Oceanography

Notes on meeting of the Advisory Board, Scripps Institution.

January 5, 1928.

At two p.m. Dr. Fred Baker, Mr. J.C. Harper, and Dean B. M. Woods met in the office of the Director. The subjects listed on the accompanying memorandum were discussed. Mr. N. B. Scofield, who was prevented from attending the meeting of the Advisory Board, visited the Institution on Saturday morning, January 7, and went over all of the matters discussed at the meeting.

The Director of the Institution first pointed out that if the applications of investigators were granted for next summer, after taking into consideration probable additions to the staff of the Institution, it would not be possible to accommodate all of the applicants in the present laboratory building. Further expansion of the work of the Institution and the continuance of granting privileges for research at the Institution by visitors necessitates the erection of an additional laboratory building at the earliest practicable date. It was suggested that the additional building be of virtually the same size as the present laboratory building, namely two floors, 48 feet wide, and 74 feet long, and that there be on each floor of the building 12 space units, all of which need not necessarily be divided from one another by partitions. The Director of the In stitution was advised to have blue prints made of the plans of the present laboratory building and after making notes on them to forward them to the Office of the President of the University for review and estimates of cost, and after the return of the blue prints

from the Office of the President to forward them to Mr.Harper.

With reference to the aquarium building, Mr. Harper suggested that it might be possible to interest the residents of San Diego in the erection of such a building as a compliment to Miss Scripps.

With reference to possible extension of the program of the Institution in physical oceanography and marine meteorology, the Director read a note from Mr. H.A.Barre, the executive engineer of the Southern California Edison Company, dated December 15, 1927, a copy of which is as follows:

> "The committee we met this morning has agreed to a participation of $5000 to the fund. I haven't yet heard the details but will let you know".

It was also stated that the matter had been brought to the attention of the California Development Association by Mr. Barre and that at the request of Mr. H.F.Ormsby, the secretary of the Association, information regarding the Scripps Institution of Oceanography and plans and estimates for the extension of the program of the Institution had been forwarded to him. An endeavor is being made to raise between $10,000 and $12,000 a year for a period of ten years for financing the proposed extension.

The advisability of the employment of Major Gray, who has been retired from the Army because of physical disability due to an embolism, was discussed, and the Director of the Institution was advised to employ him for mathematical work provided Doctor McEwen is entirely satisfied as to his mathematical capacity and that, if employed, his salary be $2700 a year, any action to be contingent upon the receipt of adequate funds

for the extension of the program of the Institution for researches in physical oceanography and marine meteorology.

The problem of getting in usable form records of sea surface temperatures and marine meteorological conditions reported to the U.S.Weather Bureau and the U.S.Hydrographic Office, was discussed, and it was suggested that the matter be taken up with the California Congressional delegation in time for consideration by the Bureau of the Budget for the appropriation for the year 1929-30, any action to be taken to be contingent on its being acceptable to Professor Marvin, the chief of the Weather Bureau.

Other subjects were discussed but the more important matters considered were those mentioned above.

At four p.m. the meeting adjourned.

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BOARD OF ADVISERS

January 5, 1928

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1. Conditions within the laboratory.

   Need of additional laboratory building.

   Aquarium.

2. Extension of program in physical oceanography and marine meteorology.

   Present status - correspondence with H.A.Barre and H.F.Ormsby

   Cummings

   Richardson

   Major Gray

   Replacement of Miss Curtis

   Records in the Hydrographic Office and the Weather Bureau

   Program of the joint meeting of the sections of Meteorology and Oceanography.

3. Doctor Haldane Gee and marine bacteriology

4. Marine sediments

   P.D.Trask

   Proposed assistant

5. Some problems in physics, chemistry, and physiology.

   (a) physics - solar radiation, evaporation, dynamical oceanography to be cared for under no. 3. Additional: Penetration of light into sea water, the depth of penetration of light of different wave lengths, the factors that limit depth of penetration, and the influence of light of different wave-lengths on organisms. The physics of the formation of aggregates of particles in the sea - flocculation and concretion.

(b) chemistry - some problems already cared for and others will be considered in connection with the work on bacteriology. Additional: Effects of substances in solution in sea water on the solubilities of one another (see work of A.A.Noyes).

(c) physiology- partly cared for by Doctor Sumner' s and Doctor Esterly's work, the proposed studies of marine bacteriology, and it is intimately related to some of the suggested investigations in physics. The plankton studies at present conducted at the Institution are yielding important results but they are empirical and need to be put on a physiological basis - partly by statistical andpartly by experimental researches.

6. Equipment and upkeep.

Bookstacks for the library

Hoist for the "SCRIPPS"

Bulkheads

Roofs

New Automobile

7. Continuation of planting and improvement program.

T.W.V. to contribute - $600.00 to Regents + $150 personal

Special - University probably $300.00

INTERRELATIONS BETWEEN THE SEA AND THE ATMOSPHERE AND THE EFFECT OF THESE RELATIONS ON WEATHER AND CLIMATE.

I. Problems related to solar radiation.

(1) Variation of solar radiation. C.G.Abbot.

(2) Amount of solar radiation that reaches the surface of the earth on the land and on the sea, and methods by which it is measured. H.H.Kimball.

(3) Amount of solar radiation that reaches lake surfaces, the proportion penetrating the surfaces, the loss of heat by evaporation and back radiation, and the relation of evaporation to meteorological conditions. N.W.Cummings, Bert Richardson, I.S.Bowen.

(4) The rate at which solar radiation penetrates the surface of lakes and oceans, and the rate at which the surface loses heat as deduced from serial temperature observations. G.F.McEwen.

(5) The penetration of solar radiation into lakes. E.A.Birge and Chancey Juday.

(6) The penetration of light in the sea. E.O.Hulburt

II. Problems related to surface water temperature.

(7) Reliability of different methods of taking sea surface temperature. C.F.Brooks.

(8) A thermograph designed for recording sea surface temperature. Harvey C. Hayes.

(9) (a) Significance of temperature measurements not made exactly at the sea surface.
(b) Time required for temperature departures to cross from the western to the eastern side of the ocean, and the changes in their departures during the crossing. G. F. McEwen.

(10) Relation of high and low pressure areas over the ocean to ocean surface temperature distribution.
Sir Frederic Stupart, J.Patterson, T.Okada, J.Boerema.

(11) Monsoon forecasts of the Indian Meteorological Service. R.H.Weightman.

III. Problems related to atmospheric circulation.

(12) The General Circulation of the Atmosphere. C.G.Rossby.

(13) The effect of surface winds upon ocean drift. G.W.Littlehales.

(14) The Northern Hemisphere Weather Map and its relation to weather forecasting. C.F.Marvin.

(15) The effect of ocean currents upon the climate of continents. A.J.Henry.

La Jolla, California,
May 22, 1928.

Members of the Advisory Board on the

Scripps Institution of Oceanography:

Herewith enclosed is a list of the personnel and a copy of the budget of the Scripps Institution of Oceanography for the academic year 1928-29 (Appendix I) and statements regarding other matters pertaining to the affairs of the Institution.

A special fund of $6,000 composed of contributions from the Los Angeles Bureau of Light and Power and a group of light and power companies, has made possible some expansion of the Institution's program for the investigation of the interrelations between the sea and the atmosphere, inthe hope that a basis for seasonal weather forecasting for this region may be found. The budget for the expenditure of this sum is attached as Appendix II, and an outline of the proposed investigations is attached as Appendix III.

Except for the meteorological investigations, the only significant changes in the personnel of the Institution for next year are the appointment of Dr. H. Gee as Assistant Professor of Bacteriology and Mr.E. M.Thorp as research assistant in the study of marine sediments. There will be shifts in the assistants for next year but all the scientific assistantships except one have been filled and there have been four applications for the single vacancy. Two are now under consideration.

A word should here be said about additional buildings. It has been necessary to inform several investigators of high research standing and several graduate students that they could not be accommodated at the Institution this summer, and Doctor Trask is vacating the space that he has occupied, partly for the reason that it may be used by another, Professor Greenberg of the University of California. This state of affairs is unfortunate. The number of competent visiting investigators at the Institution should be increased.

Before a great while the members of the Advisory Board will receive copies of the last report of the Committee on Submarine Configuration and Oceanic Circulation, which contains a summary statement of oceanographic investigations in the Pacific during the past year and plans for work in

the immediate future. The contents of that report will not be repeated here. It will be said, however, that, at the request of the Director of the Institut für Meereskunde in Berlin, I wrote a paper on the activities of the International Committee on the Oceanography of the Pacific for the Centennial Celebration of the Gesellschaft für Erdkunde of Berlin.

During my recent visit to Washington several matters of importance for the oceanography of the Pacific were discussed. These will be summarized as follows:

1. An endeavor will be made to enlist the assistance of the lighthouse tenders to make oceanographic observations and collections in the voyages of tenders to the different lighthouses and lightships, north of the mouth of Columbia River. We already have arrangements with the tenders that are operating south of the latitude of Columbia River.

2. The observations and collections of the Coast and Geodetic Survey will be somewhat extended for the region in which its vessels are operating. The Coast and Geodetic Survey will use the boat of the Scripps Institution for more detailed work on the submarine channel which lies just north of La Jolla Point and south of the pier of the Scripps Institution.

3. An arrangement was made whereby the Scripps Institution and the University of Wisconsin will study marine bottom samples of the northeast Pacific in a coordinated way. I am aiming to get a new map of the marine bottom deposits of the northeast Pacific. Professor Twenhofel at the University of Wisconsin is having the samples from certain areas studied and the results will be pooled with the results which we get at the Scripps Institution. We have already appointed for the Scripps Institution a research assistant in marine sediments, whose term of service will begin on July 1. Already a considerable amount of work has been done at the Institution and some of it has served as the basis of preliminary publications.

4. Dr. H.B. Bigelow will spend a month at Pacific Grove during the summer and while there will undertake certain work in Monterey Bay. The Scripps Institution already has a considerable number of vertical sections made for it by the Coast and Geodetic Survey and other information, all of which will be placed at the disposal of Doctor Bigelow.

5. It has already been brought to the attention of this Board that Dr.J.C. Merriam, the President of the Carnegie Institution of Washington, regards favorably turning the ship CARNEGIE, fully equipped, over to the Scripps Institution for a period of one or two years for work at sea after that vessel completes the three years cruise on which it has just started. The recommendation of Doctor Merriam would have to be approved by the trustees of the Carnegie Institution before it would become effective. The minimum estimate of the cost of operation of the CARNEGIE is $50,000 per year. Doctor Merriam and I both are inclined to place the estimate at $60,000 per year in order to take care of unforeseen contingencies. The cost, therefore, for one year would be $60,000, and for two years $120,000.

The plan for the work of the CARNEGIE, if it should be used by the Scripps Institution, would be to devote the first year to studying the Northeast Pacific east of the longitude of the Hawaiian Islands, and the second year to similar studies along and off the west coast of South America. T he plan in general would be similar to that adopted for the oceanographic work of the CARNEGIE on its present cruise and would parallel the work of the METEOR in the Atlantic. The subjects to be covered would be marine meteorology, oceanic circulation (subsurface as well as surface movements of the water), chemical properties of the water, marine biology (especially pelagic life at all depths), marine bottom deposits, and configuration of the sea bottom. All work would be done according to the best known methods with the highest practically attainable accuracy in everything. No such work as that proposed has been done in the Pacific, and,if executed as suggested,it would be one of the major oceanographic accomplishments of modern times. If the plan should become effective, an endeavor would be made to get the Japanese to undertake, according to similar methods, a parallel investigation of the Northwest Pacific.

With reference to financing, itwould be necessary to raise $120,000 for the two years work. The National Academy of Sciences has been trying to raise a research fund of $10,000,000, of which a considerable part has been pledged, and $3,000,000 are now available for expenditure. It is suggested that an application be made to the board in charge of this fund to allot $60,000 for use in the prosecution of the oceanographic investigations on the ship CARNEGIE in the eastern Pacific in the years 1931-33, a similar sum,$60,000, to be raised to match the $60,000 requested from the research

fund of the National Academy. This proposal has been discussed with Dr.J.C. Merriam and Dr.Frank R. Lillie, the head of the Department of Zoology, University of Chicago, and a very eminent man, and they both consider it appropriate and reasonable.

This report is submitted to the Members of the Advisory Board for their information, and they are earnestly requested to make such comments, suggestions, or recommendations as they may consider appropriate.

Sincerely yours,

T. Wayland Vaughan

T.Wayland Vaughan,
Director, Scripps Institution
of Oceanography

APPENDIX I.

Personnel and Budget for 1928-29

		Salary
Director, T.Wayland Vaughan		7,000.
Scientific Staff		
Dynamical Oceanography and Meteorology		
G. F. McEwen, Professor		4,000.
S.W. Chambers, Associate		2,000.
N.W.Cummings, physicist (part time)	)	
A. T. Gorton, meteorologist	) Special	
B.Richardson, physicist (part time)	) Fund	
Fishes		
F.B.Sumner, Professor		4,000.
P.S.Barnhart, Associate and Curator of Biology		2,500.
A.B.Keys,Assistant		1,200.
Phytoplankton		
W.E.Allen, Assistant Professor		3,600.
- - , Assistant, not yet appointed		1,200.
Zooplankton		
C. O.Esterly, Zoologist, (on leave)		
Bacteriology		
H.Gee, Assistant Professor		2,700.
Chemistry		
E. G. Moberg, Instructor		2,600.
Maurine Leslie, Assistant		1,200.
Marine Sediments and Foraminifera		
T.W.Vaughan		
D.Gravell, Assistant for foraminifera		1,200.
E.M.Thorp, Assistant for marine sediments		1,200.
E.L.Whipple,Assistant for foraminifera (temporary)		225.
Museum and Aquarium		
F.Baker, Honorary Curator of Mollusks		
P.S.Barnhart, Curator of Biology		
Collectors and observers		
Antar Deraga, Balboa		180.
Glen Dewara, Pt. Hueneme		180.
P.E.Hendricksen, Blunts Reef		120.
John Kunder, Farallon Light		120.
O.B.Lokken, Scotch Cap, Aleutian Islands		180.
H.Miller, Pacific Grove		60.
J.Nielsen, Columbia Lightship		90.
H.W.Rhodes, San Francisco, for Lighthouse tenders		120.

Clerical and library		
	Tillie Genter	1800.
	- - assistant,not yet appointed ($600 to be paid out of Special Fund)	600.
Buildings,Grounds, Boat		
	J.Ross,Superintendent and Captain of the "Scripps"	2,600.
	A.Bornowski, Gardener	1,800.
	R.S.Fuller, Janitor	1,560.
	T.F.Riche, General Assistant	1,440.
	M.Ross, Engineer	1,500.
	A.Winner, Assistant Gardener	1,200.

Total Salaries as given above	48,175.
Additional assistance (reserve)	955.
Expense and equipment	15,470.*
	64,600.

*To this will be added any balance carried forward, which will be small,about $1000, because of the number of emergency expenditures during the year 1927-28.

APPENDIX II.

SpecialFund for Meteorological Research
contributed by Power and Light organizations.

Total fund		6000.
N.W.Cummings, 2 mos. at $225	450.	
A.T.Gorton ~~(under consideration)~~ 1 year	3465.	
B.Richardson, 3 mos. at $150	450.	
Clerk, salary for half year	600.	
Equipment and incidentals	1035	6000.

(These proposals subject to approval by the
President of the University of California)

APPENDIX III

Investigations of interrelations between the sea and the atmosphere to be undertaken at the Scripps Institution in attacking the problem of seasonal weather forecasting.

General Introductory Statement.

Investigations proposed for the purpose of coordinating and explaining certain outstanding atmospheric and oceanic phenomena, and thus contributing to the local problem of seasonal forecasting may be grouped into three classes.

First there are certain fundamental quantitative investigations such as the problem of determining rate of evaporation from the sea, which involves investigations of the amount of solar radiation at the sea surface. Another fundamental problem is that of the quantitative relations that vertical temperature and salinity gradients bear to vertical circulation, solar radiation, and evaporation. Evaporation phenomena form one of the important links in the chain of processes by which water is brought from the ocean to the land.

Second, and apparently bearing more directly on the problem of forecasting, there is the search for advance indices. Handicapped by the present inadequate knowledge of a physical basis of seasonal forecasting this search for advance indices is mainly one of trial and error leading to empirical rules. The likelihood of discovering appropriate indices and intelligent use of them should increase as knowledge of the physics of the processes increases. However, this empirical study should begin at once, since past experience indicates that forecasts having some practical value may be expected from such efforts as the general investigation proceeds.

Third, the development of fundamental laws, and empirical methods of forecasting and the accumulation of pertinent data will gradually provide a basis for a synthesis. Thus we may expect the larger problem of explaining and interpreting empirical rules of forecasting to take definite shape. From its study should come a knowledge of the physical basis underlying the empirical rules of forecasting. This study should ultimately provide an estimate of the reliability of each empirical rule and may be expected to reveal additional advance indices.

In order to provide a tentative guide for commencing the investigations the following outline of specific problems has been prepared. Provisional assignments of these problems to members of the staff have been made in accordance with their interests and work already done.

Evaporation and Radiation.

The following work is suggested for Burt Richardson.

Estimate coefficients of atmospheric transmission from available data on humidity, and cloudiness, in order to determine the amount of solar radiation that reaches the sea surface. This work will involve some cooperation with Dr. Kimball.

Continue studies of literature on radiation and evaporation.

Begin special experimental work at the Scripps Institution involving the two evaporating pans already here and equipment to be brought from Pasadena, one pan, solar radiation recorder, thermometers, psychrometer, etc.

Two pans should be installed at the end of the pier at

different levels and means provided for measuring wind velocities and humidities at sea level and near each pan. From these investigations of lapse rate attempt to estimate evaporation from sea at end of pier.

The following work is suggested for N. W. Cummings. Make experiments on the effect of salinity on evaporation, and on the computation of evaporation rate from standard pans of various sizes. Begin a critical study of "Die Verdunstung auf dem Meere" by G. Wüst, as a start towards estimating sea evaporation from pans.

Work on the design of a portable standard pan of as small a size as practicable by means of which evaporation from large surfaces can be estimated. Cooperate with Richardson on the pier observations.

On account of the need of making observations of the amount of solar radiation reaching different depths below the sea surface keep in touch with available methods. This will involve cooperation with Dr. Millikan, Dr. Kimball, and Dr. R. C. Burt, maker of the Burt-Cell.

The work of Richardson and Cummings should result in a definite plan of continuous observations. The primary object of their undertaking is to estimate the monthly, or at least seasonal evaporation rate from certain areas of the Pacific with sufficient accuracy to detect changes the evaporation rate undergoes from year to year.

Oceanic Circulation.

The following investigation being carried on by G. F. McEwen

should be continued and extended.

Computation of surface currents in the Pacific from surface temperatures and winds in order to obtain the seasonal variation and the change from year to year of the surface drift. Application of McEwen's theory of the relation of vertical temperature and salimity gradients to the seven year series of data at Stations 5 and 10 miles west of La Jolla. Find out if yearly differences in computed upwelling are significant and if they are in accord with differences in surface drift. Find out the relation of these differences to differences in barometric pressure.

Select a rectangular area, about 2 or 3 miles on a side, Make the usual serial observations to a depth of 125 meters at each corner and possibly at the middle. Repeat these at intervals of two weeks from June to November. Include appropriate pan and meteorological observations. Estimate evaporation from this area by McEwen's gradient method and from the pan observations.

Meteorological Investigations.

The following purely meteorological part of the investigation will be assigned to Dr. Gorton or whoever holds the position of meteorologist on the staff.

Attempt a classification extending back possibly 25 or 30 years of the principal storms of each year with reference to their origin. One important criterion of grouping would be the accompanying pressure distribution. This would involve cooperation with Blake and others of the Weather Bureau and of the Aerological Department of the Navy.

Attempt to find advance indices of the amount of precipitation yielded by each of these types. Among the advance indices that should be considered are sea temperatures, velocity of upwelling, surface drift, and barometric pressure over the Pacific and at certain continental and island stations at which long continued records are available.

Apply appropriate correlation methods to these possible indicators, and determine the corresponding regression equations relating them to precipitation. Try to find variations of other factors, i.e. sun spot numbers which correspond to failure of the formula and thus attempt to improve the formula. Some attention should be given to the possibility that certain variations in meteorologic and oceanic phenomena may proceed in cycles sufficiently significant to be of use in seasonal forecasting.

Attempt to relate the several rainfall indices whether their occurrence is a long or short interval before precipitation to antecedent ocean conditions.

Later attempt to make a synthesis of the various relationships and of quantaties not directly measureable, evaporation for example, for the purpose of tracing the cycle of water from the ocean to the land and back to the sea and thus obtain a physical explanation of the whole process.

This should yield a physical basis underlying relations of rainfall to the various indicators used in forecasting, and should reveal other indicators.

Supplementary Remarks.

Evaporation data from other Sources.

In connection with the problem of estimating evaporation from large areas by means of pan observations and appropriate meteorological observations attention is called to the following investigation.

A special evaporation experiment has been conducted at Fort Collins, Colorado, for more than a year and will be completed by the fall of 1928. This work is conducted at the State College of Agriculture and Mechanic Arts by two engineers Messrs. Frank Parschal and Rower. The completed experiment will make available more than 2000 observations, usually one at 7 A.M., and one at 1 P. and at 6 P.M., in addition to several special more intensive series. There is a large circular tank 80 feet in diameter, a standard square ground pan used by engineers, a standard engineer's floating pan, anemometers, psychrometers, and micrometer hook gauges.

By an "observation" is meant the set of readings on all of these instruments. In addition to this rather high altitude station their program includes observations with a standard ground pan at other altitudes. They are attempting to find a formula for estimating tank (or large area) evaporation from known pan evaporation and the usual meteorological observations (not including radiation), and to find the effect of altitude on evaporation.

As a result of an interview with Messrs. Parschal and Rower it was learned that they are attempting to work out a simple

approximate empirical formula that will meet the practical requirements of irrigation problems. They are not attempting an exhaustive statistical analysis of the data accumulated, nor are they attempting to work out the physical basis of their formula.

They will gladly place all of these data at our disposal, and arrangements can be made for having copies made early this winter at the conclusion of the observations. The details will not be published, but only a report on their conclusions, including certain summaries of the observations presented by graphs and tables. Such a body of accurate observations should certainly be very carefully studied. This matter should be referred to Richardson and Cummings.

In connection with the proposed program of physical observations on one of the Great Lakes, Lake Erie, Dr. Charles J. Fish of the Buffalo Museum of Science, Humboldt Park, Buffalo, New York has offered to consider any observations requested bearing upon evaporation.

Equipment.

Purchase of equipment for radiation measurements should be deferred probably till the fall of 1928 before which time new information regarding the best type is expected.

Three anemometers or other devices for measuring the wind velocity at different positions in connection with the evaporation pans should be provided as soon as possible. The cost will be about $40.00 each.

Three psychrometers for humidity measurements have been ordered made up at a cost of about $8.00 each except for the

thermometers which are in stock.

The meteorological investigations involving the statistical handling of large quantities of observations already made and to be made will require, in addition to clerical assistance at least partly provided for, special facilities. These include "forms", appropriate filing facilities, and possibly a tabulating machine such as the Hollerith equipment for sorting and tabulating punched cards. The latter equipment, suggested as an important labor saving device which might be used in cooperation with other departments, should be considered in connection with the types of statistical work to be undertaken.

In cooperation with the program of obtaining ocean surface temperatures by means of thermographs, organized by Sir Frederick Stupart and J. Patterson of Canada, probably two thermographs should be provided, one for the coastal belt Seattle to San Diego and one from Seattle or San Francisco to Hawaii.

In regard to the use of Oceanographic and Meteorological data on file at the United States Weather Bureau Office, Washington, D.C. it is the opinion of F. G. Tingley that photostatic copies made at the Office is the most practicable. The cost is about fifteen cents per sheet. Careful consideration should be given to the errors in these data, in order to select the most suitable.

Oceanography

1928

To the Members of the Advisory Board
of the Scripps Institution of Oceanography.

Preliminary Report of Progress from June 15 to July 21, in Investigations at the Scripps relating to Seasonal Weather Forecasting.

Three groups of investigations have been pursued. These include the continuation of work established here years ago as well as that added to contribute to the solution of problems involved in seasonal forecasting.

I. A theoretical paper by G. F. McEwen on the general physical problem of the vertical distribution of temperature and salinity in the sea in relation to evaporation, solar radiation, turbulence, and upwelling velocity, has been prepared for publication. This paper brings together the result of studies carried on intermittently for several years and includes the derivation of formulae, and detailed directions for making numerical applications, and special tables computed to facilitate the numerical work.

Dr. Cummings has read the manuscript and offered suggestions which have resulted in certain improvements in presentation.

Tabulation on special forms of data on surface temperature, salinities, and winds taken mainly in the North American coastal region has been continued by Captain Chambers. Thus a great mass of material is being put in shape for use in the estimation of seasonal surface velocities which will soon be undertaken. A paper by G. F. McEwen bringing together investigations of methods of making these computations is in preparation for publication. This will make available in convenient

form tables and diagrams prepared to facilitate the computations as well as the derivation of methods which have been in use here for several years.

II. In order to observe changes in evaporation rates and in related meteorological conditions at different levels above the sea, three insulated evaporating pans have been installed at the end of the Scripps Institution Pier. The lower one is near sea level, the middle one is thirty feet above, and the upper one is fifty feet above sea level.

Mr. Richardson has taken the responsibility of installing the equipment. He has made the observations, including sea surface temperatures, and summarized the results of a ten day series including a continuous record of solar radiation. This summary indicates, contrary to his expectations, very small vertical gradients of atmospheric conditions. The values of solar radiation deduced from pan observations at each level agreed within a few percent with pyranometer indications. If similar observations at other Pacific regions lead to the same general conclusions, meteorological and evaporation observations at any height up to 50 feet or possibly more can be used in connection with sea surface temperatures for estimating evaporation from the sea. This apparent simplification indicates that there is no need of attempting to observe precisely at the water surface. However, the conclusion is only tentative and should be carefully tested, because of its great practical significance.

Dr. Cummings has made a critical summary of methods that have been used to estimate the evaporation from the sea. This

work, together with his familiarity with the recently developed technic of evaporation measurements should result in a tentative way of proceeding to obtain the actual evaporation from the sea.

III. Dr. Gorton's work which will continue for at least a year from July 1, 1928, has involved reading bearing on the general problem of seasonal forecasting. He has given special attention to suggestions that have resulted from preliminary studies of the local problem made by others. In addition to this basic preparatory type of research, his work has involved a survey of the data for the North Pacific ocean, published by the Imperial Marine Observatory of Kobe, Japan (1925). Atmospheric pressures have been plotted for five-degree squares of longitude and latitude, and the monthly departure from the five year mean of each year from 1916 to 1925 is being calculated. Attention has been centered on those years for which the rainfall in California was abnormal, and conclusions have been drawn as to the accumulation of air over the Pacific preceding wet seasons, the movement of air, and the history of surface temperatures during the years involved.

A preliminary sutdy has been made of the types of storms entering California during the past winter (1927-1928), with especial reference to the latitude at which the "lows" crossed the coast, and the intensity of the accompanying "high" off the coast.

It is now too early to expect any very definite conclusions from a program of work involving so much tabulating and charting.

The indications are that his way of approach will in a reasonable time yield useful leads to be followed up by studies of longer records. Moreover, it is expected that certain fundamental problems requiring a mathematical treatment from the point of view of a physicist will be thus suggested and receive due attention.

SCRIPPS INSTITUTION OF OCEANOGRAPHY

Budget 1928-1929

(Tentative)

Assets.

Balance brought forward (estimated)	$ 2,500.00
Revenue from property and supply dept.(estim.)	7,500.00
State, regular appropriation	22,500.00
State, supplemental	10,000.00
Miss E.B.Scripps, annual donation	9,000.00
Miss E.B.Scripps, supplemental donation	10,000.00
Mr.R.P.Scripps	5,000.00
T.W.Vaughan	600.00
	$ 67,100.00

BUDGET

	1927-28		1928-1929	
Salaries - Group A				
T.W. Vaughan	$7,000.00		$ 7,000.00	
F.B. Sumner	4,000.00		4,000.00	
G.F. McEwen	3,600.00		4,000.00	
W.E. Allen	3,000.00		3,700.00	
P.S. Barnhart	2,500.00		2,600.00	
Assistant Professor Sediments		20,100.00	2,700.00	23,500.00
Salaries - Group B				
E.G. Moberg	2,400.00		2,600.00	
C.O. Esterly	on leave		600.00	
J. Ross	£,400.00		2,600.00	
S.W. Chambers	1,800.00		2,000.00	
Tillie Center	1,800.00		1,800.00	
M. Ross	1,500.00		1,500.00	
Marion W. Moberg	1,200.00		1,200.00	
Maurine Leslie	1,200.00		1,200.00	
Horace Buley	1,200.00		1,200.00	
A.B. Keys	1,100.00		1,200.00	
Dorothy Curtis	1,200.00		1,200.00	
T.F. Richs	1,320.00		1,380.00	
A Bornowski	1,680.00		1,800.00	
F.S. Fuller	1,500.00		1,560.00	
R. Romero	1,200.00		1,200.00	
Collectors and observers				
Antar Deraga	$180.00			
Glen Dewar	$180.00			
John Kunder	120.00			
O.B. Lokken	180.00			
H. Miller	60.00			
J. Neilsen	90.00			
H.W. Rhodes	120.00	930.00	930.00	
		22,430.00		23,970.00
Unspecified assistance		1,250.00		2,210.00*
		43,780.00		49,680.00

*Includes 1 additional scientific assistant.

Expense and equipment

Laboratory, equipment, etc.	3,000.00
Boat	2,000.00
Sumner, researches on fishes	700.00
Travel and field expenses	1,200.00
Library	1,200.00
Automobiles, repairs and operation	600.00
Telephone and telegrams	250.00
Gas and electricity	1,200.00
Water	1,000.00
Office supplies	370.00
Express	300.00
Cottage supplies	600.00
Unbudgeted	700.00
Grounds, plants and fertilizer	600.00
Paint	300.00
Insurance - cottages	250.00
Emergency and contingent	3,150.00
	$ 17,420.00

Salaries and wages		
Group - A	$23,500.00	
Group - B	23,970.00	
Unspecified	2,210.00	$49,680.00
Expense and equipment		17,420.00
		$67,100.00

Reamuscript

W. W. CAMPBELL,
PRESIDENT OF THE UNIVERSITY

THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
OF THE
UNIVERSITY OF CALIFORNIA

T. WAYLAND VAUGHAN,
DIRECTOR

LA JOLLA, CALIFORNIA

September 25,1928.

To the members of the Advisory Board

On the Scripps Institutionof Oceanography.

I hope that it will be possible for you to attend a meeting of the Advisory Board on the Scripps Institution at ten o'clock,Saturday, October 6th,in the office of the Director of the Institution.

It is intended to discuss at this meeting plans for extensive oceanographic research in the Pacific,with special reference to oceanographic expeditions, and plans for proposed new buildings for the Institution.

I also cordially invite you to be my guest at luncheon at twelve thirty after the meeting.

I trust that I may be favored with your acceptance.

Sincerely yours,

T. Wayland Vaughan

T.Wayland Vaughan.

W. W. CAMPBELL,
PRESIDENT OF THE UNIVERSITY

THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
OF THE
UNIVERSITY OF CALIFORNIA

T. WAYLAND VAUGHAN,
DIRECTOR

LA JOLLA, CALIFORNIA

October 6, 1928.

To the Members of the Advisory Board,
on the Scripps Institution of Oceanography.

I hope that it will be possible for you to attend a meeting of the Advisory Board on the Scripps Institution at ten o'clock, Tuesday morning, October 23, in the office of the Director of the Institution.

It is intended to discuss at this meeting plans for extensive oceanographic research in the Pacific, with special reference to oceanographic expeditions, and plans for proposed new buildings for the Institution.

I also cordially invite you to be my guest at luncheon at twelve thirty after the meeting. I trust that I may be favored with your acceptance. Anyone who wishes to do so, may get the train after luncheon from Del Mar at two thirty seven for Los Angeles.

Sincerely yours,

T. Wayland Vaughan

T. Wayland Vaughan

Advisory Board on the Scripps Institution of Oceanography

Notes for Meeting

Tuesday, October 23, 1928, 10 A.M.

Mimeographed Statements.-

1. Annual Report to the President of the University.
2. Expenditures 1927-28
3. Budget 1928-29
4. McEwen report on cooperative meteorological investigations.

Notice of Constitution of Biological Preserve of the sea front of the Institution's property.

Desired Additions to Staff.-

Sedimentarian. Dr.Parker D.Trask, at $3,300.00

Zooplanktologist

"Import or bring up" at $1800 to $4,000
(one or two years hence)

Assistant in bacteriology at $1,200.

Water Rates.-

Recent raise in rates serious for the Institution. Since it maintains a museum and an aquarium open to public without charge and as its grounds are virtually a public park, it appears unjust for the City to impose a tax on its operation.

Committee Relations of the Director.-

National:

Submarine Configuration and Oceanic Circulation

Oceanography of the Pacific

National Academy Committee on Oceanography.

International:

Oceanography of the Pacific

Fourth Pacific Science Congress in Java.

Possible solution of the difficulty:

Divide Committee on Submarine Configuration and Oceanic Circulation into subcommittes on Atlantic and Pacific and combine the one on the Pacific with the National Committee on the Oceanography of the Pacific.

Provide a Secretary for the International Committee on the Oceanography of the Pacific. This has been presented to the different National Committees and to National Academy Committee on Oceanography. A fund of about $2500 per year should be provided; but a larger amount $4000 to $5000 would be preferable.

Building Program.-

Report from Dean Woods

Chairman of Committee to serve during Director's absence.

Expedition in the Eastern Pacific.-

Status of investigations in other countries.

Proposal for use of the Carnegie.

Area to be covered if the proposal is accepted:

to be about 2000 miles from the west coasts of North and South America.

Program of scientific operations.

Cost of expedition, $120,000.00.

Raising of funds.

Shall the application to the National Academy be made through the President's Office or directly, all pertinent information being supplied the President of the University?

1928 Oct. 29

To the Committee on the

Research Fund of the National Academy of Sciences.

Sirs:-

It is desired to present for your consideration and such support as you may find practicable a plan for oceanographic research in the Eastern Pacific Ocean. Your attention, however, should first be called to the present condition of knowledge of the oceanography of the Pacific and to investigations on that subject now in progress or soon to be undertaken.

Present knowledge of the Physical Oceanography of the Pacific.

What is now known regarding the physical oceanography of the different oceans is very well summarized by Dr.A. Defant, Director of the Institut für Meereskunde in Berlin, in an article entitled "Die systematische Erforschung des Weltmeeres", (Jubiläums-Sonderband 1928, Zeitschrf. Gesellsch. Erdk., Berlin.) This article is illustrated by four charts, photostat copies of which are attached to this communication. Although a little more is known than the chart of the Pacific indicates, it shows a lamentable lack of information on the Pacific, and that much more has been done on its western than on its eastern side. The Japanese have led during recent years in the study of the Pacific.

Oceanographic Investigations in Progress and Provided for in the Pacific.

The work now in progress or to be undertaken within the next twelve months includes, as follows:

(a) The voyage of the CARNEGIE of the Carnegie Institution of Washington (1928-31).

(b) The voyage of Johannes Schmidt on the DANA from Panama to the East Indies to make investigations in the eastern Pacific to complete his studies of the breeding places of eels (1928).

(c) Work of the Russians off the Siberian coast (1928).

(d) The expedition from the Netherlands to the East Indies (1920-30).

(e) The combined British and Australian investigations of the Great Barrier Reef of Australia and adjacent areas (1928-29).

Attached as appendices are the programs of operation of the CARNEGIE (Appendix V), and of the Netherlands Expedition (Appendix VI), and a statement regarding activities in Australia (Appendix VII).

On the eastern side of the Pacific near the coast investigations are being made by the Coast and Geodetic Survey, the International Fisheries Commission in its study of the halibut, the Marine Biological Station at Nanaimo, the Hopkins Marine Station at Pacific Grove, and the Scripps Institution of Oceanography at La Jolla. The last mentioned Institution receives help from the U.S.Navy, the Peruvian Navy, the U.S. Bureau of Lighthouses, the Grace Steamship Line, and other sources. The body of information indicated above is obtained mostly from near the coast and mostly from the sea surface, and, although valuable, it is not adequate for elucidating the large problems of oceanic circulation, marine meteorology, the biological interrelations within the sea, and the geological phenomena exhibited by it. There is urgent need for

more research on the high seas of the Pacific and the United States may reasonably be expected to do its share of the work.

Proposal for Use of the Ship CARNEGIE.

The President of Carnegie Institution of Washington, Dr.J.C. Merriam, has said that he will recommend to the Trustees of that Institution that the ship CARNEGIE, fully equipped, be placed at the disposal of the Scripps Institution of Oceanography of the University of California for a period of one or two years, provided that the Scripps Institution can supply the funds necessary for the operation of the vessel. The Scripps Institution can provide most or all of the needed scientific staff for the vessel and undertake the working up of most of the scientific data and collections. It would, however, like to have associated with the work distinguished representatives of other institutions. But Scripps Institution has not at its disposal the funds necessary to defray the expense of the operation of the vessel. This opportunity for making a really great contribution to knowledge of a considerable part of the Pacific is until now unsurpassed and it is earnestly hoped that the needed funds may be raised by a combination of contributions from different sources. If the expedition should be undertaken the following would be the essential features of the program:

Area to be investigated.

The approximate western boundary of the area is indicated on the attached chart of the Pacific Ocean, Appendix IV, by the black line southward from the Aleutian Islands along merdian 170° W to the Hawaiian Islands, thence southeastward to the equator at longitude 120° W, and thence southward along merdian

120° W to approximately latitude 60° S. The operations in general would extend from the shore to a distance seaward between 2000 and 2500 miles, except that at the northern end of the area and perhaps near its southern end the distance would be shorter.

Stations to be made and length of voyage.

At least 14 or 15 lines of sections should be possible. An approximate estimate of the length of the cruise on which stations would be occupied is 35,000 miles, and an estimate of the length of the cruise on which stations would not be occupied is about 7,000 miles. The total cruise would be approximately 42,000 miles, perhaps somewhat longer, because of the necessity of deviating from the lines of the sections, in order to make port at the ends of the successive voyages. The time needed for occupying a station is between 4 and 6 hours. Only one station should be made per day. The average speed of the vessel per day while making stations is about 90 miles. The part of the cruise on which stations would be occupied would, therefore, consume about 390 days, with 390 stations. The number of days should probably be somewhat increased, because the vessel should be anchored at several places on the deep sea in order to measure currents at different depths. For such work it might be necessary to spend more than one day on a station. The probability of the need of such additional time is taken into consideration and allowance made for it. The time required for making the 7000 miles, during which stations would not be occupied, would be about 53 days, assuming the average speed to be 125 miles per day. The time at sea, therefore, would be approximately 445 days. Assuming that

the time in port would be one half that at sea, the total time required would be 665 days, 65 days less than two years. The 65 days would be available to make up for delays in the voyages from causes above mentioned.

The lines of the sections should be adjusted to the data obtained by both the CARNEGIE and the DANA and the significance of data from other sources should be considered. The other possible sources will not be enumerated here, as to do so would unduly prolong this communication. Unless it should appear advisable to repeat previously made lines of sections, the sections on the proposed expedition would be in addition to those already made. Since after the cruise of the CARNEGIE (1928-31) and the DANA (1928) there will be available the results of about 10 lines of sections in the Eastern Pacific, the 14 or 15 lines of sections here proposed would bring the number up to 24 or 25 for 110° of latitude or a line of sections for about each 4 1/2° of latitude. This frequency would compare favorably with the work in the Atlantic south of latitude 20° N.

Scientific procedure.

This may be appropriately divided into two categories, (a) While under way and (b) While on the stations, followed by (c) Other remarks on the program.

(a) <u>While under way</u>.- There would be continuous records of the depth of water by means of the sonic depth-finder (assuming that the Navy Department will continue the loan of the apparatus now installed on the CARNEGIE), continuous records of sea-surface and air temperatures by means of thermographs, and records of barometric pressure, solar radiation, humidity, and other

phenomena of meteorological significance, including data on lapse rates to available heights above sea level. Special attention would be paid to evaporation rates. Water samples for the determination of salinities and for plankton counts would be taken at frequent intervals, perhaps every hour, and hauls would be made with plankton nets.

(b) <u>While on the stations</u>.- Vertical sections of the water from the surface to the bottom would be made to ascertain temperature and to collect water samples for the determination of salinity, for chemical examination, and for plankton counts. The collections and records near the surface would be at 5-meter intervals to a depth of 50 meters; and below that depth, in general, at 75, 100, 200, 300, 400, 500, 700, and 1000 meters, and below 1000 meters at 500-meter intervals to the bottom. The chemical determinations would include pH, O_2, CO_2, Ca, SiO_2, PO_4, and NO_3. If satisfactory apparatus should become available, measurements of the depth of the penetration of the different wave lengths of light into sea-water would be made. The vessel should be anchored at a certain number of stations in order to measure currents at different depths with current meters and thereby obtain a basis for converting the dynamical calculations for relative movement in the different layers of water into actual velocities. The biological work would consist in the collection and study of all obtainable plankton and other pelagic organisms, but especially of phyto- and zoo-plankton, including pelagic fish eggs and larval fishes. Both water bottles and nets would be used at various depths below the surface. If possible a centrifuge would be employed to obtain such plankton as the Coccolithi-

phoridae, which are too small to be retained in nets. It is also intended to undertake for the first time on shipboard as much bacteriological work as is possible. Bottom samples would be taken at all stations. It has not been intended to do deep sea dredging or trawling, but if circumstances should be favorable some work of that kind might be undertaken. Most of the records made while under-way would be continued while on the stations, and, if possible to do so, pilot-balloon flights would be made to obtain data on the movement of the upper air.

(c) Other remarks on the program.- The program as outlined above is very nearly the same as that of the METEOR in the South Atlantic and that of the expedition from the Netherlands to the East Indies for 1929. It is very similar to that for the present cruise of the CARNEGIE, but it is more intensive and devotes more attention to some subjects, especially those biological and chemical, than is being given them by the CARNEGIE. It does not include studies of atmospheric electricity and terrestrial magnetism. Some work on those subjects might be done by members of the staff of the Carnegie Institution of Washington.

While on the voyages the determinations of salinity, the chemical examination, and the preliminary examinations of the biological collections and bottom samples would be made. The calculations for the density and specific volume of the water in situ would be made. Whether it might be possible to make dynamical calculations while at sea remains to be determined, but that would be done if practicable. Two other methods for determining the surface movements of ocean water would also be tested: they are Ekman's theory of wind currents and McEwen's method of deducing

the movement of surface water from differences in temperature.

Scientific personnel.

The total personnel of the CARNEGIE on its present cruise consists of 25 men, 8 of whom constitute the scientific staff. It may reasonably be expected that the Carnegie Institution of Washington would wish one or two members of its staff to accompany the projected expedition for 1931-33. A surgeon and a radio operator would be necessary, but both should help with some of the scientific work. It might not be practicable to supply quarters for all those suggested below.

Chief of Scientific Staff, for the entire cruise if found desirable, geology and foraminifera	*T.W.Vaughan
Dynamical oceanography and marine meteorology	*G.F.McEwen
	Burt Richardson
Chemistry and phytoplankton	*E.G.Moberg
Zooplankton	T. Skogsberg
Bacteriology and chemistry	*A.H.Gee
Geology and general	P.D.Trask
Apparatus and scientific equipment	*J.M.Ross

Those whose names are preceded by an asterisk (*) have already been interviewed and they are willing to go on the expedition. The others on the list have not been interviewed. The following notes are made on the proposed personnel, myself excepted:

G.F.McEwen, physical oceanographer of the Scripps Institution, the leading research man in dynamical oceanography in the United States; much actual experience at sea in the coastal waters of California.

E.G.Moberg, the chemist of the Scripps Institution and one of the leading authorities on the chemistry of seawater; also a student of plankton from the chemical point of view (a paper by him is hereto attached as Appendix VIII); he has had charge of the scientific operations on the boat of the Scripps Institution for 5 consecutive seasons and for three seasons he has been the navigating officer of the Institution's boat SCRIPPS, which is equipped with nearly all the oceanographic apparatus aboard the CARNEGIE, except the sonic depth finder. He is thoroughly trained in the techniqure of oceanographic work.

A.H. Gee, the bacteriologist of the Scripps Institution and a trained physical chemist and biochemist; as yet with very little experience at sea,but he may acquire considerable during the next two and a half years.

J.M.Ross superintendent of buildings and grounds, Scripps Institution, an instrument-maker, formerly instrument-maker to Lord Kelvin; a licensed marine engineer for boats of 65 ft. length; familiar with the construction and operation of the usual kinds of oceanographic instruments and equipment; has invented several pieces of oceanographic apparatus, including the best known combination of opening and closing deep-sea plankton net with a device for taking a

water sample and recording the temperature at the end of the subsurface haul.

Burt Richardson, a specialist on methods of measuring solar radiation and evaporation; familiar with the general methods of dynamical oceanography; licensed air-plane pilot, familiar with Morse code; some, but limited, experience at sea. (Might serve as radio operator.)

T. Skogsberg, of the Hopkins Marine Station, Stanford University; an authoritative student of several groups of marine animals; with considerable oceanographic experience.

P.D.Trask , a specialist on marine sediments, with a broad foundation for such investigations; has devoted particular attention to marine bottom deposits as possible source-beds of petroleum; with extensive experience at sea.

The names of others, not all citizens of the United States, have been mentioned, for consideration, among them Dr. L.B.Beeking of the Jaques Loeb Laboratory at Pacific Grove. It has been suggested that the Coast and Geodetic Survey might assign one of its officers for the cruise, but no official inquiry has been made to ascertain the feasibility of the suggestion. It should also be mentioned that there are at the Scripps Institution several young graduate-student assistants who are becoming competent in the study of physiology of marine animals and of marine bottom deposits and their associated organisms.

Although the foregoing statement regarding personnel for

the expedition is tentative, it should make clear that a highly trained staff, with experience in oceanographic operations at sea, is available.

The preparation of the scientific results for publication would be by those who would take part in the expedition and other specialists selected for their qualifications to deal with particular subjects.

Expenses.

Since the vessel would be supplied by the Carnegie Institution of Washington and the scientific staff would be furnished principally by the Scripps Institution of Oceanography and other institutions invited to participate, funds need to be raised only for the operation of the vessel, that is for provisions, fuel, up-keep during the voyage, and salaries of the crew. It does not appear necessary to present the details of the estimates communicated by the Carnegie Institution of Washington. The amount needed is $60,000.00 (sixty thousand dollars) per year, or $120,000.00 (One hundred and twenty thousand dollars) for two years.

Raising the funds.

It is hoped that the National Academy of Sciences will endorse the proposal herewith submitted and that the Committee on the Research Fund of the Academy will contribute toward the expense of the expedition as large an amount as it practicable. It would be highly gratifying if one-half of the amount, $60,000.00, could be provided by the Academy through its Research Fund, but it is recognized that this may not be practicable. With endorsement and a substantial contribution, the way would be cleared for

appeal to other sources from which funds might be obtained. Although there are no commitments, I have been led to the opinion that probably one half the needed amount can be found in California, if the endorsement above indicated is received and if one half of the funds can be provided outside California.

Results that may be expected from such an Expedition.

The most obvious expected scientific results may be tabulated as follows:

1. Increase in knowledge of the major circulation of the Pacific Ocean.
2. Increase in knowledge of the interrelations between the sea and the atmosphere, and possible assistance in both short-time and long-range weather forecasting for the eastern side of the Pacific.
3. Increase in knowledge of the configuration of the ocean bottom and of what lies on it.
4. Increase in knowledge of the chemical properties of seawater and of the interrelation between physical and chemical properties, including those of biological and geological significance.
5. Increase in knowledge of the organisms of the sea, especially the plankton, including bacterial floras, and other pelagic organisms, and of their interrelations one to another and to physical and chemical conditions in the sea.
6. Increase in knowledge of fishes, particularly fish eggs

and larvae, and perhaps of the spawning places and migrations of economically important species.

Possible Influence on other Oceanographic Research in the Pacific.

The chart of the Pacific, Appendix IV, exhibits what would be the state of knowledge of the oceanography of the Pacific at the end of the proposed expedition above outlined, if the proposal were made effective. Two large areas, concerning which information would be inadequate, would still be left in the Pacific. One of them would be that part of the Pacific between the Aleutian Islands and latitude 10° S and between the meridians of longitude 170° W and 150° E. The other would be an area near whose north end are the Marquesas, Society, and Paumotu groups of islands, whence the western boundary would extend by New Zealand and thence to Tasmania and along meridian 150° E longitude to Antarctica; the eastern boundary would be meridian 140° W longitude from the Equator to Antarctica. If the proposed expedition were realized, there is strong probability of expeditions being undertaken by other countries.

Work in the Northwest Pacific has already been informally discussed with Dr. N. Yamasaki, the Chairman of the Japanese Committee on the Oceanography of the Pacific. Obviously he could not commit the Japanese authorities but he said that, when the subject was formally presented to him, he would take it up with the appropriate authorities. He also said two other pertinent things. One was that whatever the Japanese might do might have to be spread over several years. The other was that the

Russians might help with the work in the area off the Siberian coast, an area for which there had been planned an expedition for the summer of 1928. Since the territorial waters of Japan and Siberia are adjacent, I suggested to Dr. Yamasaki, that the problem of an adjusted program between Japan and Russia would better be left to those countries.

In discussing a program for oceanographic research in the Pacific, Prof.A. Lacroix, the French delegate, told me in Tokyo, that, if it were definitely indicated to the French what it was desired that they do, an endeavor would be made to have France do its share. An inquiry may with propriety be made of the French if they would undertake an expedition to cover an area which would extend from the Equator north of the Marquesas Islands, include the Society and Paumotuan groups, and reach to latitude 20° S.

If the arrangements above discussed could be made, there would remain only the area south of Tasmania and New Zealand, east of New Zealand and the Fijis to approximately meridian 140° W, and between latitudes 20° and 70° S. Because of their interests in this area, the British, Australians, and New Zealanders may appropriately be asked if they would provide for the work on it.

The plan above outlined is a very large one, probably the largest program for oceanographic research that has as yet been proposed, and there are no actual commitments to its adoption, although some work that fits into it is under way. However, the prospects for the realization of much of it are good, and, if the proposed expedition in the Eastern Pacific, as it has been outlined, can be undertaken, the stimulus that it would give

to oceanographic research in the Pacific would be such, that it may be confidently expected that most, if not all, of the program for the Pacific here presented will be realized within relatively few years. The relations indicated supply an additional argument for undertaking the expedition in the Eastern Pacific.

Respectfully yours,

T. Wayland Vaughan.
Director of the Scripps Institution of Oceanography and Chairman of the International Committee on the Oceanography of the Pacific.

The only accompanying Appendices are

IV, VI, VII, VIII.

Appendix IV

Tafel XXXII

Lamberts flächentreue Azimutalprojektion. Hauptpunkt auf dem Aequator in 160° W.

Maßstab 1:100 000 000

In die Karte ist nur das Material eingetragen, das dem Institut für Meereskunde Berlin bis zum 1.2.1928 bekannt wurde. Bodenbeobachtungen sind nicht berücksichtigt.

- *Temperatur*
- *Temperatur und Salzgehalt*
- *Station mit einer Beobachtungstiefe von mehr als 3000 m.*
- *Isobathe von 1000 m nach M. Groll.*
- *Grenzen der Ozeane nach E. Kossinna.*

Abb. 50. Hydrographiſche Reihenmeſſungen ſeit 1870 im Stillen Ozean mit Beobachtungstiefen von mehr als 1000 m bzw. 3000 m.

—— Routes of "Carnegie", 1928-31.

—— Route of "Dana" (Johs. Schmidt)

—— Western boundary of area proposed for "Carnegie", 1931-33.

Additional expeditions in the Western Pacific

a. Off the west coast of Siberia by the Russians during the summer of 1928.
b. Expedition to the East Indies from the Netherlands during 1929.
c. Expedition to the Great barrier Reef of Australia and along and off the Queensland coast by the British and Australians during 1928-29.

Appendix VI.

The Netherlands Oceanographical Expedition in the East Indian Archipelago.

By P.M. van Riel, Leader.

The purpose of the Netherlands Oceanographical Expedition is to enlarge our knowledge of the deep basins in the eastern part of the Archipelago. Physical, oceanographical, and geological investigations will predominate over the biological ones. From the meteorological observations only those will be made, which are directly connected with oceanography. Besides these, it is intended to make solar radiation observations.

The field of research will embrace the eastern part of Netherlands East India between Borneo and the Philippines - New Guinea - Australia and besides, the adjacent parts of the Pacific and the Indian Ocean. Observations in these last mentioned regions are necessary in order to study the exchange of water between the deep basins and the open oceans. The total surface of this area will be nearly as large as that of the Mediterranean and the Black Sea, i.e. 3 million square Kilometers.

The scientific staff will be composed ~~mf~~ as follows: An oceanographer (leader) with two assistants (one physical, one chemical), a chemist, a geologist and a biologist.

The research vessel will be a newly-built naval ship, Willebrord Snellius, destined for surveying work in the colonies. She has a deplacement of 1050 tons, a length of 62 m. and a maximum speed of 11 knots. The naval staff will be composed of a commander, 3 naval officers, a doctor, a paymaster and a naval engineer, the crew of approximately 90 men.

The following information may be given concerning the projected observations:

At every station (probably 300 or more) a wire-sounding will be made, by which also a bottom-sample and a water-sample, with its temperature near the bottom, may be obtained. The wire-soundings will be supplemented by acoustic soundings between the various stations, when the ship is under way.

By means of serial observations at the stations the temperature will be observed in the ordinary way at the surface and at many intermediate depths, water samples being collected at the same time. The depth readings will be tested by using ~~xk~~ at the same time both protected and unprotected thermometers. When under way the temperature of the seawater will be continually registered by a resistance thermometer fitted outside the ship, below the water surface, instead of in the inflow condensor tube.

The water samples will be examined in the ship's laboratory for:

The salinity, by chlorine titrations and probably by means of electric conductivity with a view to comparison of the results of both methods.

The hydrogen-ion concentration.

The gases of seawater as far as oxygen and carbon dioxyde are concerned.

The alkalinity.

The food substances as phosphates and, as far as the time of the chemist will permit, nitrates and nitrites.

Current observations at anchor-stations on the threshold of the deep basins may prove the existence of an important exchange of water near the bottom, as supposed on the ground of observations, made during the Siboga Expedition.

Next to these current observations serial observations at the anchor-stations will be repeated in the upper strata during one or two days in order to study from temperature and salinity curves the variations caused by vertical oscillations, i.e. internal waves.

Plankton samples will be collected by the biologist from the surface water and also from various deeper layers, in order to study the vertical and horizontal distribution. Special attention will be paid to the vertical distribution of the plankton in the deeper layers of the more or less isolated deep basins. In the vicinity of coral reefs and islands several bottom samples will be collected to a depth of 300 m. by dredging; besides which a few deep sea dredgings are intended. The biologist will also join the geologist ashore for the study of reefbuilding corals and the conditions under which these are living.

The work of the geologist[1] on board will be the analysis of sea bottom deposits; ashore and on the living and raised coral reefs the geological and biological investigations may help to solve the problems concerning the rising and subsidence of the sea bottom, a perpetual phenomenon in this region.

The most important appliances and machinery necessary for the above mentioned purposeswill be the following:

A large electric Lucas sounding machine with 11000 m. wire of 1 mm. is available for wire soundings and the collection of bottom samples; moreover a small Kelvin machine and some small Lucas sounding machines; the last mentioned for the use on board and in boats.

For acoustic soundings: A sonic depth finder, constructed by the Atlas Werke at Bremen and the Hughes patent (British Admirality system).

For collecting water samples, measuring temperature and the use of vertical plankton nets in various depths (serial observations) two electric winches with 8000 m.wire of 4 mm. will be used.

For anchoring in great depths a drum with a steel wire rope of 7500 m. will be mounted on the fore-deck.

A steel boom attached at the main mast will be used for dredging purposes and the fishing of plankton with large horizontal townets.

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1) A more extensive description of the geological investigations from the hand of Dr. van Waterschoot van der Gracht will appear in the Weekly Science News-Letter. This communication deals also with the peculiar conditions in the eastern part of the East Indian Archipelago.

Appendix VII.

AUSTRALIAN OCEANOGRAPHIC COMMITTEE.

Report of Chairman.

The Committee consists of two Sub-Committees, namely:-

(1) Physical and Chemical Oceanography. Chairman, E. C. Andrews.

(2) Fundamental Marine Biology. Chairman, Professor W.E.Agar.

No Sub-Committee has been appointed on Fisheries Technology.

All the members have been advised as to the necessity of contributing their reports in time for this Annual Meeting of the Research Council, but, with the exception of Mr. G. H. Halligan and Professor H. C. Richards, there has been no contribution, owing apparently to the inability of the various members to furnish material of value earlier than the date of the Java Meeting of the Pacific Science Congress in 1929.

Dr. Richards' contribution is contained in the Barrier Reef Committee's Report, and it is understood that a considerable amount of detailed information will be gathered by the expedition to the Barrier Reef under the leadership of Dr. Yonge, This report will deal with problems of currents, tides, sea temperature, invertebrate fauna, marine botany, and Fisheries, during 1928-1929. This information may be expected to be a valuable contribution to the Oceanography of the Australasian Region.

In the meantime, a very laborious but very valuable work is being conducted by Mr. G. H. Halligan. The information concerning the surface and subsurface temperatures, both drift and tidal work collected by him is being summarized on four large charts to be exhibited at the Java Meeting of the Pacific Science Congress, 1929.

Mr. Halligan reports that, as no definite boundaries had been suggested for the Australian region, he has adopted the Isobaric Chart of the Commonwealth Meteorologist, which is conveniently ruled in quadrangles of one degree over an area of 34,346,870 square miles, or $\frac{1}{5.7}$ of the total surface of the earth, or $\frac{1}{4.2}$ of the sea surface. This chart is plotted on the conical projection, and extends from longitude 85° east to Longitude 160° west at the equator, and from Longitude 170° west at Latitude 65° south. Certain modifications were necessarily made by Mr. Halligan, and a zinc plate was prepared from the lithographic stone used for showing the daily barametric changes, employed by Mr. H. A. Hunt in weather forecasting. The cost of this

work, including the draftsman's time, was defrayed by the Meteorological Weather Bureau on the recommendation of Mr. Hunt, to whom this Committee desires to express its deep indebitedness.

The work of the Physical Section, as carried out by Mr. Halligan, may be divided conveniently into five parts, mamely:-

1. The surface and subsurface temperatures.
2. The surface "current-set" (so-called).
3. Bottle drift.
4. Salinity.
5. Tidal work.

SEA SURFACE TEMPERATURES.

The vessels of the Australian Navy, and about 500 vessels of the Merchantile Marine, supply daily records of the surface temperature and surface current-set while at sea, the former being stored in the hydrographic Office, and the latter in the Commonwealth Meteorologist's office, both in Melbourne. These records were placed unreservedly at the disposal of Mr. Halligan by Comm. Stevens, R.N., and Mr. Hunt. The naval records extend back to 1912, but those of the merchant service began during the latter part of 1924. The records for 1924-5-6 have been tabulated, analysed, averaged, and roughly plotted on the chart referred to by Mr. Halligan. Copies of these will be made in the near future, and from them helioprints may be taken for distribution amongst the members of the National Oceanography Committee of the Pacific Science Association. The records for 1927 are not as yet tabulated, as the whole of them had not been received when Mr. Halligan was last in Melbourne.

Mr. Halligan is now in Melbourne completing this, together with other, work in connection with Physical Oceanography, and he hopes to furnish a report upon the subject in time for the meeting in Java during May, 1929.

For the years 1924-5 and 1926, the average annual mean temperatures of each 5° quadrangle for each year are shown, but for 1927 it is proposed to show the average quarterly means, as well as the average annual means, in order to meet the wishes of the Chairman of the National Oceanography Committee. The value of tabulating the average quarterly means for each quadrangle for oceanographic purposes will be much reduced owing to the limited number of such observations.

It may be stated here that there are 364 quadrangles on the chart under consideration, and the number of observations from which the means have been deduced amount to 8,000 approximately for 1925 and 1926, or about 22 for each quadrangle, the maximum being 130 and the minimum one. The mean area of the 5° quadrangle is 94,909 square miles. In this estimate, Mr. Halligan has made allowance for the form of the geoid, and he has calculated the area in statute miles.

Mr. Halligan intends, at the next meeting of the National Oceanographic Committee in Java, to move that the practice of fixing the position of a vessel by dead reckoning - either by taking the number of revolutions of the propeller, or by the use of the log, - and comparing it with the position by astronomical observations, and calling the difference "current-set", be abandoned, as such practice appears to be inaccurate. However, in order to comply with the wishes of the National Committee, he has tabulated some thousands of observations taken by merchant vessels during the years 1925, 1926, and 1927, and has indicated by this means the so-called "current-set" in each 5° quadrangle on the chart. None of the "current-set" records in the logs of naval vessels are included in these tables, it being the naval practice to allow first for wind action on the vessel, or leeway, and second to allow for the deflection caused by an imaginary or real current, and apply these connections to the position found by dead reckoning. The difference between the position so found, and that by astronomical observation is called "current-set".

BOTTLE DRIFT.

Every year many thousands of bottles are thrown overboard, containing a statement of the time and the position of the vessel from which it was thrown, and asking the finder to return the paper sta ting the time and place where it was found.

In order to illustrate the extraordinary courses bottles may take when delivered to the mercy of winds, waves, and currents, Mr. Halligan has collected four charts issued by the Commonwealth Meteorological office, giving the history of 157 bottles thrown overboard between 23rd January, 1890, and 7th October, 1919.

TIDAL WORK.

All records of the work done in connection with tidal flow, tide prediction, and the drawing of co-tidal lines around the Australian coast, are being collected and so arranged as to be of use for reference by future investigators. A report upon this matter will be ready for submission to the Java Meeting of the Pacific Science Congress in May, 1929.

(signed) E. C. Andrews,
Chairman,
Oceanographic Committee.

Appendix VIII.

THE INTERRELATION BETWEEN DIATOMS, THEIR CHEMICAL ENVIRONMENT, AND UPWELLING WATER IN THE SEA, OFF THE COAST OF SOUTHERN CALIFORNIA

BY

ERIK G. MOBERG

Scripps Institution of Oceanography of the University of California

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THE INTERRELATION BETWEEN DIATOMS, THEIR CHEMICAL ENVIRONMENT, AND UPWELLING WATER IN THE SEA, OFF THE COAST OF SOUTHERN CALIFORNIA

BY ERIK G. MOBERG

SCRIPPS INSTITUTION OF OCEANOGRAPHY OF THE UNIVERSITY OF CALIFORNIA

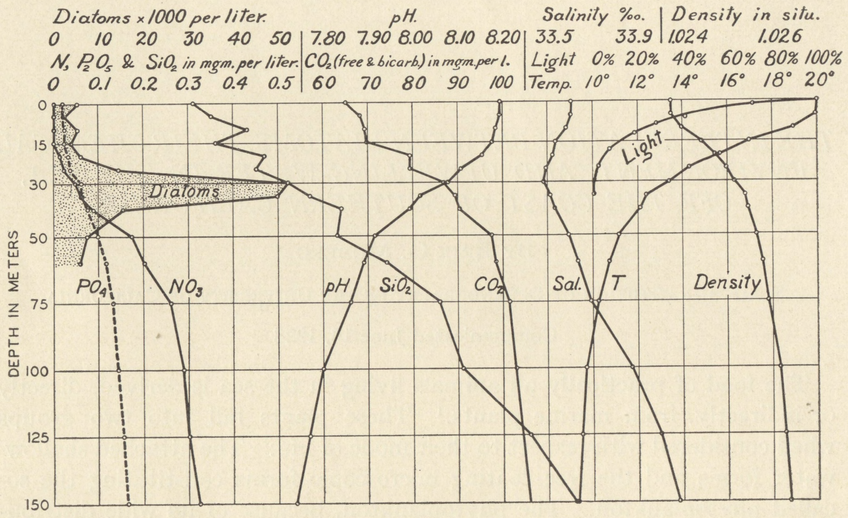
Communicated June 16, 1928

The food of practically all animals living in the sea is derived, directly or indirectly, from marine plants.[1] These plants fall into two groups when considered with respect to their mode of life: The attached shallow-water forms and the free-floating microscopic forms constituting the so-called phytoplankton. The phytoplankton, because of its wide distribution over deep as well as shallow water and because of the large numbers and rapid growth of the organisms composing it, is probably far more important than the other group as regards the synthesis of substances upon which all marine animals ultimately depend. A correlation between the abundance of phytoplankton, which may vary not only with depth and season but with locality and year, and the abundance of animals, including those of commercial importance, is consequently to be expected and efforts to ascertain what factors control the production of phytoplankton are of interest from both a purely scientific and an economic point of view.

For the growth of phytoplankton certain favorable physical conditions and an adequate supply of a number of chemical substances are required. Many of these chemicals occur in sea water in relatively large amounts and are always available to the plants, whereas others are exceedingly scarce and at times may be so small in quantity as to escape detection by the most

sensitive methods. To the latter category belong inorganic nitrogen compounds, phosphates, silicates, and possibly others. These substances, together with carbon dioxide and certain physical factors, probably control the production of plants and, thus indirectly, of animals in the sea.

The Scripps Institution has, for a number of years, been engaged in making quantitative investigations of phytoplankton, physical conditions, and, more recently, of some of the chemical constituents of the water along the coast of Southern California. Most of these investigations have been made on surface water near shore, especially at the Institution pier, but since 1921 intensive studies have been made, during at least six weeks each summer, of both surface and subsurface water from two stations



located five and ten miles seaward from the pier. The depths at these stations are about 350 and 700 meters, respectively.

In the course of these studies it has been found that in this locality the diatoms greatly outnumber any other component of the phytoplankton at all seasons and may therefore be used as an index of photosynthetic activity. The same has been found to be true in most other localities where plankton has been studied and as a consequence more information is available concerning the abundance and ecological relation of diatoms than of any other marine plants. For these reasons only the diatoms are considered in this paper.

The graph illustrating this paper represents the results of studies made during the summer of 1926 at the ten-mile station mentioned above and is intended to show the distribution of the diatoms and the physical and chemical conditions in a column of water and to indicate the relation of

diatoms to various environmental factors. The diatom curve was drawn from figures published by Allen[2] and for each depth indicated shows the average number of cells per liter for sixteen hauls taken between June 3rd and August 21st. The other curves, with the exception of light, represent averages for the same station and the same period as the diatom curve. Unfortunately, no information concerning submarine illumination is available for this locality and the curve shown was constructed from data obtained by Poole and Atkins[3] on October 1, 1925, in the English Channel about 20 miles from Plymouth.

The graph shows that all of the physical and chemical conditions varied greatly with depth and that in nearly all cases most of the variation was confined to a relatively narrow zone, which may be referred to as the transition zone, between the 15- and 50-meter levels. Above this zone the conditions were relatively uniform whereas below they varied at a slow but constant rate.

The graph also shows very pronounced differences in the vertical distribution of the diatoms. They were most numerous at 30 and 35 meters below the surface, i.e., in about the center of the transition zone, where they averaged 50,000 to the liter, whereas at most other depths only about one-tenth as many, or 5000, were found.

Because of this marked accumulation of diatoms in a relatively narrow zone, the environmental conditions as they were found in this zone will be discussed in more detail. Although, due to our imperfect knowledge of the metabolism of diatoms and of many of the environmental factors, definite conclusions are not justified, the data indicate certain relationships and suggest a number of problems which require further investigation, preferably both by laboratory experiments and by field observations.

The graph shows that the diatoms occupied a stratum of water in which the temperature varied according to depth from 10° or less to 20° and that they were most abundant at depths where the temperature averaged about 13° or 7° less than at the surface. The temperature optimum for diatoms is not known but, judging by the relation of temperature to photosynthesis in the case of other plants, it might be supposed that 20° would be more favorable for growth than 13°. In this connection it is of interest to recall that the seasonal distribution of diatoms varies almost inversely as the temperature but the relation is probably not one of cause and effect.

It is realized that the light curve does not necessarily represent the submarine illumination off the coast of Southern California but a number of investigators in various localities have obtained curves essentially similar to the one here shown. According to this curve most of the light was absorbed in the first few meters of water below the surface, only about one per cent of the total daylight reaching a depth of 30 meters. The penetra-

tion of light increases, of course, with decrease in latitude provided other factors, such as turbidity, are constant and it may be assumed that at the station under consideration the amount of light reaching the stratum of greatest diatom content was probably somewhat greater than indicated by the curve. The photosynthetic activity of diatoms at various depths, and therefore at various light intensities, was recently studied by Marshall and Orr[4] by suspending diatom cultures at different levels below the surface. At the latitude of Northern Scotland the maximum amount of photosynthesis occurred at 2 or 3 meters below the surface and above this depth the light was too intense, causing injury to the diatoms. Below the level of optimum illumination photosynthesis gradually diminished until at 20 or 30 meters it was just sufficient to balance respiration. In our latitude an effective amount of photosynthesis would no doubt be possible somewhat below 20 or 30 meters but when it is realized that a dense layer of diatoms, such as was found at 30 and 35 meters, is an effective screen for obstructing the passage of light, it seems very probable that during the summer of 1926 the production of diatoms below 35 meters was limited by insufficient illumination.

In regard to the important chemical substances, carbon dioxide, silica, phosphate, and nitrate, we find that the quantities were in all cases greater in the diatom zone than at the surface. The graph shows only the carbon dioxide existing as bicarbonate, except for small quantities of carbonic acid below 35 meters. Although only half the bicarbonate CO_2 can be utilized by plants it is doubtful if this substance retarded the growth of diatoms since even at the surface the quantity available was about 30 milligrams per liter and it is known that much smaller quantities will support photosynthesis. Silica, also, appears to have been present in sufficient quantities at all levels. Its distribution differed from that of the other substances in that the increase in quantity with depth was at a nearly uniform rate throughout the entire column of water represented by the graph. This was probably due to gradual dissolving of the tests of sinking dead diatoms. Phosphate was, on the average, less abundant than any other substance determined, although it was not completely lacking at any depth, the quantity at the surface being 0.02 milligram per liter. It is known that even smaller amounts can be utilized by diatoms since Atkins[5] has found that during periods of rapid diatom growth phosphate may be completely removed from the surface water of the English Channel. At the station represented by the graph the cause of the low diatom content in the upper 25 meters of water was consequently not an insufficient supply of phosphate. The increase in quantity with depth was shown most strikingly by the nitrate. Above 20 meters this substance was entirely lacking, or at least could not be detected with a reagent which is sensitive to quantities as small as 0.002 milligram per liter of nitrate and nitrite nitrogen. Below 25 meters nitrate increased rapidly and the rate of increase in the transition zone was more pronounced than for other substances. A causal relation between the abundance of diatoms and the quantity of nitrate is thus strongly indicated and, assuming that no other source of nitrogen, for example ammonia, was available, it can be stated that lack of nitrogen prevented a greater production of diatoms in the upper 25 meters of water.

The effect of various hydrogen-ion concentrations upon the growth of diatoms has not been investigated, but, since growth processes of some plants appear to be affected by changes in the hydrogen-ion content of the external medium, it is of interest to note that in the photosynthetic zone the variability of pH was the greatest.

Other properties of sea water which require consideration when attempting to explain the distribution of organisms in a vertical column of water are density and viscosity. These are not directly concerned with growth but are practically the only external factors affecting the floating power of organisms. According to the graph, density increased rapidly with depth between 5 and 35 meters and more gradually at greater depths. A curve for viscosity is not shown but it can be stated that it would be practically the reverse of the temperature curve since viscosity is but slightly affected by variations in salinity. At 35 meters the water was about one-fifth more viscous than at the surface and hence resisted the vertical movement of organisms to a corresponding extent. Some investigators maintain, for reasons that cannot be discussed here, that organisms are independent of, or can adjust themselves to, changes within a certain range of the density and viscosity of the medium in which they live but it is at least possible that the majority of the diatoms here dealt with were unable to maintain their position except in the water of intermediate density and viscosity occurring at 30 and 35 meters.

To summarize, the data presented above show that during the summer of 1926, the diatoms in the area studied were confined chiefly to a relatively narrow zone at 30 and 35 meters below the surface. The data also suggest that an extensive development of diatoms was possible only in this zone, since at the higher levels the water was deficient in nitrate and at lower levels, where there was an abundant supply of all the materials required for plant growth, the illumination was inadequate. It cannot be stated however whether the vertical position of the diatoms was determined by factors directly concerned with growth, by purely physical factors, or by a combination of the two types.

Under conditions such as those summarized in the preceding paragraph, and assuming that there is no vertical movement of water, heat from the sun, aided by wind action, will lower the thermocline until a stratum of water of uniform physical conditions will extend well below the present

diatom zone. The temperature of this water will be high and the density and viscosity low. If the diatoms are unable to float in this water they will sink to depths where light is insufficient for photosynthesis but if they are independent of density and viscosity the supply of one or more of the chemical substances will ultimately be exhausted at all levels where light is sufficient for photosynthesis. In either case further diatom production will be impossible until more favorable physical and chemical conditions are reëstablished.

In any locality the restoration of chemicals may be accomplished by one or more of the following agencies: By run-off from land, by decomposition of organic material, or by influx of water from other localities and depths. In a region of slight rain-fall, such as Southern California, run-off from land is probably a negligible factor and it has been found that decomposition takes place chiefly at or near the bottom. It may be concluded therefore that in this locality water from the deeper layers is the principal agency supplying nutrient salts to the photosynthetic zone. The same agency, as well as cooling of the surface water due to seasonal changes, will also alter the physical conditions of the water near the surface.

There are three quite distinct ways in which subsurface water may be elevated. One is simply a mechanical mixing of water of uniform density and is caused by wind action. This mixing is of great importance in the higher latitudes where the temperature and density gradients are eliminated when the surface water cools in the fall.[6] In the latitude of Southern California these gradients are never entirely eliminated, although considerably reduced during the winter. Consequently, mixing extends below the photosynthetic zone during a relatively short period only and, except in very shallow water, never to the bottom. McEwen calls attention to another type of turbulence which he describes as follows:[7] ". . . .heat is removed from the water surface by evaporation, back radiation, and conduction through the air. The resulting increase in specific gravity of a thin surface layer of the water causes a settling of relatively heavy and cool masses of surface water, compensated by a rise of relatively warm and lighter water." When the gradients are as pronounced as shown by the graph the transfer of water due to this circulation is probably negligible below a few meters from the surface.

The third type of vertical circulation, commonly known as upwelling, consists of a more or less continuous upward movement of bottom water and is characteristic of certain areas along the western shores of the African and American continents. The existence of this phenomenon along the coast of Southern California has been demonstrated by McEwen[8] who found that the rate of upwelling varies with the season and locality. He also showed that temperature reduction, i.e., the difference between

the observed and the normal temperature for the latitude and season, can be used as an index of the rate of upwelling.

The relation of upwelling to the production of organisms in this region was pointed out by Michael[9] who found indications of a positive correlation between temperature reduction and quantity of plankton. The probability of the existence of such a relation is greatly strengthened by the data presented in this paper. The graph clearly shows that an upward movement of water will result not only in a reduction of the temperature but in an increase of density, viscosity and chemical substances in the photosynthetic zone, i.e., all the environmental conditions, with the exception of light, will be affected. The magnitude of the effect will, of course, be proportional to the rate of upwelling and the exact manner in which the diatoms are affected depends to a certain extent upon their relation to density and viscosity.

Referring again to a situation similar to that represented by the graph, a certain amount of upwelling is required to maintain the existing conditions, or to replace the water heated by the sun and depleted of nutrient substances by the plants. If the rate of upwelling is too slow to maintain equilibrium, conditions similar to those resulting from stationary water will be established, although with some delay. On the other hand, if water is moving toward the surface at a speed greater than necessary to counteract the changes caused by the sun and the diatoms, the heavier water, together with its load of chemicals, will be carried past the diatom zone and possibly to the surface. This will make photosynthesis nearer the surface possible and will enable the diatoms, provided they are able to float in water of any density, to occupy a wider stratum of water, the upper limit of which will be determined by excessive illumination and the lower by insufficient illumination. In the case represented by the graph the upper limit of the diatom zone would thus be raised from about 30 to about 5 meters below the surface. The width of the diatom zone would probably not be increased to a corresponding extent since, if the total number of diatoms is augmented, more light will be absorbed and perhaps become inadequate for photosynthesis before reaching the 35-meter level. If the distribution of diatoms is controlled also by density and viscosity, rapid upwelling will not necessarily widen the diatom zone but will bring it nearer the surface where light conditions are more favorable.

[1] In this article all photosynthetic organisms are considered as plants.

[2] Allen, W. E., *Bull. Scripps Inst. Oceanog. Tech. Ser.*, **1**, 201 (1928).

[3] Poole, H. H., and W. R. G. Atkins, *J. Mar. Biol. Assoc.*, **14**, 177 (1926).

[4] Marshall, S. M., and A. P. Orr, *Ibid.*, **15**, 321 (1928).

[5] Atkins, W. R. G., *Ibid.*, **15**, 191 (1928).

[6] See, for example, Atkins, W. R. G., *J. Cons. Internat. Explor. de la Mer*, **1**, 197 (1926).

[7] McEwen, G. F., ms.
[8] McEwen, G. F., *Int. Rev. Hydrobiol. u. Hydrog.*, **5**, 243 (1912).
[9] Michael, E. L., Spec. Publ. Bernice P. Bishop Museum No. 7, 555 (1921).

October 30,1928.

To the Members of the Advisory Board
on the Scripps Institution of Oceanography.

Memorandum on meeting of the Advisory Board on the Scripps Institution of Oceanography in the office of the Director of the Institution, ten a.m., Oct.23,1928.

There were present at the meeting Dr.Fred Baker, Mr. J.C.Harper, Mr. L.M. Klauber, Dean C. B. Lipman, Mr.N.B.Scofield, Dean B.M. Woods, and T.W.Vaughan.

Notes for the meeting, to which were attached (1) a copy of the annual report of the Director of the Institution to the President of the University; (2) expenditures 1927-28; (3) budget 1928-29; (4) McEwen's report on cooperative meteorological investigations, were prepared for the meeting. Since each of those who attended the meeting took a copy of the notes and attached papers, they are now sent only to those who were unable to be present.

In the discussions that followed, the following matters should be mentioned:

1. It was recommended that the annual allotment to the library for the purchase of books, periodicals, and binding be increased to $1800 per year as a minimum and to a larger amount if that should be practicable.

2. With reference to having a biological preserve made of the sea front of the Institution's property, it was recommended that the matter be taken up with Mr. Scofield in charge of Commercial Fisheries, California Fish and Game Commission, as well as with the Office of the President of the University and that

an endeavor be made to bring together Mr.Scofield and the proper representative of the President's Office.

3. With reference to the increase in water rates, it was recommended that no action be taken at present because of the financial difficulties in which the City of San Diego finds itself.

4. It appeared to be the consensus of opinion of those present that the Director of the Institution should attend the Pacific Science Congress which is to meet in Java in May and June, 1929, in order that he might present the case of cooperative investigation in the study of oceanography of the Pacific.

5. Dean Woods reported that although preliminary studies had been made of the plans for the new buildings, that it is hoped will be erected at the Institution, it was thought better not to complete them until it should be definitely known that the needed funds would become available.

6. Considerable attention was devoted to the proposed expedition in the eastern Pacific and the Director of the Institution was advised to transmit through the President of the University a letter addressed to the appropriate member of the Committee on the Research Fund of the National Academy.

In accordance with the advice of the members of the Advisory Board, a letter regarding the use of the ship CARNEGIE of the Carnegie Institution of Washington in an expedition in the eastern Pacific was prepared and a copy of that letter is hereto attached. As each member who attended the meeting took a copy of Appendix IV it has been omitted from the papers intended for him.

T. Wayland Vaughan

T.Wayland Vaughan.

7]

Synopsis of Accompanying Proposal for an
Oceanographic Expedition in the Eastern Pacific.

Since the accompanying communication is rather long an endeavor has been made to present an abstract of it. The details for each caption will be found in the fuller statement that follows.

Present knowledge of the oceanography of the Pacific is lamentable deficient. More is known of the western than of the eastern side.

Outline of investigations under way or to be undertaken within twelve months: Ship CARNEGIE (1928-31); Johannes Schmidt and the DANA (1928); Russians off the Siberian Coast (1928); expedition from the Netherlands to the East Indies (1929); British and Australian work on Great Barrier Reef and in adjacent areas (1928-29); work near and along the coast in the Eastern Pacific.

Proposal for use of the CARNEGIE by the Scripps Institution of Oceanography of the University of California: on condition that the Scripps Institution defray operating expenses.

Area to be investigated: from the eastern shore of the Pacific to a distance seaward between 2000 and 2500 miles, from the Aleutian Islands at the north to the southern end of South America at the south.

Stations and length of voyage: 14 or 15 lines of sections, 390 stations; 390 days or more while making stations; 35,000 miles while make stations; 7,000 while not making stations, 53 days; about 445 days at sea; about 220 days in port; 65 days

extra to provide for possible delays. Combining the proposed 14 or 15 lines of sections with 10 other available lines would give 24 or 25 lines of sections in the Eastern Pacific.

Scientific procedure: While under way, bottom profiles by sonic method; thermograph records, air and surface water; records of air pressure, solar radiation, humidity, other meteorological phenomena; special study of evaporation and lapse rates; water and plankton samples. On stations vertical sections of water from surface to sea-bottom, serial temperatures, water samples, and plankton and other biological collections, bottom samples; penetration of light, if feasible; send up pilot balloons, if practicable. Program similar to that of the METEOR, the Netherlands East Indian Expedition, and the CARNEGIE on its present cruise, but more intensive than that of the CARNEGIE and with more attention to biology and chemistry. All practicable determinations and examinations and bacteriological cultures to be made on ship-board.

Scientific peronnel: To consist of chief of scientific staff, geology and foraminifera, T.W.Vaughan; dynamical oceanography and meteorology, G.F.McEwen; chemistry and phytoplankton, E.G.Moberg; chemistry and bacteriology, A.H.Gee; instruments and apparatus, J. M.Ross. Zoologist and assistants proposed. Some invitations to participate to be extended to members of staffs of other institutions, not necessarily in the United States; Carnegie Institution will probably wish to supply one or two of the personnel.

Expense of operation: $60,000.00 for one year; $120,000.00 for two years.

Raising the funds: Endorsement from National Academy of Sciences is desired and as large a contribution from the Research Fund as is practicable is requested. It is hoped that one half of the funds, $30,000.00 per year for two years ($60,000.00) may be found outside of California.

Scientific results that may be expected: The most obvious expected scientific results may be tabulated as follows:

1. Increase in knowledge of the major circulation of the Pacific Ocean.
2. Increase in knowledge of the interrelations between the sea and the atmosphere, and possible assistance in both short-time and long-range weather forecasting for the eastern side of the Pacific.
3. Increase in knowledge of the configuration of the ocean bottom and of what lies on it.
4. Increase in knowledge of the chemical properties of sea-water and of the interrelation between physical and chemical properties, including those of biological and geological significance.
5. Increase in knowledge of the organisms of the sea, especially the plankton, including bacterial floras, and other pelagic organisms, and of their interrelations one to another and to physical and chemical conditions in the sea.
6. Increase in knowledge of fishes, particularly fish eggs and larvae, and perhaps of the spawning places and migrations of economically important species.

Possible influence on other oceanographic research in the Pacific: If the expedition to the Eastern Pacific here proposed were carried out, it is probable that work by the Japanese, Russians, French, and British, Australians, and New Zealanders, would cover the other areas in the Pacific and thereby make possible a general picture of conditions in the largest of the oceans. Stimulus to research by others would be one of the great results of the proposed expedition in the Eastern Pacific.