . Univ. Calif. Press, 1944. - - - - -	228
ZoBell, C.E., and J.D. Beckwith. The deterioration of rubber products by microorganisms. Amer. Water Works Assn., Jour., v.36, p.439-453, 1944. - - - -	219
ZoBell, C.E., and B.F. Brown. Studies on the chemical preservation of water samples. Jour. marine research, v.5, p.178-84, 1944. - - - - -	231
ZoBell, C.E., and H.C. Upham. A list of marine bacteria including descriptions of sixty new species. Scripps Inst. Oceanogr., Bull., v.5, p.239-292, 1944. - - - -	226
<u>Papers in Press</u> -- Most of the following papers by members of the staff and visiting scientists are expected to appear in the near future:	
Allen, W.E., "Red water" in La Jolla Bay in 1945. Amer. Microsc. Soc., Trans. - - - - -	283
Barnhart, P.S., and C.L. Hubbs, <u>Pontinus vaughani</u> , a new scorpaenid fish from Baja California. Scripps Inst. Oceanogr. Bull. - - - - -	281
Fox, Denis L. Francis Bertody Sumner (1874-1945). Amer. Philos. Society, Year book. - - - - -	272
Hubbs, C.L. Francis Bertody Sumner. Anatomical Record. -	274

	<u>Contribution</u>
	<u>No.</u>
Hubbs, C.L., and Laura C. Hubbs. Natural hybrids between two species of catostomid fishes. Michigan Acad. Sci., Papers	285
McEwen, G.F. The reality of regularities indicated in sequences of observations. Symposium on mathematical statistics and probability. - - - - -	
Sverdrup, H.U. The humidity gradient over the sea surface.	271
ZoBell, C.E. Characteristics of water bacteria. Nat'l Assn. Sanitarrians, Jour. - - - - -	286
- - Studies on redox potential of marine sediments. Amer. Assn. Petrol. Geol., Bulletin. - - -	279
Anderson, C.A. The 1940 "E.W.Scripps" cruise to the Gulf of California; Geology of islands and neighboring land areas. Geol. Soc. America. - - - -	In press
Durham, C.W. The 1940 "E.W.Scripps" cruise to the Gulf of California; Megascopic paleontology and marine stratigraphy.	In press
Shepard, F.P. Submarine topography of the Gulf of California.	In press

III. INSTRUCTION AND STUDENTS

The following graduate students have been registered during the biennium:

1944-45. Burke, C. J. Burke	Summer term
Jankowski, Gregory	Summer term
Munk, Walter H.	Summer term
Novelli, G. David	Summer term
Rosenfeld, William D.	Throughout the year
Senn, Josephine Beckwith	Throughout the year
Switzer, Jean	Fall, Spring

Mr. William D. Rosenfeld was awarded the doctor's degree in June, 1945.

1945-46.	Arthur, Robert S.	Throughout the year
	Burke, C. J.	Summer, Fall
	Hamilton, Clara E.	Summer term
	Hutton, William E.	Summer, Spring
	Leipper, Dale F.	Spring term
	Munk, Walter H.	Throughout the year
	Senn, Josephine B.	Throughout the year
	Walker, Boyd	Spring term

Mrs. Josephine Beckwith Senn was awarded the doctor's degree in June, 1946.

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

IV. VISITORS

Visiting investigators during the biennium, not including those on war projects, with the subjects upon which they worked, were as follows:

Dr. Edgar Anderson, Washington University, St. Louis. Problems in evolution. January 12-22, 1945.

Dr. Frances N. Clark, California Division of Fish and Game. Various times throughout the year.

Dr. W. R. Coe, Prof. Emeritus, Yale University. Studies on marine invertebrates. Throughout the year.

Mrs. Laura C. Hubbs. Volunteer assistant in fish research. Throughout the year.

Dr. J.C. Ireland and Dr. J.V. Beck. Penn Grade Crude Oil Assn. Thigmotactic bacteria. February, March, 1945.

Dr. F. M. MacFarland, Calif. Acad. of Sciences. Nudibranch mollusks.
March 8 - 29, 1946.

Mr. Vincent Senn, U.S. Fish and Wildlife Service. Studies on agar.
Throughout the year.

Mr. Fred Stoye, New York. Color adaptation in fishes. February, 1946.

Dr. Beatrice M. Sweeney. Volunteer assistant in agar research. Various times
throughout the year.

Dr. R. T. Young, Prof. Emeritus, University of Montana. Investigations in
marine biology. Throughout the year.

V. MUSEUM AND AQUARIUM

In order to make space for navy personnel the curator, Mr. P. S. Barnhart, was asked to give up his pleasant office room and the board room. All of the office equipment was moved to the basement laboratories and the large cases containing the shell, marine bird, and marine herbarium collections were moved from the board room out into the main museum.

During the biennium the following mounted specimens of fishes were added to the museum exhibit:

Midshipman, Porichthys notatus Girard.

Speckled ragfish, Icosteus aenigmaticus Lockington.

Horned shark, Gyropleurodus francisci Girard.

Tidepool sculpin, Clinocottus analis Girard.

Leiocottus hirundo Girard, a small rare fish from deep water.

Bonito shark, Isurus glaucus (Gill), a forty-six inch specimen.

Monterey skate, Raja montereyensis Gilbert.

The addition of these specimens make a total of 95 mounted fishes of this region in the museum exhibit.

New accessions to the research collections included the following:

Speckled ragfish, Icosteus enigmaticus Lockington from the Lower California Fisheries Company.

Holothurian, a large sea-cucumber from the New Hebrides, not yet identified, given by Lt. Jay Rockwell, USNR.

Batfish, Zaliectes elater (Jordan and Gilbert) taken at Turtle Bay, Lower California, by the tuna boat "Westgate."

Footis of a porpoise given by Daniel Eaton.

Luvarius imperialis Rafinesque given by Mrs. W. Welch.

Pomfret, Brama raii (Bloch), given by Mr. C. L. Hubbs.

Allartedius corallinus Hubbs, a rare small fish collected by Mr. C. L. Hubbs.

Ruscariops cresaeri Hubbs, a rare small fish collected by Mr. C. L. Hubbs.

Aulorhynchus flavidus Gill, a rare small fish, 2 specimens, collected by Mr. C. L. Hubbs.

Humpback salmon, Oncorhynchus gorbuscha (Walbaum).

Rockfish, Sebastes hopkinsi Cramer, from deep water off La Jolla.

Cusk eels, Otophidium sp., 2 specimens from deep water off La Jolla.

Deep-water crab, Homola flaxoni Schmitt, a rare species from deep water, new to our collections.

Sunflower starfish, Ptychopodia helianthoides (Brandt), from deep water off La Jolla, new to our collections.

Several informal talks on the work of the Institution and the exhibits in the museum and aquarium were given by Mr. Barnhart to visiting groups of students from grammar and high schools. These talks have covered the work of the Institution, explanations of the exhibits, and specific information on marine life. If many such talks had been given in a class room to forty or more persons they would have been considered

lectures, but in this case they were just casual information given to thousands of individuals, teaching and service to the general public.

It is not possible to give a value, although it is very great, to such visual education exhibits which are maintained at this Institution as well as at larger museums and aquariums throughout the world. Much information on and identification of marine specimens was furnished to various persons seeking such information. The usual care was taken of the aquarium, museum, and biological collections. Mr. Claude W. Palmer assisted in the care of the aquarium.

During 1944-45 visitors to the museum and aquarium who signed the register numbered 5765. There were 6445 visitors who signed the register during 1945-46. This probably represents one-half or two-thirds the actual number of visitors, as many do not sign, and indications are that there certainly have been more visitors in 1945-46 than in any previous period or year. As the museum and aquarium are open every day in the year, including Saturdays, Sundays, and holidays, more and more people are taking advantage of the opportunity to become acquainted with the marine life of this region.

There were 1267 fishes, representing about 40 species, collected and exhibited in the aquarium. Many hundreds of invertebrates and many species of seaweeds were also shown in the tanks. Some fishes and other material were furnished for use in the laboratories.

The aquarium has also been used a number of times by outside agencies in visual education for schools. As one person remarked: "This is the only place south of San Francisco where we are able to take visual education pictures of marine animals."