THE
WOODS HOLE OCEANOGRAPHIC
INSTITUTION

REPORT FOR THE YEAR
1935
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Trustees, as of December 31, 1935</td>
<td>3</td>
</tr>
<tr>
<td>II Members of the Corporation, as of December 31, 1935</td>
<td>4</td>
</tr>
<tr>
<td>III Report of the Treasurer</td>
<td>5</td>
</tr>
<tr>
<td>IV Report of the Director</td>
<td>9</td>
</tr>
<tr>
<td>V  Staff, as of December 31, 1935</td>
<td>18</td>
</tr>
<tr>
<td><strong>APPENDIX:</strong> Reports of progress by investigators working at the</td>
<td></td>
</tr>
<tr>
<td>Institution during 1935</td>
<td>19</td>
</tr>
</tbody>
</table>
I

TRUSTEES
(As of December 31, 1935)

To serve until 1939
IASIAH BOWMAN, Johns Hopkins University, Baltimore, Md.
E. G. CONKLIN, Princeton University, Princeton, N.J.
ALEXANDER FORBES, Harvard Medical School, Boston, Mass.
ROSS G. HARRISON, Yale University, New Haven, Conn.
FRANK R. LILLIE, University of Chicago, Chicago, Ill.
HARLOW SHAPLEY, Harvard University, Cambridge, Mass.

To serve until 1938
CHARLES FRANCIS ADAMS, Boston, Mass.
BENJAMIN M. DUGGAR, University of Wisconsin, Madison, Wis.
JOHN A. FLEMING, Carnegie Institution, Washington, D.C.
FRANK B. JEWETT, New York, N.Y.
ELIHU ROOT, JR., New York, N.Y.

To serve until 1937
MARION EPPELEY, Newport, R.I.
The Hydrographer, United States Navy Department, for the time being.
T. H. MORGAN, California Institute of Technology, Pasadena, Calif.
R. S. PATTON, U. S. Coast & Geodetic Survey, Washington, D.C.
Commander EDWARD H. SMITH, U. S. Coast Guard, Woods Hole, Mass.

To serve until 1936
WILLIAM BOWIE, U. S. Coast & Geodetic Survey, Washington, D.C.
A. G. HUNTSMAN, University of Toronto, Toronto, Canada.
ALFRED L. LOOMIS, Tuxedo Park, New York.
HENRY L. SHATTUCK, Boston, Mass.
T. WAYLAND VAUGHAN, Scripps Institution of Oceanography, La Jolla, Cal.

Ex officio
LAWRASON RIGGS, JR., New York, N.Y.

OFFICERS
FRANK R. LILLIE, President of the Corporation, University of Chicago, Chicago, Ill.
LAWRASON RIGGS, JR., Treasurer, 120 Broadway, New York, N.Y.
MEMBERS OF THE CORPORATION
(As of December 31, 1935)

CHARLES FRANCIS ADAMS, Boston, Mass.
ISAIAH BOWMAN, Johns Hopkins University, Baltimore, Md.
E. G. CONKLIN, Princeton University, Princeton, N.J.
BENJAMIN M. DUGGAR, University of Wisconsin, Madison, Wis.
MARION EPPLEY, Newport, R.I.
JOHN A. FLEMING, Carnegie Institution, Washington, D.C.
ROSS G. HARRISON, Yale University, New Haven, Conn.
A. G. HUNTSMAN, University of Toronto, Toronto, Canada
THE HYDROGRAPHER, U. S. Navy Department, for the time being, Washington, D.C.
FRANK B. JEWETT, New York, N.Y.
FRANK R. LILIE, University of Chicago, Chicago, Illinois
ALFRED L. LOOMIS, Tuxedo Park, N.Y.
T. H. MORGAN, California Institute of Technology, Pasadena, Calif.
R. S. PATTON, U. S. Coast & Geodetic Survey, Washington, D.C.
LAWRASON RIGGS, JR., New York, N.Y.
ELIHU ROOT, JR., New York, N.Y.
HARLOW SHAPLEY, Harvard University, Cambridge, Mass.
HENRY L. SHATTUCK, Boston, Mass.
T. WAYLAND VAUGHAN, Scripps Institution of Oceanography, La Jolla, Calif.
REPORT OF THE TREASURER
May 26, 1936

TO THE MEMBERS AND TRUSTEES OF THE
WOODS HOLE OCEANOGRAPHIC INSTITUTION:

GENTLEMEN:

The accounts of the Treasurer to the end of the fiscal year February 29th, 1936, have been audited by Messrs. Stagg, Mather & Hough, public accountants, and a copy of their report is on file in the office of the Institution.

At the time of the organization of the Institution the Rockefeller Foundation in addition to the Endowment Funds and Plant Funds contributed by it, made a grant of Five Hundred Thousand Dollars ($500,000) or so much thereof as might be necessary for current expenses over a period of ten (10) years commencing March 1, 1930, payments in any one year not to exceed Fifty Thousand Dollars ($50,000). This arrangement has been cancelled by agreement between the Foundation and the Institution and in its place the Foundation has added One Million Dollars ($1,000,000) to the Endowment Funds of the Institution, which was paid in October 1935, as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>In stock</td>
<td>$349,711.00</td>
</tr>
<tr>
<td>In bonds</td>
<td>$349,987.50</td>
</tr>
<tr>
<td>In accrued interest on bonds</td>
<td>$244.00</td>
</tr>
<tr>
<td>In cash</td>
<td>$300,057.50</td>
</tr>
<tr>
<td></td>
<td><strong>$1,000,000.00</strong></td>
</tr>
</tbody>
</table>

The Treasurer wishes to acknowledge the invaluable services of the Finance Committee consisting of Messrs. Adams, Shattuck and Root in connection with the investment and reinvestment of the Endowment Funds. The duties of the Finance Committee have been exceptionally heavy this year due to the receipt of the additional Endowment Funds and to the calling of many issues held by the Institution.

Following are summaries of the various accounts:

PLANT ACCOUNT

| Description                                                      | Amount    |
|                                                                |           |
| Gift from the Carnegie Corporation for purchase of land         | $27,542.13 |
| Endowment by Rockefeller Foundation                             | $580,100.00 |
| Appropriated from current funds                                 | $26,106.71 |
| Reserve for depreciation (Reserve for periodical replacements) appropriated from current funds | $18,972.11 |
Laboratory plant:
Land ........................................ $27,072.32
Building ..................................... 323,213.12
Laboratory equipment ...................... 21,361.93
Crew room equipment ...................... 557.95
Library ...................................... 9,000.00

Ship Atlantis
Construction ................................ 218,674.47
Equipment ................................... 27,298.50

Asterias construction and equipment .... 6,570.55

Depreciation fund (reserve for periodical replacements):
Bonds ........................................... 7,000.00
Cash ............................................ 11,972.11

$652,720.95 $652,720.95

ENDOWMENT FUNDS
Received from Rockefeller Foundation for Endowment Funds
General ...................................... $2,000,000.00
For upkeep of plant ........................ 419,419.96

Less—Unamortized losses on securities sold
Reserve for amortization of bond premiums  $10,983.69
Less—Losses sustained on securities called or sold chargeable to the reserve  5,007.25

$2,420,700.35 $2,420,700.35

This is represented by the following investments at cost:
Bonds (market value $1,511,198.75) .................. $1,452,622.95
Stocks (market value $1,019,878.25) .................. 959,432.49

$2,412,055.44

Cash in bank .................................. 1,668.42
Receivable (consisting of appropriation since received and amount transferable from accounts payable)  6,976.49

$2,420,700.35 $2,420,700.35

A full list of the securities will be found in the Auditors' report.

RESERVE FUND
Anonymous gift of March 14, 1931, in cash and securities ........ $30,000.00
Accumulated income of prior years ........................................ 2,805.91
Income of current year ..................................................... 611.74

$33,417.65

Appropriation of prior years ............................................... 2,000.00

$31,417.65

GENERAL ACCOUNT

For the period from March 1, 1935 to February 29th, 1936:

<table>
<thead>
<tr>
<th>Income:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>From the Rockefeller Foundation for current expenses for the year ended February 29, 1936</td>
<td>$41,732.49</td>
</tr>
<tr>
<td>Interest from investments</td>
<td>53,217.38</td>
</tr>
<tr>
<td>Dividends from investments</td>
<td>22,414.25</td>
</tr>
</tbody>
</table>

$117,364.12

Less—Custodian fees                                                     1,097.15

TOTAL INCOME:                                                          $116,266.97

Expenses:

<table>
<thead>
<tr>
<th>Upkeep of Plant</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Upkeep of building &amp; grounds</td>
<td>$6,344.86</td>
</tr>
<tr>
<td>Upkeep of Atlantis</td>
<td>8,713.18</td>
</tr>
<tr>
<td>Upkeep of Asterias</td>
<td>164.23</td>
</tr>
<tr>
<td>Insurance</td>
<td>6,897.52</td>
</tr>
<tr>
<td>Reserve for depreciation</td>
<td>6,000.00</td>
</tr>
</tbody>
</table>

$28,119.79

<table>
<thead>
<tr>
<th>Operating Expenses:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation of Atlantis</td>
<td>$29,086.48</td>
</tr>
<tr>
<td>Operation of Asterias</td>
<td>820.20</td>
</tr>
<tr>
<td>Scientific salaries</td>
<td>27,865.22</td>
</tr>
<tr>
<td>Scientific supplies and equipment</td>
<td>2,945.46</td>
</tr>
<tr>
<td>Travelling expense</td>
<td>574.44</td>
</tr>
<tr>
<td>Publications</td>
<td>3,756.14</td>
</tr>
<tr>
<td>Administration</td>
<td>7,224.66</td>
</tr>
<tr>
<td>Amortization of bond premiums</td>
<td>7,693.83</td>
</tr>
<tr>
<td>Contribution to retirement fund</td>
<td>1,753.87</td>
</tr>
</tbody>
</table>

$81,720.30

$109,840.09

<table>
<thead>
<tr>
<th>Expenditure for Permanent Plant Additions:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Additions to library</td>
<td>$ 1,000.00</td>
</tr>
</tbody>
</table>

$110,840.09

<table>
<thead>
<tr>
<th>Excess of income over expenditures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$ 5,426.88</td>
</tr>
</tbody>
</table>

$116,266.97

$116,266.97
In June 1934, a system of retiring allowances, participation in which is voluntary, was established. At the end of the fiscal year there was in the Savings Bank accounts to the credit of the seventeen (17) participants, the sum of, $6,197.75 of which $3,050.46 was deducted from salaries, $3,050.45 was contributed by the Institution, and 96.84 is interest from the Savings Bank.

CURRENT POSITION

The situation on March 1, 1936, the beginning of the present fiscal year, was as follows:

<table>
<thead>
<tr>
<th>Current Assets</th>
<th>Current Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>Accounts payable</td>
</tr>
<tr>
<td></td>
<td>$8,238.27</td>
</tr>
<tr>
<td>Accrued salaries</td>
<td>$1,733.09</td>
</tr>
<tr>
<td>Interest receivable (accrued interest on bonds purchased)</td>
<td>62.50</td>
</tr>
<tr>
<td>1,602.49</td>
<td>Current Surplus and reserve for &quot;Working Balance&quot;:</td>
</tr>
<tr>
<td></td>
<td>Reserve for Working Balance</td>
</tr>
<tr>
<td></td>
<td>5,000.00</td>
</tr>
<tr>
<td>Current Surplus—Deficit at Feb. 28, 1935</td>
<td>$2,381.71</td>
</tr>
<tr>
<td>Deduct—Excess of income over expenditures, year ended February 29, 1936</td>
<td>$5,426.88</td>
</tr>
<tr>
<td></td>
<td>3,045.17</td>
</tr>
<tr>
<td>$9,840.76</td>
<td>$9,840.76</td>
</tr>
</tbody>
</table>

Respectfully submitted,
LAWRASON RIGGS, JR.
Treasurer.
IV
SIXTH ANNUAL REPORT OF THE DIRECTOR
FOR THE YEAR 1935
BY HENRY B. BIGELOW

Equipment

The chief mechanical addition to our equipment on shore was the installation, in the pump house, of a motor generator to supply electric current to "Atlantis" while she is at the dock. In the laboratory building, the reading room has been comfortably furnished to serve as a lounge and the kitchenette made available to all scientific workers in the Institution, filling a long felt want; and a large scale chart of the Gulf of Maine has been installed in the chart room in addition to the Atlantic chart, so that all "Atlantis" stations can now be shown.

A new scavenger pump was purchased and installed in the main engine on "Atlantis," and the main governor, which had been giving trouble, was replaced with one of different design without marked advantage. A survey of the hull and machinery was made by Lloyds.

Accidents on "Atlantis" included a bent propeller blade, and damage to the steering gear, mishaps which did not seriously delay her operations.

There have been no important alterations on "Asterias." Both vessels are in excellent condition.

Five current meters of new design were manufactured for use in the horizontal closing nets. An improved heavy dredge was constructed for Mr. Stetson's work; 22,000 feet of new hydrographic wire, and two new psychrometers were purchased; an Ekman current meter was assembled from odd parts; and a pump-filter installed on "Asterias" for collecting plankton. Routine purchases of scientific supplies need no special mention.

The U. S. Coast Guard loaned us a one-meter range finder which was used on "Atlantis" in connection with Dr. Watson's current-meter work.

A ship theodolite, borrowed two years ago, was returned to the Navy Department.

Acknowledgments

Furnishings for the lounge and photographs for the Institution's collection of pictures were donated by various members of the Laboratory.
The U. S. Coast and Geodetic Survey and the U. S. Hydrographic Office assisted us in providing charts.

While "Atlantis" was working on Georges Bank on June 14 the otter trawl was tangled around her propeller making it impossible to use the engine until the propeller was cleared. "Atlantis" could have returned to port under sail, but as the U. S. Coast Guard cutter "Faunce" was nearby at the time, Captain McMurray was glad to accept a tow from her to Boston. Again on July 8 while "Atlantis" was at anchor in Nantucket Sound, off Monomoy, one of our seamen was taken suddenly ill. The Monomoy Station sent out their surf boat and took him ashore, whence he returned to Woods Hole. For these services, we are greatly indebted to the Coast Guard and I have transmitted our thanks to the Commandant.

Library

Our general relationship with the Marine Biological Laboratory continues as heretofore. Our contribution to the Library for the fiscal year 1935–1936 was $1000, spent on subscriptions to serials, filling out back sets of the latter, purchasing new books and binding serials.

We now receive about 200 titles yearly by gift or exchange, which are deposited in the library.

Personnel

There have been no changes among the staff.

It was my sad duty to report that on March 16th, Delano Potter, second officer, was instantly killed in an automobile accident in Pensacola, Florida, T. S. Greenwood, technician, so badly injured that he died in the hospital a few hours later, and Marshall Bishop, assistant to Professor Parr, less seriously injured. As they were not on duty at the time, there was no financial liability for the Institution. To fill the vacancies, Knute Nielsen, former boatswain, was promoted to second officer and Harold C. Williams appointed wireless operator.

"Asterias" was again in charge of Captain G. W. Carlson, and Charles Butcher II served as engineer. Mr. Iselin continues to supervise the operation of both our vessels.

The same sum, $4000, was appropriated for Fellowships as in previous years, stipends to range from $60. per month to $100. per month for graduate students.

The following appointees worked at the Laboratory during the summer: Victor M. Emmel, John L. Fuller, Margaret Hotchkiss,

A grant was also made enabling Dr. Kurt Buch, Professor of Chemistry at Åbo Academy, Åbo, Finland, and chemist at Havsforsknings Institutet, Helsingfors, Finland, to spend the summer at the Institution.

The following visiting investigators worked at the Institution: A. P. Crary, Gardner Emmons, Dr. Maurice Ewing, Dr. R. M. Field, Dr. Charles J. Fish, Dr. Philip H. Mitchell, Dr. G. H. Parker, Dr. H. M. Rutherford, Louis A. Toth, Dr. Morgan Upton, Dr. Charles B. Wilson and Donald J. Zinn. There were also eleven assistants to the staff, of whom two worked as volunteers, and one laboratory technician.

The following were represented in the laboratory and on “Atlantic” cruises for this year; Åbo Academy, Finland, Barnard College, Berkshire School, Bass Biological Laboratory, Brown University, Byrd Antarctic Expedition, Dartmouth College, Flower Medical College, Harvard University, International Ice Patrol, Lehigh University, Massachusetts Institute of Technology, Massachusetts State Teachers College, University of Chicago, University of Cincinnati, University of Rochester, U. S. Coast Guard and Yale University.

Ninety-five persons, of all categories, worked at the Institution during the past year.

Foreign Travel by the Staff

Dr. Waksman and Professor Rossy both went to Europe in July, the former to attend the Sixth International Soil Conference at Oxford, England, and the International Botanical Congress at Amsterdam, the latter to visit in Sweden.

In May the Director attended the annual meeting of the International Council for the Exploration of the Sea, in Copenhagen.

Publication

Numbers 3 and 4 of Volume III and numbers 1 and 2 of Volume IV “Papers in Physical Oceanography and Meteorology” were published.

Between January 1, 1935 and December 31, 1935, the following numbered contributions appeared from the Institution:


No. 79. Keys, Ancel, E. H. Christensen, and August Krogh. The Organic Metab-


The bound volume of "Collected Reprints" for 1934 was distributed in May. The annual report for 1934 was printed, and the physical and chemical data from "Atlantis" stations for the year 1934 were forwarded to the International Council for the Exploration of the Sea for publication in their Bulletin Hydrographique for 1934.

Cooperation

During the winter of 1935 "Atlantis" worked in the Gulf of Mexico, continuing our cooperative program with Bingham Oceanographic Foundation of Yale University, the Foundation again contributing $1,500 toward the expenses. Professor Parr acted as scientist-in-charge, with Marshall Bishop, M. D. Burkenroad and Y. Olson acting as his assistants.

During the month of June and again in December "Atlantis" was put at the disposal of the U. S. Bureau of Fisheries for haddock investigations on Georges Bank, Mr. W. C. Herrington of the Bureau in charge, the Bureau assisting by supplying fuel oil for the two cruises.

Laboratory provision for the International Ice Patrol Service continues, as does operation of the tide gauge for the Coast and Geodetic Survey. Certain routine data are regularly forwarded to the Director of Fisheries Research at St. John's, Newfoundland, to the International Hydrographic Bureau at Monaco and to the U. S. Hydrographic Office.

Field Work

During the year "Atlantis" made the following cruises:

Cruise 41: January–April; Gulf of Mexico.
Cruise 42: May; Gulf of Maine.
Cruise 43: June; Georges Bank for U. S. Bureau of Fisheries.
Cruise 44: July; off Cape Cod.
Cruise 45: July; South from Woods Hole.
Cruise 46: August; Continental Shelf.
Cruise 47: August; Gulf of Maine.
Cruise 48: August–September; South from Woods Hole.
Cruise 49: September–October; off Newfoundland.
Cruise 50: October–November; off Virginia Capes.
Cruise 51: November; Gulf of Maine.
Cruise 52: November–December; Georges Bank for U. S. Bureau
of Fisheries.

Summary of observations
Total distance sailed ............................................ 20,829 miles
Number of days at sea ........................................ 246
Deep stations .................................................. 77
Shallow stations ............................................... 82
Trawling stations .............................................. 154
Long Anchor stations ......................................... 1
Temperature, Salinity and Oxygen ........................... 1,598
Other chemical determinations .............................. 1,200
Horizontal tows with closing nets ........................ 48
Light intensity stations ...................................... 2
Bacteriological stations ..................................... 23
Mud cores and bottom samples ............................ 43

“Asterias” was occupied chiefly in connection with the investigations of Dr. Clarke, Mr. Hough, Miss Lillick, Dr. Powell and Dr. Renn.

Staff Meetings

Continuing our previous custom staff meetings were held weekly during the active season, with the following list of speakers: Dr. Kurt Buch, Dr. George L. Clarke, Bostwick H. Ketchum, Benjamin B. Leavitt, Raymond B. Montgomery, Dr. Alfred C. Redfield, Dr. Charles E. Renn, S. Edward Roos, Prof. C.-G. Rossby, H. R. Seiwell, O. E. Sette, Henry C. Stetson, Dr. E. E. Watson, Dr. John H. Welsh.

Financial

The original grant of the Rockefeller Foundation to the Woods Hole Oceanographic Institution included an annual payment of $50,000 to continue for a period of ten years which terminates in 1940. Although no definite commitment was made, it has been our hope that on the termination of this grant the Foundation would replace it by the payment of additional endowment of equivalent capital value.

During the winter of 1935, changes in policy made the Foundation desire to terminate their financial obligations to the Institution. Accordingly on April 10, 1935, the Trustees of the Rockefeller Foundation voted
"to appropriate the sum of $1,000,000 to the Woods Hole Oceanographic Institution for endowment, upon condition that the Institution shall agree to cancel as of the date of such contribution to endowment the Foundation’s present appropriation to current maintenance."

And we were informed of their hope that such cancellation might take place within the year 1935.

After weighing the matter carefully, your President, Treasurer and Director recommended that the offer be accepted, for while the income from the new endowment would be less than the annual grant, acceptance would make the Institution permanently independent of outside sources. In accordance with this recommendation, the Executive Committee unanimously voted to accept the offer and the Rockefeller Foundation was so informed. This action was approved by the Trustees at the meeting on August 15th. The new endowment was paid over in October.

Amplifying the Treasurer’s report, the following items may be of interest: the cost of maintaining and operating “Atlantis,” including replacements, for the fiscal year 1935-1936 (exclusive of insurance) was $37,800, or an average of about $153 for each day at sea. The cost of operating “Atlantis” continues to average about $3,000 a month as previously.

In my last report I mentioned the increasing cost of all commodities. Fortunately for us there has been but little change in this respect the last year.

**Scientific Program**

The general division of our scientific program under direction of the members of the staff has proved productive. The visiting investigators either cooperate with the staff or carry on investigations in related fields. The activities of the various workers during the summer may be summarized as follows:

**Ocean Physics and Meteorology**

Preparation of report on hydrology of Northwest Atlantic and Labrador Sea, based on U. S. Coast Guard cruises of 1928, 1933 and 1934; E. H. Smith.

Preparation of oceanographic report of International Ice Patrol of 1934; Floyd M. Soule.

Preparation of report on Circulation of the Western North Atlantic, based on “Atlantis” cruises; C. Iselin.

Preparation of report on Circulation in the Bay of Fundy, calculations of the interchange of waters through the deep channels of the

Simultaneous measurements of humidity at various heights from 1 to 40 meters above sea surface, the data to be used to determine evaporation; also measurements of wind velocity at different heights above the sea surface; C. G. Rossby and R. B. Montgomery.

Analysis of movements of air masses along the coast and over the neighboring ocean; Gardner Emmons.

Measurements of reflection of light from sea surface, as related to absorption of light-energy by the water; George L. Clarke, Wilson M. Powell, Jr.

*Physical and Biological Chemistry of Sea Water*

Investigations on Phosphorus and Oxygen distribution in water and sediments of the North Atlantic and in the Caribbean, based on "Atlantis" cruises; H. R. Seiwell, Gladys Seiwell and Allyn White.

Standardization of indicators for measuring alkalinity of sea water; Philip H. Mitchell, Francis Maynard.

Study of nitrogen gas, nitrogen compounds, and iron in sea water; N. W. Rakestraw, Henry Mahncke and Victor M. Emmel.

Measurements of CO₂ tension in sea water, and comparison of methods for determining alkalinity; Kurt Buch.

Factors determining distribution of oxygen in the Gulf of Maine; Alfred C. Redfield.

*Marine Bacteriology*

Investigations of a) availability of suspended and dissolved organic matter in sea water; b) rôle of bacteria in phosphorus cycle in the sea; c) correlation between nitrogen and carbon cycles in the sea; and d) wasting disease of eel grass (*Zostera marina*); Selman A. Waksman, Charles E. Renn, Theone Cordon.

Measurements of electric potential in sea water; Wm. A. Burrows.

Oxygen consumption and metabolism of marine bacteria; Frank H. Johnson.

Census of bacterial population in sea water, and relationship of bacteria to the nitrogen cycle; Margaret Hotchkiss.

*Submarine Geology and Topography*

Preparation of report on fossiliferous rocks and sediments dredged from walls of the submarine canyons of Georges Bank in 1934, and similar dredging in the submarine canyons to the southward during the summer; Henry C. Stetson, Marshall Schalk.

Distribution of bottom deposits of Cape Cod Bay, and of the
Cape Cod sands in relation to the action of waves and currents; Jack L. Hough.

Preparation of bathymetric chart of Ross Sea, and depth-plotting for South Pacific, from echo soundings obtained on the last Byrd Antarctic Expedition; E. Roos.

First trials in deep water of a coring tube operated by an explosive charge, designed to obtain longer cores than had heretofore been taken; C. L. Piggot.

A seismic profile across the continental shelf off Chesapeake Bay by the adaption of the existing land technique to marine conditions; Maurice Ewing, R. M. Field, H. M. Rutherford, A. P. Crary.

**Plankton Studies**

Relative importance of various groups of microorganisms as food for oceanic copepods; George L. Clarke, John L. Fuller, Sidney Cobb.

Regional and seasonal survey of phytoplankton of Vineyard Sound; Lois Lillick.

Survey of zooplankton of neighboring waters in relation to tide, season and so forth; George L. Clarke, Donald Zinn.

Preparation of reports on zooplankton of Gulf of Maine and Bay of Fundy, based on field work in 1931–1933; Charles J. Fish. Preparation of report on zooplankton of continental shelf waters, Cape Cod-Chesapeake Bay; Mary Sears.

Quantitative study of vertical distribution of pelagic animals, in the Atlantic basin, based on hauls with closing nets from “Atlantis”; Benjamin B. Leavitt.

**Physiological Studies**

Metabolism of diatoms; Bostwick H. Ketchum, Homer P. Smith.

Experiments on correlation between rate of growth of scales and increase in body-length of cod, at different temperatures; Wm. C. Schroeder.

A study of the rôle of changing temperature in the seasonal migration of Scup and Mackerel; Morgan Upton.

Investigation of blood-flow through the kidney, in the toadfish; Louis Toth.

Color changes in two species of dogfish in relation to nerves; G. H. Parker.

Diurnal changes in eye pigments of lobster, and eyes of deep sea crustacea; John H. Welsh.

**Miscellaneous**

Fungi parasitic on marine diatoms; Frederick K. Sparrow, Jr.

Examination of mud and sand-living copepods from northern part of the Gulf of Maine; C. B. Wilson.
V

STAFF
(As of December 31, 1935)

HENRY B. BIGelow, Professor of Zoology, Harvard University, Director
CORNELIA L. CAREY, Barnard College, Research Associate in Marine, Bacteriology
GEORGE L. CLARKE, Tutor and Instructor, Harvard University, Junior Biologist
COLUMBUS ISELIN, Assistant Curator of Oceanography, Museum of Comparative
Zoology, Research Associate in Physical Oceanography
A. E. PARK, Curator of the Bingham Oceanographic Collection, Yale University,
Research Associate in Oceanography
NORRIS W. RAKESTRAW, Associate Professor of Chemistry, Brown University, Re­
search Associate in Physical Chemistry
ALFRED C. REDFIELD, Professor of Physiology, Harvard University, Senior Biologist
C. E. RENN, Tutor and Instructor, Harvard University, Junior Marine Bacteriologist
C. G.Rossby, Professor of Meteorology, Massachusetts Institute of Technology,
Oceanographer
H. R. SEIWELL, Investigator in Oceanography
FLOYD M. SOULE, Senior Physical Oceanographer, U. S. Coast Guard, Research As­
socite in Oceanography
HENRY C. STETSON, Assistant Curator in Paleontology, Museum of Comparative
Zoology, Research Associate in Submarine Geology
SELMAN A. WAKSMAN, Microbiologist, New Jersey Agricultural Experiment Station,
Marine Bacteriologist
E. E. WATSON, Lecturer in Physics, Queen's University, Research Associate in Phys­
ical Oceanography
CAPTAIN SIR HUBERT WILKINS, Research Associate in Oceanography

WILLIAM C. SCHROEDER, Business Manager
MISS VIRGINIA B. WALKER, Secretary and Administrative Assistant
WILLIAM SCHROEDER, Superintendent of Buildings and Grounds
APPENDIX

Reports of progress by investigators working at the Institution during 1935.

EFFECT OF TEMPERATURE ON GROWTH OF COD, AND OF THEIR SCALES
HENRY B. BIGELOW AND WILLIAM C. SCHROEDER

During the summer of 1935 an experiment was conducted in the aquarium room of the Institution to determine what effects, if any, temperature has on the growth of cod, and of the scales.

Three cod were held in water of a seasonal temperature, while four were kept in chilled water. Measurements and scale samples were taken periodically, and record kept of food consumed. The experiment, beginning May 10, continued without interruption until August 19th, when the “warm” water fish died because of a mishap to the water system. Two of the cold water fish were then transferred to the warm tank and this condition continued until September 24th when a further mortality necessitated discontinuing the experiment.

The colder temperature fluctuated, because of mechanical difficulties with the cooling system, between 7.6° and 4.1° C. while in the warm tank the extremes were 15° and 12° C.

It is planned to continue the experiment in 1936.

PHYSICAL OCEANOGRAPHY OF THE WATERS ON THE CONTINENTAL SHELF, CAPE COD TO CHESAPEAKE BAY
HENRY B. BIGELOW AND MARY SEARS

The report on Salinity was finished and published in Papers in Physical Oceanography and Meteorology, Vol. 4, No. 1.

ZOÖPLANKTON STUDIES
HENRY B. BIGELOW AND MARY SEARS

1. Studies of the waters of the continental shelf, Cape Cod to Chesapeake Bay. Zoöplankton.

   The quantitative measurements and identifications of all the catches were completed.


19

Two Danish assistants, in Copenhagen, have continued sorting the Siphonophores from the plankton catches during the present year and two large shipments have arrived in this country for further study.

CHEMISTRY OF SEA WATER

K. BUCH, P. H. MITCHELL, NORRIS W. RAKESTRAW

Progress has been made during the last season by the chemical division of the Institution in the following directions:

1. Investigations on the occurrence of free, inorganic iron in sea water, which have been going on during the last three seasons, were finished, and a paper embodying these results has been published.

2. A short paper on the occurrence of boron in North Atlantic waters has also been published.

3. Work on the distribution and significance of nitrite in sea water was continued this season and a paper on this subject is now being prepared.

4. The main features of a new and more convenient method for the determination of dissolved gaseous nitrogen have been worked out, with the help of Mr. Emmel, and after a few minor points have been perfected, the method will soon be ready to apply.

5. Professor Kurt Buch, of Åbo Academy, Finland, carried out a study of the carbonic acid—carbonic dioxide equilibrium in Atlantic water, employing methods which he has used with success elsewhere. Determinations of temperature, salinity, alkalinity, oxygen and carbon dioxide tension were made on surface samples obtained from one cruise of "Atlantis," and also during the crossing to and from Denmark. The carbon dioxide content of the atmosphere was determined simultaneously, and the results, which will be published during 1936, should extend our knowledge of the conditions of exchange of CO₂ between the atmosphere and the ocean. In connection with this same study, a few determinations were made during the summer of the carbon dioxide content in masses of air of different origin. Also, during one cruise of "Atlantis" samples of air were taken at different heights, which showed a decided CO₂ gradient.

6. Dr. Mitchell, with Mr. Maynard, studied the behavior of certain pH indicators in sea water. Simultaneous measurements with the glass electrode and bicolorimeter established the dissociation curves in water of varying salinity for the indicators phenol red and
cresol red at 20° and 25° C. These results confirmed and extended previous observations and should make possible an improvement in the precision of future measurements of the pH of sea water. Dr. Buch coöperated in this study by making simultaneous pH determinations by other colorimetric methods, which led to a redetermination of the salt-error curve for cresol red. The results of all this work have given us a clearer understanding of both the opportunities and limitations of pH measurements in sea water.

7. Additional water samples from between Labrador and Greenland were obtained for the determination of dissolved helium and neon, in the effort to explain peculiar results reported in a preliminary study by Dr. W. D. Urry. These samples are being analyzed at the Massachusetts Institute of Technology.

PHYSIOLOGY OF COPEPODS, SEASONAL DISTRIBUTION OF PLANKTON, AND PENETRATION OF LIGHT INTO THE SEA

GEORGE L. CLARKE

1. The investigation of the feeding of the copepod, Calanus finmarchicus was continued as a step in a general analysis of the factors controlling plankton production. A technique was developed for rendering the copepod cultures practically sterile thus making possible critical experiments on the rôle of bacteria in the nutrition of these animals. (In collaboration with Dr. John Fuller and assisted by Mr. Sidney Cobb.)

2. In June a survey was begun of the distribution of the plankton in the Woods Hole region and its changes in relation to the tides and the season. The major part of the work was carried on at a station 7 miles off No Man's Land where a sustained population of Calanus was found to exist. Observations were continued at this station, at monthly intervals, throughout the remainder of the year to trace the yearly cycle of hydrographic and biological events, at a point which is as far removed from land influences as possible and still accessible from Woods Hole. Besides collections with net and with pump for the larger and smaller elements of the zoöplankton respectively, and measurements of temperature and light penetration, water samples were taken for analysis of phytoplankton and bacteria and for determination of phosphates, nitrates, and total salinity. (Assisted by Mr. Donald Zinn.)

3. Data was compiled for the calculation of the maximum depth at which vision is possible for fish in various parts of the sea. The
results indicate that during hours of bright sun at the surface fish can see at the bottom in in-shore waters and on the continental shelf.

4. An illustrated account of the work of the Institution was prepared and published by the American Museum of Natural History in their magazine *Natural History*.

5. Measurements were undertaken to ascertain the cause of the large “surface losses” which have been found in the investigation of submarine illumination and to determine the influence of different conditions of sky and sea on the magnitude of such losses. The light moving upward from the surface of the water was investigated by securing photoelectric photometers in an inverted position at the top of a floating tower. A new sea photometer and a new deck photometer were constructed using the Westinghouse Photox Cell and a highly damped micro-ammeter. These instruments were carefully tested and standardized and found satisfactory for the measurement not only of reflection but also of the illumination beneath the surface. The light reflected from the surface, plus the light which enters the water but escapes out again through the surface, represents that fraction of the light fall on the ocean which does not contribute to its supply of energy. The greater part of the “surface loss” was found to be accounted for by a stratum of relatively opaque water extending to a depth of about one meter and caused by bubbles in this stratum, the abundance of which is proportional to the roughness of the sea surface. (In collaboration with Dr. W. M. Powell.)

**ZOOPLANKTON OF THE GULF OF MAINE AND NARRAGANSETT BAY**

CHARLES J. FISH

Preparation of a report on the biology of the zooplankton population of the Gulf of Maine and Bay of Fundy has been continued during the past year, and individual papers on *Calanus finmarchicus* and *Pseudocalanus minutus*, with special reference to production and dispersal, have been completed and are now in print.

In October, a two year program of field investigations was started in Narragansett Bay, the objective being a continuation of similar studies of the biology of the zooplankton population in the region south of Cape Cod.

**NUTRITION OF CALANUS FINMARCHICUS**

JOHN L. FULLER

In conjunction with Dr. Clarke the study of the nutrition of the copepod, *Calanus finmarchicus*, was continued. Experiments were
designed to test the possibility that bacteria might be an important source of food under natural conditions. Since in the laboratory bacteria alone, even in high concentration, did not support growth of *Calanus*, it was concluded that they must be negligible as a food source in the sea where they are distributed sparsely. The observations of Clarke and Gellis in 1934, that *Calanus* thrives in sea water from which diatoms and other large plankton have been removed by filtration through paper, was confirmed. *Calanus* grew more rapidly however, in untreated sea water than in paper filtered water. This means that certain elements of the nannoplankton, probably naked flagellates, can support the growth of *Calanus*. Since flagellates were less abundant in filtered than in unfiltered water, the relative importance of diatoms and flagellates cannot be determined from these experiments.

Preliminary measurements on the rate of filtration of sea water by *Calanus* suggested that diatoms were too sparsely distributed in the sea to provide all the food necessary for an individual copepod. If these measurements are substantiated, the importance of the nannoplankton as a food for *Calanus* in nature will be established.

**PHYSICAL OCEANOGRAPHY OF THE WESTERN NORTH ATLANTIC**

**COLUMBUS ISELIN**

During the past year the "Atlantis" occupied only 183 hydrographic stations. Thus the work of correcting the routine observations has been considerably less than in previous years. Moreover, on the two occasions when the ship made extended surveys, Mr. Woodcock determined the salinity values on board so that there has been no difficulty in keeping the corrected observations up to date.

During the summer months Mr. S. Edward Roos, who acted as oceanographer on the Byrd Antarctic Expedition II, prepared a report on his sonic sounding material, chiefly from the Ross Sea. About 2700 soundings have been corrected and a report is now in the process of being published.

The "Atlantis" temperature and salinity data from the western North Atlantic have been studied further and the manuscript of a general report has been revised as our ideas concerning oceanic circulation have developed. A course in dynamic oceanography is again being given at the Massachusetts Institute of Technology and a considerable amount of time during the past autumn has been devoted to the preparation of the lectures.
INVESTIGATIONS OF BATHYPELAGIC ZOOPLANKTON AND EXPERIMENTS WITH CLOSING NETS

BENJAMIN B. LEAVITT

Investigations of the quantity of animals living at different depths in the sea have been continued. Two trips were made on "Atlantis" during the past summer and much more data have been gathered by the use of two-meter closing nets. Several stations were completed during the summer and information has been obtained on the amount of plankton collected at definite levels down to a depth of thirty-two hundred meters. Closing devices for two-meter nets have been improved and found serviceable. In order to gather information on how much water actually passed through the nets while they were being towed, current meters have been devised to measure the passage of water through the mouths of the nets. These were used on a trip on "Atlantis" late in the summer and are still in an experimental stage. The quantities of animals collected at different depths at nine stations have been measured and the Euphausiids contained therein have been identified. The different species have been correlated with the depths at which they live. The fish collected have been sent to Professor A. E. Parr, who has generously offered to identify them.

QUANTITATIVE AND QUALITATIVE STUDY OF THE PHYTOPLANKTON OF BUZZARDS BAY AND VINEYARD SOUND

LOIS C. LILICK

During the past summer a qualitative and quantitative survey of the phytoplankton of Buzzards Bay and Vineyard Sound was begun in relation to certain physical and chemical factors. Two stations in the Bay and three in the Sound were investigated. Biweekly samples were taken at surface, median, and bottom depths from the first of July to the first of September. Qualitative and quantitative determinations of samples taken from two of the stations in the Sound have been completed through the middle of August.

A check-list of the marine diatoms known and recorded from the western Atlantic between the northern part of West Greenland to the southern part of Central America is being compiled in connection with this survey.
COLOR CHANGES OF FISHES
G. H. PARKER

Work was continued on the color changes of the spiny dogfish, *Squalus acanthias*. This dogfish is dark in color and maintains this condition through pituitary neurohumors carried in its blood. It gives very little evidence of a pale phase and in this respect it is very unlike the smooth dogfish, *Mustelus canis*. There is no reason to believe that nerves play any significant part in inducing a blanching of the spiny dogfish's skin as they do for that of the smooth dogfish. These results are already in process of publication in the Proceedings of the National Academy of Sciences.

Work, begun last year, on the lipohumor concerned with the pale phase of the smooth dogfish, was also continued. Extracts of the skins of some 200 smooth dogfishes were made and studied biologically and chemically. The resistance to heat of the contained neurohumor was demonstrated as well as its solubility in oil, ether, etc. A report is in preparation for publication.

INVESTIGATIONS IN COÖPERATION WITH THE BINGHAM OCEANOGRAPHIC FOUNDATION OF YALE UNIVERSITY
A. E. PARR

The various coöperative projects mentioned in the previous reports were continued also through the year 1935.

In the hydrographic study of the Central American Seas the observations gathered by the "Atlantis" in the Caribbean region, south of the Yucatan Channel, during 1933 and 1934 were subjected to further analysis in the Bingham Oceanographic Laboratory and the first section of the report on the results of this investigation, dealing with the Temperature-Salinity correlations and the horizontal distributions of the various types of water found to occur within the Caribbean area is now almost ready for publication. The greatest part of the calculations, tabulations and drawings necessary for the preparation of the second part of the same report were also completed during 1935. During February to April, 1935, the "Atlantis" made 106 stations in the Gulf of Mexico to obtain further information concerning a peculiar hydrographic instability in the middle layers in this region, first discovered by the Yale Oceanographic Expedition in 1932. As in 1932, a change was again found to have occurred between the early and the later part of the cruise in 1935.
In regard to the distribution of surface salinities, the observations for the two separate years show some very interesting and important differences in detail, while agreeing in the essential feature of a prevalence of very high surface salinities in the interior of the Gulf proper as compared with the surface salinities of the Caribbean region. The data collected in 1935 are now also in the process of preparation for publication in the Bingham Oceanographic Laboratory.

The collecting of records and samples of the floating Sargassum weeds was continued during the 1935 cruise, and served to disclose a surprising degree of variation from year to year both in total quantity and in the ratio of abundance of the two dominant species. Experiments were also made to prove the validity of the collecting method employed by showing that the occurrence of the weeds under normal conditions is strictly limited to the very surface alone, in so far as quantitatively significant amounts are concerned. M. D. Burk­ enroad continued his studies of the animal life associated with the floating weeds, and is now preparing for publication an account of the general ecological principles governing the life of the epizoan community, and of such specific biological details as have already been established through his work. A report, mainly on the quantitative results of the study of the weeds themselves, is also being prepared for simultaneous publication by A. E. Parr, while further work along biological and taxonomic lines is already in progress or in contemplation as part of the future program.

During the visit to the Gulf of Mexico, bottom trawlings were attempted along the slope of the continental shelf in the north. Although bad bottom conditions caused great damage to the trawls, the results nevertheless give clear evidence of an astounding abundance of bottom life below the region in which the Mississippi outflow meets the offshore waters of the Gulf at the surface. It is the intention to pursue the study of this phenomenon further on the next cooperative cruise of the "Atlantis" to these waters, tentatively planned for 1937.

Taxonomic investigations of deep-sea fishes and various invertebrate groups collected by the "Atlantis" were continued through 1935.

**BIOLOGY OF THE GULF OF MAINE**

**ALFRED C. REDFIELD**

The analysis of data obtained during the survey of the waters of the Gulf of Maine in June, 1933 and September, 1934 had indicated
that the abundance of zooplankton occurring at various times and places may be explained by the peculiarities of the non-tidal drift of the superficial waters of the Gulf. The distribution of certain plankton-feeders such as petrels and mackerel, as well as the chief sites of phytoplankton activity, are also related to the circulation system. It has consequently been possible to develop a general theory based on hydrographic data to account for important aspects of the ecological situation presented by the Gulf as a whole.

The importance of vertical mixing in establishing the conditions for physiological activity in the Gulf is under investigation and it has been possible to estimate tentatively the rate at which oxygen is supplied to the deeper water by this process.

Mr. Bostwick Ketchum is conducting an investigation of the rôle of phosphate and nitrate in ecological concentrations in controlling the growth and metabolism of diatoms.

DYNAMIC OCEANOGRAPHY
C.-G. ROSSBY

The theoretical investigation of the dynamics of ocean currents reached a certain degree of completion with the publication of a report in which the characteristics of the wind-produced surface layer of homogeneous water was discussed. A computation was then made by Mr. R. B. Montgomery of the wind-produced convergence of surface water in different parts of the North Atlantic. An analysis of vertical wind and vapor pressure gradients in the immediate vicinity of the sea surface seem to indicate the existence of a thin laminar boundary layer next to the water, at least for low wind velocities. The presence of this laminar layer will reduce very markedly the shearing stress between air and water and therefore necessitate a recomputation of the convergence.

We have begun to investigate the effect of large scale horizontal turbulence in producing lateral shearing stresses acting on vertical planes parallel to the direction of the mean motion. These stresses should reveal themselves through the existence of certain preferred velocity profiles cross-stream. With this in mind we are now studying velocity profiles in various sections through the Gulf Stream. Theoretically the investigation is of great interest since it deals with turbulent flow in a rotating system and thus may shed some light on the relative merits of the "momentum transfer" and "vorticity transfer" theories.
DISTRIBUTION OF PHOSPHATES AND OXYGEN IN 
THE WESTERN NORTH ATLANTIC 
AND CARIBBEAN SEA

H. R. SEIWELL

A descriptive discussion of phosphate distribution in the western Atlantic was published as contribution No. 64 and two other papers on new methods for calculating the production of organic matter in the open ocean as contributions No. 24 and 77. In this work I was assisted during the year by Gladys Eddy Seiwell who performed the laboratory experiments needed to supplement the field observations and also acted as general assistant.

Our investigation of the mechanism controlling the circulation of phosphorus, oxygen, and other dissolved substances of biological importance in the sea has led to a study of the agencies which bring about vertical exchange of dissolved substances between strata in the deeper parts of the ocean basins. The problem is now being investigated from both field and experimental viewpoints.

In the late summer, during a cruise on "Atlantis" to the Labrador Basin, we obtained phosphorus, oxygen, salinity, and temperature data for 16 deep stations thus enabling us to extend ten degrees northward the picture of oxygen and phosphorus distribution in the western Atlantic and to test certain theoretical ideas advanced in contributions No. 32 and 64 in more northern latitudes than had heretofore been possible.

The oxygen data from "Atlantis" cruises to the Caribbean Sea and Gulf of Mexico in 1932, 1933, and 1934 have been turned over to me for analysis. With the assistance of Mr. Allyn White, a detailed bathymetric chart of the Caribbean Sea is now prepared and all the data have been reduced and corrected and the sections drawn preparatory to study.

During the year I have also cooperated with Professor C.-G. Rossby on certain problems of physical oceanography.

PHYSICAL OCEANOGRAPHY OF DAVIS STRAIT, LABRADOR SEA AND NEWFOUNDLAND BANKS

EDWARD H. SMITH

The past year has been devoted to a study of the distribution of temperature and salinity in the waters around the Grand Banks and northward between Labrador and Greenland to the southern part of Baffin Bay.
The report as described in last year's report is expected to be ready for publication sometime during the spring of 1936 as Part 2 of U.S. Coast Guard Bulletin No. 19.

PHYSICAL OCEANOGRAPHY OF THE GRAND BANKS REGION AND LABRADOR SEA
FLOYD M. SOULE

Work was continued on the report on the physical oceanography of Baffin Bay, Davis Strait and the Labrador Sea in collaboration with Edw. H. Smith and Olav Mosby until March, 1935. The months of April, May and June were spent on the oceanographic vessel of the International Ice Patrol, the U.S.C.G. Patrol Boat “General Greene,” in the region of the Grand Banks, supplying dynamic topographic charts of the region to the Ice Patrol cutters “Mendota” and “Pontchartrain.” During this period three current surveys of the critical area were made with reference to the 1000 decibar surface although the temperature and salinity measurements extended in many cases to 1400 meters where the depth of water permitted. In this work 167 oceanographic stations were occupied. An additional 110 oceanographic stations were occupied on an intensive post-season cruise in the region of the Labrador Deep and the supposed location of the Newfoundland Ridge hypothesized by Wüst. The measurements on the post-season cruise took place between July 10 and August 23, all stations being occupied from the surface to as near bottom as was practicable. At 12 stations, selected to form a section from Cape Farewell southwestward to deep water and thence south-southeastward to a point south of the supposed Newfoundland Ridge, a total of 95 samples were taken for oxygen determinations and an equal number of helium samples were taken.

On the post-season cruise 2036 sonic soundings were taken with the Fathometer. These have been corrected, tabulated, and transmitted to the Hydrographic Office and to the International Hydrographic Bureau. An additional 1355 corrected soundings taken on the “Marion” Expedition in 1928 were tabulated and forwarded to the same offices. A bathymetric chart of the Labrador Sea based on all available soundings has been constructed.

Since the return of the “General Greene” to the United States on September 5 the oceanographic section of the U.S. Coast Guard Bulletin No. 25, dealing with the 1935 season’s work, has been prepared for publication and the work of collaboration on the report on the physical oceanography of Baffin Bay, Davis Strait and the Labrador Sea has been resumed.
Experiments were made on cultivation, in an artificial medium, of *Sirolpidium bryopsidis* an endophytic marine fungus, found in nature as a facultative saprophyte of the green alga *Bryopsis plumosa*. After trying a number of different media, it was found that 0.5% and 1.0% solutions of dextrose in filtered sea water had a markedly stimulating effect on the production of extra-matrical growth.

**STUDIES IN SEDIMENTATION AND ON THE GEOLOGY OF SUBMARINE CANYONS**

H. C. STETSON, J. L. HOUGH, MARSHALL SCHALK

The work begun in the summer of 1934 on the submarine canyons of Georges Bank was continued in the outer part of the Hudson Gorge and in three canyons further south off the Delaware-Maryland coast. In 13 successful tows material was dredged from the walls of these valleys, very different in lithology, mechanical composition, degree of consolidation and fauna from the product of present day sedimentation. It is possible that these samples came from the truncated outcrops of strata forming the canyon walls. However, because the contained foraminifera are Recent forms which cannot range farther back than Pleistocene, the implications involved are too far-reaching to warrant a full acceptance of the evidence at this time. A detailed report is in progress.

We were accompanied on this cruise by Dr. Charles J. Piggot of the Geophysical Laboratory of the Carnegie Institution who tried out for the first time in deep water a new type of coring tube. With this tube, operated by explosives, cores were obtained, some of which are among the longest ever taken.

A paper in three parts, with J. A. Cushman and L. W. Stephenson, on the results of the work on the Georges Bank canyons, was completed and is now in the hands of the Geological Society of America awaiting publication.

A report is in preparation on the cores taken last January on "Atlantis" in the fine grained calcareous sediments that mantle the volcanic cone of Bermuda.

Mr. Edward Roos of the 2d Byrd Antarctic Expedition very kindly donated several cores which he obtained on the "Bear" in the Ross Sea. They are of especial interest as they represent deposition directly from the front of a large continental ice sheet. Mechanical and mineralogical analyses are at present being carried out.
In October a program of seismological work was carried out on "Atlantis" by Dr. Maurice Ewing under the general direction of Professor Richard M. Field. A profile was run from Cape Henry to the break in slope for the purpose of ascertaining the thickness of the Coastal Plain wedge. The ordinary seismic instruments used in oil prospecting were employed, with the geophones adapted for use under water. Four successful stations, with several shots at each, were made and report is in progress.

During the summer of 1935, J. L. Hough took samples of the bottom deposits and beach sands of Cape Cod Bay. The study was extended to the region north of the tip of Cape Cod, and includes the southern portion of Stellwagen Bank. Mechanical analyses of the samples have been made, and the work of correlating between the characters of the sediments and the environment is in progress. Further studies of the material, involving measurement of roundness of grains and identification of minerals, are planned.

EFFECT OF EPINEPHRINE ON RATE OF WATER EXCRETION IN THE TOADFISH

L. A. TOOTH

The effect of injections of epinephrine on the water excretion in mammals and in the frog has been extensively studied by various investigators. Their results indicate that either a polyuria or an oliguria can be brought about after such injections, depending on the conditions of the experiment. To determine whether or not the same results could be obtained in agglomerular kidneys, in which the circulatory system is much different from that of the mammalian or amphibian kidney experiments were made on the toadfish (Opsanus tau), under ethyl urethane anesthesia. The rate of water excretion was studied by annulating one of the ureters and observing the movement of the meniscus in the urine column. Sixteen injections of 0.2, 0.05, and 0.02 mgm. of epinephrine hydrochloride in one cubic centimeter of 25 per cent sea water occasionally resulted in a small and transitory increase in the rate of water excretion. Control experiments in which only sea water was injected seemed to indicate that this transitory increase was due to the added fluid.

To extend the investigation of circulatory factors in urine production, studies of the effect of anoxemia, and of the occlusion of the dorsal aorta, were also begun. The anoxemia was produced by bubbling nitrogen through the water near the gills of a fish in a closed vessel.
INFLUENCE OF CHANGING TEMPERATURES ON THE BEHAVIOR OF SCUP (*STENOTOMUS CHRYSOps*)

MORGAN UPTON

The behavior of Mackerel when the temperature of the water in which the fish are swimming is lowered was studied during the summer of 1934 with the hope that information regarding the causes of the fall migration of the fish would be obtained (cf. Report of Woods Hole Ocean. Inst., June, 1935).

Since Scup are known to migrate to definite offshore regions in the late fall, an investigation of the behavior of this fish was carried out under conditions analogous to those which obtained in the experiment with the Mackerel.

The fish were placed in a tank containing 40 gallons of fresh sea water which was cooled by a motor driven refrigerating unit. Fresh sea water was circulated continuously through the tank while the water was being cooled, and a siphon system kept the water at a constant level. The temperature of the sea water at the beginning of each experimental run was approximately 20° C. and about twelve hours were required to lower the temperature of the water to 6° C.

Four sets of observations involving four groups of six fish each were made. As the temperature of the water fell the general activity decreased. At 14° C. all the fish still were normally oriented and swimming slowly but responded only slightly when poked with a glass rod. At 8.5° C. swimming movements were interrupted by periods of quiescence during which the fish turned bottom up and settled slowly to the bottom. At 7.5° C. several of the fish were completely immobile, displaying no response to poking with a glass rod. At this temperature two of the immobile fish from each group were placed in a small tank and gradually warmed by circulating fresh sea water (temperature 20° C.) into the tank. All of the fish which were so treated recovered full vigor and lived for several weeks in one of the large laboratory storage tanks.

Between 7° C. and 6° C. all the fish were immobilized and none of them recovered on being warmed if the temperature of the water had gone below 7° C. This seems to be a lethal temperature for Scup under these conditions.

It was thought that the relatively rapid cooling might have killed the fish, because of some shock effect. To test this, twenty-eight Scup (5 to 12 inches in length) were placed in a large concrete laboratory storage tank to be cooled by the normal temperature change brought about by the onset of winter.
The behavior of the fish under the effect of slow cooling was not greatly different from that of those which were cooled rapidly. All the fish in this group were fairly vigorous and ate regularly, until the temperature of the water was lowered to 7° C.

Below this temperature the eating ceased and all the fish died in a period of ten days during which the temperature fell from 7° C. to 4° C.

STUDIES IN MARINE BACTERIOLOGY

SELMAN A. WAKSMAN, C. E. RENN, MARGARET HOTCHKISS, W. BURROWS, F. H. JOHNSON, ASSISTED BY T. CORDON

During 1935, the investigations in Marine Bacteriology were grouped around the following problems: 1) transformation of organic matter in sea water; 2) abundance of bacteria in water as determined by plate, microscopic, and attachment slide methods; 3) fixation of nitrogen by marine bacteria; 4) respiration and utilization of different carbohydrates by marine bacteria; 5) oxidation-reduction potentials of sea water, as modified by bacterial activities; and 6) the nature of the causative agent of the eel-grass disease.

It was calculated that under laboratory conditions, using oxygen consumption as the index, that about half of the dissolved organic matter of sea water may be decomposed by bacterial action, about 60% of this being completely oxidized and 40% converted to bacterial cell substance. Temperature, concentration of available organic matter and inorganic nutrients, especially nitrogen and phosphorus, and the position of the water mass involved are factors influencing the rate of extent of decomposition.

In the comparative studies of plate, direct, and attachment slide methods of determining numbers of marine bacteria all procedures showed considerable variation, but correlations were always positive—the direct microscopic methods gave from 100 to 1000 times the number counted on plates; the wider ratio in freshly collected water, and the lower in cultures or stored water. Pure cultures gave ratios between direct and plate methods of 1–15:1.

Nitrogen fixing organisms of the Clostridium type were demonstrated in marine mud, surface water, and on algal material, appearing more abundantly in the mud than in the water. Thirteen cultures of this organism, all fixing nitrogen with glucose as a source of energy, were investigated. The Azotobacter type has been demonstrated in the sea only occasionally (M. Hotchkiss).

The cultural characteristics of 50 pure strains of marine bacteria
isolated at random from sea water and bottom material were studied. Marked differences in their ability to ferment ten different carbohydrates were observed. The endogenous oxygen uptake of twenty-five of these cultures was studied under carefully controlled conditions, confirming information secured earlier by other methods in this laboratory. In cultures enriched by glucose appreciable excess in oxygen uptake over the endogenous metabolism was secured only when the concentration of glucose exceeded the equivalent of organic matter in natural sea water. Glucose appeared to be a more readily available source of energy for marine bacteria than did alginic acid, though many bacteria were capable of utilizing the latter (F. H. Johnson).

In the studies on oxidation-reduction potentials in water and muds, it was found that sea water, on standing, showed an initial negative drift followed by a return to original levels, that organic matter retarded this return, and that the behavior was unaffected by light. Potential measurements of initial reactions in the Gulf of Maine indicated increasing negativity with depth and potentials of bottom materials approximated those of surface water (W. Burrows).

Inoculation experiments were performed with the unidentified Labyrinthula previously isolated from diseased eel-grass. These tests demonstrated the specific parasitic nature of the protozoan and indicated its rôle as the immediate cause of the Zostera disease (C. E. Renn).

WATER MOVEMENTS IN THE GULF OF MAINE

E. E. WATSON

A paper on mixing and residual currents in tidal waters, based largely on observations from the Bay of Fundy, has been completed and sent to press.

A series of temperature and salinity measurements were taken every two hours at an anchor station in the Gulf of Maine. The calculated dynamic heights of the surface at this one station in September showed a maximum variation of 4.4 cm which is about half the variation shown by Bigelow over the major part of the Gulf. This means that dynamic contours constructed from single series of observations at each station may be misleading unless the contour interval is several cms. At least dynamic contours should not be used for current charts in a region until it is known how large the variation in dynamic height at any one station during a tidal period
may be, and also whether the theoretical condition of no bottom current is even approximately true.

With the assistance of Madeleine Watson the observations on nearly all of the Gulf of Maine cruises from June, 1933, to September, 1934, have been plotted on graphs, including many T-S diagrams, and the corrected densities calculated for use in dynamic computations.

Calculations made for the velocities and transport across sections from Nova Scotia to Georges Bank and from Georges Bank to Nantucket Shoals indicate that serious errors are introduced by the theoretical assumption of no bottom current, but when sections completely bounding the Gulf are available the assumption may be partly corrected by considerations of continuity. There appears to be an increasing demand for direct current measurements, especially near the bottom, to furnish absolute values as a basis for the relative values which can be obtained from the dynamic heights.

MODIFICATIONS OF THE EYES AND OF VISION IN DEEP-WATER CRUSTACEANS

JOHN H. WELSH

As a first step in a program of study of the structure and function of the eyes of deep-water crustaceans two trips were made on "Atlantis" during which collections of crustaceans were taken at known depths down to 3200 meters. Modification with depth, hence with light intensity, of the eyes of these forms is now being studied with the cooperation of F. A. Chace, Jr. Particular attention is being paid to the relative size of the eyes, the degree of pigmentation, and the development of the rhabdomes or image receptors.

Attempts to keep certain of the acanthephyrids alive for a sufficient length of time to make possible observations on their reactions to light, and future studies of their visual acuity were successful. At low temperatures they were maintained in apparently normal condition for at least three days.

During the time not occupied by the trips at sea, an investigation of the internal control of pigmentary changes in the eyes of shallow water crustaceans was continued. Lobsters were kept in constant darkness for 58 days and at the end of this period daily movements of pigment within the eye were still occurring as they do under normal conditions. This indicates the presence of an internal cyclical mechanism which continues to operate under constant conditions. These findings have some general significance as diurnal changes in degree
of activity are widespread among marine organisms and it is now evident that they may not be entirely due to daily changes in the external environment.

STUDIES OF COPEPODS

C. B. WILSON

During the present summer copepods were identified from plankton taken during the Johnson-Smithsonian Expedition to the Porto Rican Deep. I have also worked upon a collection of sand and mud dwelling copepods obtained around Mt. Desert Island on the Maine coast. This includes many new genera and species which have been carefully described and figured, ready for future publication.

In August I received the plankton collected during Admiral Byrd's last trip to the Antarctic and have made a preliminary examination of a portion of it, in preparation for more complete identification and future report.