THE WOODS HOLE OCEANOGRAPHIC INSTITUTION

REPORT FOR THE YEAR 1939

TABLE OF CONTENTS

		Page
I	Trustees, as of January 1, 1940	3
II	Members of the Corporation, as of January 1, 1940	4
III	Report of the Treasurer	5
IV	Report of the Director	9
V	Staff, as of December 31, 1939	16
APPENDIX:	Reports of progress by investigators working at the Institution during 1939	17

I. TRUSTEES

(As of January 1, 1940)

To serve until 1943

ISAIAH BOWMAN, Johns Hopkins University, Baltimore, Md.
E. G. CONKLIN, Princeton University, Princeton, N. J.
ROSS G. HARRISON, Yale University, New Haven, Conn.
THE HYDROGRAPHER (Captain G. S. Bryan), U. S. Hydrographic Office, for the time being, Washington, D. C.
FRANK R. LILLIE, 5801 Kenwood Avenue, Chicago, Ill.
HARLOW SHAPLEY, Harvard University, Cambridge, Mass.

To serve until 1942

CHARLES FRANCIS ADAMS, 15 State Street, Boston, Mass.
THOMAS BARBOUR, Museum of Comparative Zoölogy, Cambridge, Mass.
JOHN A. FLEMING, Carnegie Institution, Washington, D. C.
FRANK B. JEWETT, 195 Broadway, New York, N. Y.
ALBERT E. PARR, Bingham Oceanographic Foundation, New Haven, Conn.
ELIHU ROOT, JR., 31 Nassau Street, New York, N. Y.

To serve until 1941

THE COMMANDANT (Admiral R. R. Waesche), U. S. Coast Guard, for the time being, Washington, D. C.
MARION EPPLEY, The Eppley Laboratory, Inc., Newport, R. I.
LAMAR R. LEAHY, U. S. Navy, Retired, International Hydrographic Bureau, Monaco
T. H. MORGAN, California Institute of Technology, Pasadena, Calif.
THE DIRECTOR (Admiral L. O. Colbert), U. S. Coast & Geodetic Survey, for the time being, Washington, D. C.
B. W. ST. CLAIR, 10 Arrow Street, Cambridge, Mass.

To serve until 1940

HENRY B. BIGELOW, Museum of Comparative Zoölogy, Cambridge, Mass.
WILLIAM BOWIE, 2900 Connecticut Avenue, Washington, D. C.
A. G. HUNTSMAN, University of Toronto, Toronto, Canada.
ALFRED C. REDFIELD, Harvard University, Cambridge, Mass.
HENRY L. SHATTUCK, 50 Federal Street, Boston, Mass.
T. WAYLAND VAUGHAN, 3333 P Street, Washington, D. C.

Ex Officio

COLUMBUS O'D. ISELIN, Woods Hole Oceanographic Institution, Woods Hole, Mass.
LAWRASON RIGGS, JR., 120 Broadway, New York, N. Y.

OFFICERS

HENRY B. BIGELOW, President of the Corporation, Museum of Comparative Zoölogy, Cambridge, Mass.
LAWRASON RIGGS, JR., Treasurer, 120 Broadway, New York, N. Y.
COLUMBUS O'D. ISELIN, Clerk of the Corporation, Woods Hole Oceanographic Institution, Woods Hole, Mass.

II. MEMBERS OF THE CORPORATION

(As of January 1, 1940)

CHARLES FRANCIS ADAMS, 15 State Street, Boston, Mass.
THOMAS BARBOUR, Museum of Comparative Zoölogy, Cambridge, Mass.
HENRY B. BIGELOW, Museum of Comparative Zoölogy, Cambridge, Mass.
WILLIAM BOWIE, 2900 Connecticut Avenue, Washington, D. C.
ISAIAH BOWMAN, Johns Hopkins University, Baltimore, Md.
THE COMMANDANT (Admiral R. R. Waesche), U. S. Coast Guard, for the time being, Washington, D. C.
E. G. CONKLIN, Princeton University, Princeton, N. J.
THE DIRECTOR (Admiral L. O. Colbert), U. S. Coast & Geodetic Survey, for the time being, Washington, D. C.
BENJAMIN M. DUGGAR, University of Wisconsin, Madison, Wis.
MARION EPPLEY, The Eppley Laboratory, Inc., Newport, R. I.
JOHN A. FLEMING, Carnegie Institution, Washington, D. C.
ALEXANDER FORBES, Harvard Medical School, Boston, Mass.
ROSS G. HARRISON, Yale University, New Haven, Conn.
A. G. HUNTSMAN, University of Toronto, Toronto, Canada
THE HYDROGRAPHER (Captain G. S. Bryan), U. S. Hydrographic Office, for the time being, Washington, D. C.
COLUMBUS O'D. ISELIN, Woods Hole Oceanographic Institution, Woods Hole, Mass.
FRANK B. JEWETT, 195 Broadway, New York, N. Y.
LAMAR R. LEAHY, U. S. Navy, Retired, International Hydrographic Bureau, Monaco
FRANK R. LILLIE, 5801 Kenwood Avenue, Chicago, Ill.
ALFRED L. LOOMIS, Tuxedo Park, N. Y.
T. H. MORGAN, California Institute of Technology, Pasadena, Calif.
ALBERT E. PARR, Bingham Oceanographic Foundation, New Haven, Conn.
ALFRED C. REDFIELD, Harvard University, Cambridge, Mass.
LAWRÅSON RIGGS, JR., 120 Broadway, New York, N. Y.
ELIHU ROOT, JR., 31 Nassau Street, New York, N. Y.
B. W. ST. CLAIR, 10 Arrow Street, Cambridge, Mass.
HARLOW SHAPLEY, Harvard University, Cambridge, Mass.
HENRY L. SHATTUCK, 50 Federal Street, Boston, Mass.
T. WAYLAND VAUGHAN, 3333 P Street, Washington, D. C.

III. REPORT OF THE TREASURER

To The Members and Trustees of the
Woods Hole Oceanographic Institution:

Gentlemen:

The accounts for the year 1939 have been audited by Messrs. Stagg, Mather & Hough, public accountants.

During the year bonds costing $399,978.75 were sold at a profit of $9,911.25 to which must be added $2,491.91 the reserve for amortization of bond premium applicable to these bonds. There was invested from endowment fund cash $289,002.50 in bonds and $152,264.57 in stocks.

The Special Income account in which extra dividends are placed, increased by $4,501.33 to which $725. not earmarked as extras on receipt but so determined by the auditors is to be added.

The entire appropriation for the Depreciation Fund $4,800. was used for replacements on "Atlantis" so that no cash was transferred.

Contributions toward running expenses were received as follows, from

Bermuda Aquarium	$1,000.00
University of Havana	350.00
Carnegie Corporation	283.26

The gross income on the securities in the Endowment Fund at the end of the year was about, .0407 of the cost of those securities, and .0413 of their then market value.

The total expenses exceeded the budget by $5,824.83 but were under the total income (including special income of $3,862.33) by $3,416.45.

The reserve for "working balance" having fulfilled its purpose was transferred to surplus.

Summaries of the balance sheet and comparative income and expense statements for 1939 and 1938 appear on pages 6 to 8.

Respectfully submitted,
Lawrason Riggs, Jr.,
Treasurer

BALANCE SHEET

ENDOWMENT FUND ASSETS

	Quoted Market Value		
Endowment fund assets:			
Bonds (less reserve for amortization of bond premiums $6,017.01)	$1,275,847.50	$1,321,306.25	
Stocks	$1,140,702.11	1,126,398.70	
Cash		3,427.88	$2,451,132.83
Reserve fund assets:			
Bonds	$ 5,655.00	$ 5,510.00	
Stocks	$ 14,765.63	19,099.02	
Cash		3,306.32	27,915.34
			$2,479,048.17

PLANT ASSETS

Laboratory plant:		
Land	$ 27,072.32	
Buildings	323,213.12	
Laboratory equipment	21,361.93	
Crew room equipment	557.95	
Library	11,300.00	$ 383,505.32
Ship "Atlantis":		
Construction	$ 218,674.47	
Equipment	27,298.50	245,972.97
Small boat and equipment		6,570.55
		$ 636,048.84
Depreciation fund assets (for periodic replacements):		
Bonds (quoted market value $30,932.50)	$ 31,592.50	
Cash	2,753.64	34,346.14
		$ 670,394.98

CURRENT ASSETS

Current funds—Cash	$ 6,484.21	
Less—Due to special income cash	725.00	$ 5,759.21
Special income assets:		
Investments:		
Bonds (quoted market value $10,300.00)	$ 10,235.00	
Stocks (quoted market value $1,119.38)	1,236.16	
Cash (including $725.00 due from current funds—Cash)	13,376.03	24,847.19
Interest accrued at date of acquisition on bonds purchased		903.46
		$ 31,509.86

DECEMBER 31, 1939

ENDOWMENT FUNDS

Endowment Fund—General	$2,000,000.00	
Endowment fund—For upkeep of plant	419,419.96	
	$2,419,419.96	
Add—Accumulated net gain on securities called or sold	31,712.87	$2,451,132.83
Reserve fund	$ 23,395.57	
Add—Accumulated reserve fund income	4,519.77	27,915.34
		$2,479,048.17

PLANT FUND

Plant fund—General	$ 607,642.13	
Plant fund reserve—Transferred in prior years from current surplus	28,406.71	$ 636,048.84
Reserve for depreciation (for periodic replacements)		34,346.14
		$ 670,394.98

CURRENT LIABILITIES AND SURPLUS

Accounts payable		$ 1,392.76
Current surplus:		
Balance at December 31, 1938	$ 21,700.65	
Add:		
Transfer of reserve for "working balance"	5,000.00	
Excess of income over expenses for the year ended December 31, 1939	3,416.45	30,117.10
		$ 31,509.86

STATEMENT OF INCOME FROM ENDOWMENT FUND INVESTMENTS AND CURRENT ASSETS AND EXPENSES APPLICABLE THERETO, INCLUDING EXPENDITURES FOR PERMANENT PLANT ADDITIONS

FOR THE YEARS ENDED DECEMBER 31, 1939 AND DECEMBER 31, 1938

		Year Ended December 31, 1939			Year Ended December 31, 1938		
Income:							
Income from endowment funds:							
Interest (including in 1939 special income of $442.83)		$60,174.44			$63,530.07		
Dividends (including in 1939 special income of $3,419.50)		53,942.52			46,154.77		
			$114,116.96			$109,684.84	
Less—Custodian fees and expenses			1,508.94			1,490.73	
			$112,608.02			$108,194.11	
Contributions received for operating expenses			1,633.26			1,000.00	
Total income				$114,241.28			$109,194.11
Expenses:	*Budget*						
Upkeep of plant:							
Upkeep of buildings and grounds	$ 6,625.00	$ 7,015.20			$ 8,893.99		
Upkeep of "Atlantis"	8,100.00	9,423.10			12,629.42		
Upkeep of "Asterias"	100.00	833.91			120.36		
Insurance	5,900.00	5,658.17			5,833.90		
Depreciation	4,800.00	4,800.00			4,800.00		
	$ 25,525.00		$ 27,730.38			$ 32,277.67	
Operating expenses:							
Operation of "Atlantis"	$ 30,500.00	$33,640.26			$29,919.11		
Operation of "Asterias"	850.00	807.32			1,289.44		
Scientists' salaries	27,125.00	26,369.87			26,875.51		
Scientific supplies and equipment	5,000.00	6,013.52			6,699.13		
Traveling expenses	750.00	1,149.79			856.25		
Publications	3,500.00	3,053.37			2,917.06		
Administration	7,425.00	7,640.45			7,497.85		
Amortization of bond premiums	2,000.00	2,242.95			1,586.32		
Contribution to retirement fund	1,500.00	1,576.92			1,567.38		
Not allocated	225.00	—			—		
	$ 78,875.00		82,494.45			79,208.05	
Total expenses	$104,400.00		$110,224.83			$111,485.72	
Expenditures for permanent plant additions:							
Additions to library	$ 600.00		600.00			600.00	
	$105,000.00			110,824.83			112,085.72
Excess of income over expenses for 1939				$ 3,416.45			
Excess of expenses over income for 1938							$ *2,891.61*

IV. TENTH ANNUAL REPORT OF THE DIRECTOR FOR THE YEAR 1939

BY HENRY B. BIGELOW

Equipment

As the result of the hurricane of September, 1938, an unusual amount of outdoor repairs was required. The most important items were resetting stone blocks in the sea wall, reconditioning the lawns and resurfacing the driveway. The total cost of this work was $1725.

Last spring the "Atlantis' " mainmast was lifted out for inspection and all standing rigging was renewed. At the same time the bearings of the main engine were opened up and adjusted. During the autumn at Woods Hole, the major part of Lloyd's eight year survey was completed while the crew was busy for a month at painting and scraping.

On "Asterias" the engine was completely reconditioned during the winter. Both the vessels are now in excellent condition.

The most important additions to the scientific equipment have been 30,000 feet of special one half inch dredging cable; a Monroe calculating machine; a bench lathe, a set of Assman psychrometers with reversing thermometers; four aerometers for Professor Spilhaus' work; and a refrigerating tank for constant temperature experiments.

Accidents

On the Cuban cruise, the bow gallows of "Atlantis" carried away while being used in otter trawling, but it has since been repaired.

I regret to have to report the death of one of our foremast hands, George Temple Priest, in the smash-up of Coast Guard plane V-164 on July 15th.

Loans

We have neither made any important loans nor have we borrowed any apparatus of special mention.

Library

Our contribution to the library of the Marine Biological Laboratory was the same this year as last, namely $600. In the past year the following items were purchased: 12 books, 1 back set completed, 40 current subscriptions, and the binding of 77 current and back volumes. Seventy-two journals were received by exchange and 9 by gift, also 432 other journal numbers and reprints making a total of 513 publications added to the library.

Personnel

The only change in the scientific staff was the appointment of Mr. Charles M. Weiss as bacteriological technician to succeed Mr. D. Q. Anderson.

Fellowship holders who have worked at the laboratory during the summer are: Mr. Kenneth J. Arnold, Mr. William Gosline, Mr. Robert H. Hay, Dr. Charles W. Hock, Dr. Blodwen Lloyd, Mr. Arnold N. Morton, Professor L. V. Whitney and Dr. Claude E. ZoBell. Miss Frances L. Parker, Dr. Lois C. Lillick and Dr. Th. von Brand worked under special grants.

Twelve assistants have worked for various members of the staff and visiting investigators and there were nine volunteer workers. Dr. Seiwell employed Mr. Andrew Stergion under a grant from the American Philosophical Society.

The following visiting investigators have worked in the Institution: Dr. A. A. Abramowitz, Professor V. W. Ekman from Sweden, Dr. Maurice Ewing, Mr. H. B. Hachey, Dr. F. Ronald Hayes, Dr. Dixie Pelluet Hayes, Dr. F. L. Hisaw, Dr. Margaret Hotchkiss, Mr. John Lochhead, Mrs. Margit Lochhead, Mrs. Helen N. Moore, Dr. Clinton M. Osborn, Dr. G. H. Parker, Dr. Robert W. Pennak, Dr. Austin Phelps, Dr. E. F. Thompson, Dr. Abby H. Turner and Dr. George Wald. Among the visitors were Dr. Martin Knudsen from Copenhagen, Dr. R. H. Fleming, Scripps Institution of Oceanography, La Jolla, California, Dr. Koji Hidaka, Imperial Marine Observatory, Kobe, Japan and Dr. Wiseman, The Laboratory, Plymouth, England.

The following institutions were represented during the year in the laboratory or on cruises of "Atlantis": Barat College, Barnard College, Bermuda Biological Station, Brown University, Columbia University, Connecticut College, Cushman Laboratory for Foraminiferal Research, Dalhousie University, Fouke Fur Company, Harvard University, Massachusetts Institute of Technology, Mt. Holyoke College, New York Medical College, New York University, Queen's University, Rutgers University, Royal Technical College, Glasgow Scotland, Scripps Institution of Oceanography, Southwest Missouri State Teachers College, Stanford University, Submarine Signal Company, U. S. Coast Guard, University of Colorado, University of Havana, University of Texas, University of Washington, Wellesley College and Yale University; a total of 29, or 13 more than last year. More than one hundred persons have worked at the Institution, and this is the first year of operation in which every room in the laboratory has been in service.

There have been no changes in the officers of "Atlantis." "Asterias" was in charge of Lincoln Dow, assisted by William Butcher, Edmund Billings and Henry K. Porter.

The following members of our staff have acted, on one occasion or another, as scientist in chief in charge of "Atlantis": G. L. Clarke, Wm. C. Schroeder, H. R. Seiwell, A. F. Spilhaus, Henry C. Stetson, E. E. Watson and Alfred Woodcock.

Travel

In late August Dr. R. B. Montgomery returned from a year's visit in Europe where he visited laboratories in Germany, Finland and the Scandinavian countries.

Publications

Number 3 of Volume VII of "Papers in Physical Oceanography and Meteorology" appeared.

The following contributions were published during the year:

No. 173. Soule, Floyd M. Oceanography. Excerpt from International Ice Observation and Ice Patrol Service in the North Atlantic Ocean, Season of 1937. U. S. Coast Guard Bull., No. 27, pp. 71–126. 1938.

No. 191. Todd, Jean P. Shoal-water Deposits of the Bermuda Banks. Jour. Sed. Pet., Vol. 9, No. 1, pp. 8–13. 1939.

No. 192. Seiwell, H. R. Die Verwendung der Verteiling von Sauerstoff auf die physische Ozeanographie des Karibischen Meeresgebietes. Gerlands Beiträge zur Geophysik, Bd. 54, Heft 4, pp. 1–7. 1939.

No. 193. Clarke, George L. and Harry R. James. Laboratory Analysis of the Selective Absorption of Light by Sea Water. Jour. Optical Soc. Amer., Vol. 29, pp. 43–55. 1939.

No. 194. Bigelow, Henry B. and Mary Sears. Studies of the Waters of the Continental Shelf, Cape Cod to Chesapeake Bay. III. A Volumetric Study of the Zooplankton. Mem. Mus. Comp. Zool., Vol. LIV, No. 4, pp. 183–378. 1939.

No. 195. Wald, George. On the Distribution of Vitamins A_1 and A_2. Jour. Gen. Physiol., Vol. 22, No. 3, pp. 391–415. 1939.

No. 196. Redfield, Alfred C. The History of a Population of *Limacina retroversa* during its Drift across the Gulf of Maine. Biol. Bull., Vol. LXXVI, No. 1, pp. 26–47. 1939.

No. 197. Hsiao, Sidney C. T. The Reproductive System and Spermatogenesis of *Limacina* (*Spiratella*) *retroversa* (Flem.). Biol. Bull., Vol. LXXVI, No. 1, pp. 7–25. 1939.

No. 199. Chace, Fenner A., Jr. Reports on the Scientific Results of the First *Atlantis* Expedition to the West Indies, under the joint Auspices of the University of Havana and Harvard University. Preliminary Descriptions of One New Genus and Seventeen New Species of Decapod and Stomatopod Crustacea. Mem. Soc. Cub. Hist. Nat., Vol. 13, No. 1, pp. 31–54. 1939.

No. 201. Clarke, George L. The Utilization of Solar Energy by Aquatic Organisms. Amer. Assoc. Adv. Sci., Publ. No. 10, pp. 27–38. 1939.

No. 202. Osborn, Clinton M. The Physiology of Color Change in Flatfishes. Jour. Exper. Zool., Vol. 81, No. 3, pp. 479–515. 1939.

No. 203. Burkenroad, Martin D. Further Observations on Penaeidae of the Northern Gulf of Mexico. Bull. Bing. Oceanographic Coll., Vol. VI, Art 6, pp. 1–62. 1939.

No. 204. Phleger, Fred B., Jr. Foraminifera of Submarine Cores from the Continental Slope. Bull. Geol. Soc. Amer., Vol. 50, pp. 1395–1422. 1939.

No. 205. Waterman, Talbot H., Rudolf F. Nunnemacher, Fenner A. Chace, Jr., and George L. Clarke. Diurnal Vertical Migrations of Deep-water Plankton. Biol. Bull., Vol. LXXVI, No. 2, pp. 256–279. 1939.

No. 206. Hsiao, Sidney C. T. The Reproduction of *Limacina retroversa* (Flem.). Biol. Bull., Vol. LXXVI, No. 2, pp. 280–303. 1939.

No. 207. Johnson, W. H. and J. E. G. Raymont. The Reactions of the Planktonic Copepod, *Centropages typicus*, to Light and Gravity. Biol. Bull., Vol. LXXVII, No. 2, pp. 200–215. 1939.

No. 208. Toth, Louis A. Renal and Vascular Responses to Epinephrine Injections in Glomerular and Aglomerular Fish. Amer. Jour. Physiol., Vol. 126, No. 2, pp. 347–353. 1939.

No. 209. Young, John A., Jr. Minerals from Deep Sea Cores and Surface Deposits of Bermudian Calcareous Sediments. Amer. Jour. Sci., Vol. 237, pp. 798–810. 1939.

No. 210. Bigelow, Henry B. and William C. Schroeder. Notes on the Fauna above Mud Bottoms in Deep Water in the Gulf of Maine. Biol. Bull., Vol. LXXVI, No. 3, pp. 305–324. 1939.

No. 211. Waterman, Talbot Howe. Studies of Deep-sea Angler-fishes (Ceratioidea). I. An Historical Survey of our Present State of Knowledge. II. Three New Species. Bull. Mus. Comp. Zool., Vol. LXXXV, No. 3, pp. 65–94. 1939.

No. 212. Clarke, George L. The Relation between Diatoms and Copepods as a Factor in the Productivity of the Sea. Quart. Rev. Biol., Vol. 14, No. 1, pp. 60–64. 1939.

No. 213. Abramowitz, A. A. The Pituitary Control of Chromatophores in the Dogfish. Amer. Nat., Vol. LXXIII, pp. 208–218. 1939.

No. 214. Clarke, George L. and David D. Bonnet. The Influence of Temperature on the Survival, Growth and Respiration of *Calanus finmarchicus*. Biol. Bull., Vol. LXXVI, No. 3, pp. 371–383. 1939.

No. 216. Ketchum, Bostwick H. The Absorption of Phosphate and Nitrate by Illuminated Cultures of *Nitzschia Closterium*. Amer. Jour. Bot., Vol. 26, No. 6, pp. 399–407. 1939.

No. 217. Seiwell, H. R. Some Applications of Statistical Methods to Problems in Modern Physical Oceanography. Proc. Industrial Statistics Conference, held at Mass. Inst. Tech., Sept. 8 and 9, 1938. Pitman Publishing Corporation, pp. 156–173. 1939.

No. 218. Bermúdez, Pedro J. Resultados de la Primera Expedicion en las Antillas del Ketch *Atlantis* bajo los Auspicios de las Universidades de Harvard y Habana. Nuevo Género y Especies Nuevas de Foraminiferos. Mem. Soc. Cub. Hist. Nat., Vol. 13, No. 1, pp. 9–12. 1939.

No. 219. Ketchum, Bostwick H. The Development and Restoration of Deficiencies in the Phosphorus and Nitrogen Composition of Unicellular Plants. Jour. Cell. and Comp. Physiol., Vol. 13, No. 3, pp. 373–381. 1939.

No. 220. Iselin, C. O'D. The Influence of Vertical and Lateral Turbulence on the Characteristics of the Waters at Mid-depths. Trans. Am. Geophys. Union, pp. 414–417. 1939.

No. 221. Iselin, C. O'D. Some Physical Factors which may Influence the Productivity of New England's Coastal Waters. Sears Found. Jour. Mar. Res., Vol. II, No. 1, pp. 74–85. 1939.

No. 222. Von Brand, Theodor, Norris W. Rakestraw and Charles E. Renn. Further Experiments on the Decomposition and Regeneration of Nitrogenous Organic Matter in Sea Water. Biol. Bull., Vol. LXXVII, No. 2, pp. 285–296. 1939.

No. 223. Seiwell, H. R. *Atlantis* Cruise to the Tropical North Atlantic, January to March, 1939. Trans. Am. Geophys. Union, pp. 418–422. 1939.

No. 224. Clench, W. J. and C. G. Aguayo. Notes and Descriptions of New Deep-water Mollusca obtained by the Harvard-Habana Expedition off the Coast of Cuba. II. Mem. Soc. Cub. Hist. Nat., Vol. 13, pp. 189–197. 1939.

No. 225. Bermúdez, Pedro J. Resultados de la Primera Expedicion en las Antillas del Ketch *Atlantis* bajo los Auspicios de las Universidades de Harvard y Habana. Foraminiferos del Género Recurvoides, descripción de una Especie Nueva. Mem. Soc. Cub. Hist. Nat., Vol. 13, No. 2, pp. 57–61. 1939.

No. 226. Seiwell, H. R. The Effect of Short Period Variations of Temperature and Salinity on Calculations in Dynamic Oceanography. Papers in Physical Oceanography and Meteorology, Vol. VII, No. 3, pp. 1–32. 1939.

No. 227. Seiwell, H. R. Daily Temperature Variations in the Western North Atlantic. Jour. d. Conseil, Vol. XIV, No. 3, pp. 357–369. 1939.

No. 228. Rakestraw, Norris W., Clifford E. Herrick, Jr., and Wm. D. Urry. The Helium-Neon Content of Sea Water and its Relation to the Oxygen Content. Jour. Amer. Chem. Soc., Vol. 61, pp. 2806–2807. 1939.

No. 229. Brooks, Edward M. Transport and Convergence of the North Atlanic Drift Current Computed from the Average January Pressure Distribution. Sears Found. Jour. Mar. Res., Vol. II, No. 2, pp. 163–167. 1939.

No. 230. Soule, Floyd M. Consideration of the Depth of the Motionless Surface near the Grand Banks of Newfoundland. Sears Found. Jour., Mar. Res., Vol. II, No. 3, pp. 169–180. 1939.

No. 232. Riley, Gordon A. Plankton Studies. II. The Western North Atlantic, May–June, 1939. Sears Found. Jour. Mar. Res., Vol. II, No. 2, pp. 145–162. 1939.

No. 233. Nichols, J. T. Young Caranx in the Western North Atlantic. Bull. Bingham Oceanographic Coll., Vol. VII, Art 2, pp. 1–9. 1939.

No. 234. Parr, Albert Eide. Quantitative Observations on the Pelagic Sargassum Vegetation of the Western North Atlantic. Bull. Bingham Oceanographic Coll., Vol. VI, Art. 7, pp. 1–94. 1939.

No. 236. Clarke, George L. Variation in the Transparency of Three Areas of the Atlantic throughout the Year. Ecology, Vol. 20, No. 4, pp. 529–543. 1939.

No. 238. Anderson, D. Q. Distribution of Organic Matter in Marine Sediments and its Availability to Further Decomposition. Sears Found. Jour. Mar. Res., Vol. II, No. 3, pp. 225–235. 1939.

No. 243. Bermúdez, Pedro J. Resultado de la Primera Expedicion en las Antillas del Ketch *Atlantis* bajo los Auspicios de las Universidades de Harvard y Habana. Nueva Género y Especies Nuevas de Foraminiferos. Mem. Soc. Cub. Hist. Nat., Vol. 13, No. 4, pp. 247–251. 1939.

Coöperation

The investigations of the Gulf Stream System in which we coöperate with the Bermuda Biological Station have continued, and 6 profiles were run by "Atlantis" during the year. From the middle of March to May, "Atlantis" carried out a second trawling campaign in deep water around Cuba in coöperation with Harvard University, the University of Havana and the Bermuda Aquarium, the last two institutions contributing substantially to the expenses of the cruise. Mr. William C. Schroeder was the scientist in charge, and was accompanied by Dr. Luis Howell Rivero of the University of Havana. Out of 142 successful hauls, made in depths ranging from 200–1500 fathoms, approximately 1000 species of fishes and invertebrates were taken, of which perhaps 60–70 will prove to be new to science. There was a particularly good catch of crinoids. We are again in debt to the Cuban Government for many courtesies to the ship.

The tide gauge mentioned in my last report was operated at Cat Cay throughout the year, also the one on our own dock in Woods Hole. A preliminary investigation of the relationship of Gulf Stream velocities to shift in main sea level have proved most encouraging.

We received from the Carnegie Corporation a further contribution of $283 toward the operating expenses of "Asterias," out of Gloucester, in late March and early April. Diatoms were collected in large amount for the use of Dr. Hans Clarke, in continuation of his investigations in their chemical composition. Finally, our coöperation with the U. S. Coast Guard, through the International Ice Patrol Service, continues a close one; the oceanographer of the Patrol having his land headquarters here, and being in frequent consultation with the physical oceanographers on our staff.

Field Work

Operations of "Atlantis" for the year 1939:

Cruise 83: January–June; two Gulf Stream sections, survey of the eastern part of the Northern Equatorial current and bottom dredging around Cuba.

Cruise 84: July; Gulf Stream section.

Cruise 85: July; southern edge of Georges Bank.

Cruise 86: August; anchor station south of Montauk Point.

Cruise 87: August; Gulf Stream section.

Cruise 88: August; light intensity measurements.

Cruise 89: September; biological survey of Georges Bank.

Cruise 90: September; continental slope south of Woods Hole.

Cruise 91: October; Gulf Stream section and anchor station.

Cruise 92: November; Gulf Stream section.

Summary of observations:

Total distance sailed	16,976
Number of days at sea	236
Deep hydrographic stations	416
Shallow hydrographic stations	106
Serial temperature lowerings of internal waves	340
Plankton hauls	556
Bottom trawl hauls	183
Bottom samples	42

"Asterias" was put in commission on March 23d, and first spent two weeks collecting diatoms out of Gloucester. During the summer she was used for the usual short trips near Woods Hole and in Massachusetts Bay.

Staff Meetings

Nine staff meetings were held during the summer. The speakers were: Dr. George L. Clarke, Professor V. W. Ekman, Mr. Columbus O'D. Iselin, Dr. Norris W. Rakestraw, Dr. Charles E. Renn, Dr. H. R. Seiwell, Mr. Floyd M. Soule, Dr. E. E. Watson and Dr. Claude E. ZoBell.

A series of meetings was also held to plan work on Georges Bank.

Financial

We received from the insurance on "Atlantis" a refund of $1598. mainly as the result of sickness and injury claims. From the Carnegie Corporation we received $283; from the University of Havana $350 and from Mr. Jay Holmes in behalf of the Bermuda Aquarium $1,000 toward the Cuban trip; and from an anonymous source a gift of $170.

V. STAFF

(As of December 31, 1939)

HENRY B. BIGELOW, Professor of Zoölogy, Harvard University, Director

CORNELIA L. CAREY, Assistant Professor of Botany, Barnard College, Research Associate in Marine Bacteriology

GEORGE L. CLARKE, Tutor and Instructor in Biology, Harvard University, Junior Biologist

COLUMBUS O'D. ISELIN, Associate Professor of Physical Oceanography, Harvard University, and Assistant Curator of Oceanography, Museum of Comparative Zoölogy, Research Associate in Physical Oceanography

R. B. MONTGOMERY, Junior Oceanographer

A. E. PARR, Director of Peabody Museum and Curator of the Bingham Oceanographic Collection, Yale University, Research Associate in Oceanography

NORRIS W. RAKESTRAW, Associate Professor of Chemistry, Brown University, Research Associate in Physical Chemistry

ALFRED C. REDFIELD, Professor of Physiology, Harvard University, Research Associate in Biology

C. E. RENN, Tutor in Biology and Instructor in Sanitary Engineering, Harvard University, Junior Marine Bacteriologist

C.-G. ROSSBY, Professor of Meteorology, Massachusetts Institute of Technology and Assistant Chief, U. S. Weather Bureau, Oceanographer

MARY SEARS, Instructor in Zoölogy, Wellesley College, Junior Biologist

H. R. SEIWELL, Investigator in Oceanography

FLOYD M. SOULE, Senior Physical Oceanographer, U. S. Coast Guard, Research Associate in Oceanography

ATHELSTAN F. SPILHAUS, Assistant Professor of Meteorology, New York University, Investigator in Physical Oceanography

HENRY C. STETSON, Research Associate in Paleontology, Museum of Comparative Zoölogy, Research Associate in Submarine Geology

SELMAN A. WAKSMAN, Microbiologist, New Jersey Agricultural Experiment Station, Marine Bacteriologist

E. E. WATSON, Assistant Professor of Physics, Queen's University, Research Associate in Physical Oceanography

DEAN F. BUMPUS, Biological Technician

SIDNEY C. T. HSIAO, Technician in Physical Oceanography

CHARLES M. WEISS, Bacteriological Technician

ALFRED WOODCOCK, Oceanographic Technician

WILLIAM C. SCHROEDER, Business Manager

MRS. VIRGINIA WALKER SMITH, Secretary and Administrative Assistant

WILLIAM SCHROEDER, Superintendent of Buildings and Grounds

APPENDIX

Reports of progress by investigators working at the Institution during 1939.

ZOÖPLANKTON STUDIES

HENRY B. BIGELOW AND MARY SEARS

1. The study of the medusae collected on the "Zaca" expeditions of 1936 and 1938 is now completed and the report has been submitted for publication. (Bigelow)

2. The study of the "Dana" collection of siphonophores is still in progress. (Bigelow and Sears)

3. The completed report on the zooplankton of the continental shelf, Cape Cod-Chesapeake Bay, appeared in July as a "Memoir of the Museum of Comparative Zoölogy." (Bigelow and Sears)

4. A study of the zooplankton on the line running SSE from Montauk Point across the Gulf Stream toward Bermuda was commenced on the periodic cruise in July, to learn about annual fluctuations in the plankton on the continental shelf and to follow the seasonal cycle in the plankton of the slope water, Gulf Stream and Sargasso Sea. (Sears)

LIGHT PENETRATION AND QUANTITATIVE ZOÖPLANKTON STUDIES

GEORGE L. CLARKE

1. *Transparency of oceanic areas.* Measurements of light penetration made throughout the year at stations on the Montauk-Bermuda section showed that the coastal water was the least transparent on all occasions, the Sargasso water was the clearest, and the slope water intermediate. Variation in transparency was greatest in the slope water area and is accounted for by the fluctuations in the amounts of Sargasso water and coastal water present. The variations in the other areas are not correlated directly with the plankton but may be, indirectly, through its disintegration products. Important changes in the illumination reaching the deeper strata were produced by only slight variations in transparency.

2. *Comparative richness of plankton in oceanic areas.* The investigation of the fluctuations in the abundance of the zooplankton throughout the year in the coastal area, in the slope water area, and in the Sargasso Sea has been completed. An unexpectedly great seasonal difference in the abundance of the plankton was encountered, the average volume of the catches in the warm half of the year being as much as 20× to 40× greater than in the winter in the coastal

area and as much as 10× greater in the slope water area. The survey has made possible a quantitative comparison of the richness of coastal and off-shore regions. The average volume of the coastal area plankton for the whole year was about 4× greater than that of the slope water area, and the latter was about 4× greater than at the Sargasso Sea station. When the total volumes and the species composition of the catches were compared with the previous year and with earlier investigations, the occurrence of important annual fluctuations was revealed.

3. *Development of quantitative methods of plankton collection.* The method of collecting diatoms from the sea in sufficient quantity for chemical analysis was further developed and put into operation during April off Gloucester. Diatom sludge was obtained with this method at the rate of a pint in three hours. The plankton samplers with volume meters, developed last year for zooplankton, were perfected and operated satisfactorily during the year. The variation in seven series of oblique, vertical, and horizontal plankton hauls with nets of the same size as those used with the plankton samplers and with larger nets was studied statistically (in collaboration with C. P. Winsor). No significant difference in variability of catches was observed with different sizes of nets. The proportions of different groups caught by the various nets did not vary in a manner to indicate differential selection with net size. Therefore our smallest net was as reliable for the types of zooplankton considered (chiefly copepods) as nets of more usual size.

4. *Laboratory culture of planktonic animals.* The study of the survival and growth of important species of copepods in relation to temperature, food and other environmental conditions was continued and an additional species, *Metridia lucens*, was brought under culture. The animals lived as long as two months, under suitable conditions, without change of water, but contrary to expectation, the copepods throve as well in freshly collected sea water as in stored water. Experiments were also conducted on the development of haddock and cod eggs. Large numbers of cod eggs were hatched at four temperatures and the larvae were cultured for several weeks. Success was attained for the first time in inducing the cod fry to feed after the yolk sac had been absorbed and hence to continue growth in the laboratory beyond this stage.

5. *Quantitative plankton survey of a fishing bank.* A close net-work of 52 stations was made on Georges Bank during a ten day period in September, thus constituting a more intensive study of the biological conditions over a fishing bank than previously possible. The abun-

dance and conditions of growth of the phytoplankton at these stations were investigated by G. A. Riley. The material obtained and the observations made are now in the process of analysis.

STUDIES ON FISHES

WILLIAM GOSLINE

The redfish (*Sebastes marinus*) was studied with particular reference to growth rate. Length frequencies of commercial sizes and of the small fish available were taken. The possibility of reading age from the otoliths and opercular bones was investigated, but the greatest part of the work was devoted to a study of the scales.

DIRECT MEASUREMENT OF CURRENTS

ROBERT H. HAY

The Watson current meter was adapted for the study of bottom velocities in shallow coastal waters. The time from June 8 to August 14 was taken up with construction of auxiliary apparatus and with careful tests of it and the meter. From August 14 to August 30 four stations were made, three in Buzzards Bay and one in Vineyard Sound. Velocity and direction readings were taken at heights above bottom of 22, 54 and 87 cm. in such a manner as to give a synoptic set of average velocities at these heights. The total time on station was in all but one case over six hours. Preliminary examination of these data has shown that the velocity averages can be plotted against height to give smooth curves. However, plots of velocity against log height did not yield straight lines, nor did the average velocities, or points extrapolated from the curves, seem to fit the well-known logarithmic equation of Krey for fluid flow over a rough boundary.

INORGANIC CONSTITUENTS IN MOLLUSCAN BLOOD AND MUSCLE

F. R. HAYES AND D. PELLUET

Three representative Woods Hole molluscs, *Loligo*, *Mactra* and *Busycon*, provided blood and muscle for the estimation of chloride, sulphate and magnesium. Woods Hole and Copenhagen sea water served as standards. Salts were removed from muscle by water extraction with a Soxhlet apparatus. The work was a continuation of two summers' analyses at the Plymouth Station, and the chief attention was devoted to phases that had previously provided technical difficulties. From the standpoint of time the chief demands of the summer were 1) The development of an operative technique suitable for obtaining *Loligo* blood in the quantities required. 2) The elabora-

tion of a method for magnesium estimation which had sufficient accuracy for our purpose. This was achieved by the direct potentiometric titration of magnesium hydroxyquinolate (dissolved in acid) with potassium bromate. 3) A satisfactory method for sulphate estimation. Having previously failed with the benzidine method, we turned to the sodium rhodizonate method with better, but still unsatisfactory results.

The general aim of the work is to draw up as complete a picture as possible of the inorganic metabolism of the Mollusca. The results have not yet progressed far enough to warrant publication.

PHYSIOLOGY OF THE DOGFISH AND THE BLUE CRAB

F. L. HISAW AND A. A. ABRAMOWITZ

Due to a scarcity of material, we have not been able to make further progress in our investigation of reproduction in the dogfishes except to complete certain details of our previous work.

We have studied the influence of the pituitary on the pancreatic diabetes and normal carbohydrate metabolism of the dogfish, and have shown that the anterior lobe of the pituitary secretes a diabetogenic hormone. The neuro-intermediate lobe is devoid of a diabetogenic principle.

In crustaceans, we have found that extracts of the eyestalks will produce an intense diabetes within an hour after injection. A method of measuring the potency of such extracts has been devised, using the blue crab, Callinectes, as the test animal. We have shown that this diabetogenic substance is heat-stable, interspecific, active even after great dilution, and occurs chiefly in the sinus gland.

We were assisted in these investigations by Mr. D. A. Papandrea.

DECOMPOSITION OF CHITIN BY MARINE BACTERIA

CHARLES W. HOCK

Under experimental conditions, the decomposition of Limulus shell was found to be rapid in littoral sand, moderate in bottom mud, and negligible in sea water. During the decomposition process the carbon-nitrogen ratio of the shell remained constant. As a result of decomposition of the shell there was no change in total carbon and nitrogen of the sand, but there was an appreciable increase in the nitrogen of the mud. The number of chitin-decomposing bacteria was high in sand, lower in mud, and lowest in sea water.

Approximately fifteen types of chitin-decomposing bacteria were isolated from the following sources: sand, mud, water, decomposing

crabs, and the intestinal contents of the quahog, squid, skate, sand crab, dogfish, puffer and oyster. Among the readily demonstrable products resulting from the decomposition of pure chitin are ammonia, reducing substances, and organic acids.

HYDROLOGICAL INVESTIGATIONS

C. O'D. ISELIN

With the assistance of Dr. Sidney Hsiao, the available Gulf Stream sections on the Montauk Point-Bermuda line have been analyzed dynamically. The variability of the current found by this method appears to be consistent with the tide gauge observations from Miami, Charleston and Cat Cay. A preliminary report on the first two and a half years of this investigation of fluctuations in the transport of the Gulf Stream is now almost ready for publication.

Various routine duties at Harvard and at Woods Hole have required most of the remaining time. However, last spring a study was made of the downward transport of North Atlantic winter surface characteristics by the mechanism of isentropic mixing. Recently the seasonal temperature cycles at the bottom on Georges Bank and of the whole water-column 30 miles south of Montauk Point were examined.

Dr. E. F. Thompson, of the Bermuda Biological Station, has been at Woods Hole since last May, studying the local circulation system near Bermuda from the point of view of our Gulf Stream program. His coöperation and that of Mr. H. B. Hachey, of the Atlantic Biological Station at St. Andrews, have greatly contributed to the success of the whole project.

DENITRIFYING AND NITRIFYING BACTERIA IN THE SEA

BLODWEN LLOYD

The reduction of nitrates to nitrite and finally to nitrogen occurs readily in sea water enriched with organic matter and nitrate and having a high bacterial content. Temperature regulates the rate but not the final amount of nitrate-reduction. Hydrogen ion concentration at 8.0 to 8.4 favours denitrification, and at pH 6.0 retards but does not inhibit it entirely. Dissolved oxygen also retards denitrification, but even in oxygen-saturated sea water it still occurs. These factors are significant, but the limiting factor is very clearly the amount of available organic matter: in sea water enriched with 2.5 gms potassium nitrite per litre and 1.0 milligm peptone per litre, the nitrite loss is very slight.

Laboratory experiments confirm the oceanographic observations made on samples collected by the "Atlantis." Samples from neritic areas denitrify readily; pelagic samples with fewer bacteria and less organic matter, not so readily. During bacterial denitrification there is increased alkalinity, and in samples of several weeks' standing, calcium carbonate is precipitated. Several strains of such chalk-precipitating bacteria were isolated, from samples procured both from "Atlantis" cruises and from the research vessel of the Sponge Fisheries investigations off the Bahamas. The grains of calcium carbonate precipitated by non-denitrifying heterotrophs were not laminated; those precipitated by denitrifying heterotrophs showed concentric laminations frequently. This may throw some light on the origin of some marine oolites, and the problem is being investigated further.

Following upon the work of Dr. Waksman and Dr. Carey on nitrification in sea water, a search was made for the causative micro-organisms. Bacterial cultures similar to the recently-described *Nitrosocystis* of Mlle. Winogradsky were found, but could not be obtained free from saprophytic bacteria, nor could such cultures be repeated at will. The controlling factors are as yet imperfectly known.

From the large-scale nitrifying experiments of Dr. Rakestraw and Dr. von Brand, our attempts to isolate nitrifying bacteria were unsuccessful, but we found, however, abundant *denitrifying* saprophytes. It is hoped to continue and complete this work.

FOOD AND FEEDING MECHANISMS OF COPEPOD NAUPLII

JOHN H. LOCHHEAD AND MARGIT S. LOCHHEAD

A preliminary attempt was made to determine the feeding mechanisms in some of various pelagic copepod nauplii. Each species was found to have its own characteristic mode of swimming, with differences in the currents created which probably are of importance in feeding. Efforts to observe the mechanism of food capture were not satisfactory because all the nauplii fed only very sparingly under laboratory conditions. Of various types of food which were tried those that were eaten most freely were *Arbacia* sperm and the large green flagellate, *Platymonas*. In a few cases these half filled the gut within 2–4 hours. Smaller numbers were taken of certain ciliates. Immobile objects such as yeast cells, *Nitzschia*, and various types of small particles, were scarcely eaten at all. This result is in general agreement with some earlier observations on fresh-water forms, for which flagellates were found to be perhaps the most important source of food. The rate of feeding, however, was always much less in the

marine than in the fresh-water species. The nature of their food in the sea remains unknown, but in those taken at Woods Hole the gut contents were nearly always green.

STUDIES IN PHYSICAL OCEANOGRAPHY AND METEOROLOGY

R. B. MONTGOMERY

1. A report on simultaneous observations of humidity at various levels between 1 and 38 meters above the ocean surface made from "Atlantis" in 1935 has been computed. These data have yielded useful information on the turbulent and laminar boundary layers above the ocean surface. In particular, tentative information was derived on the factors determining the hydrodynamic character of the surface: the most important factor appears to be the temperature difference (water) − (air), the surface being "rough" when this is positive and "smooth" when this is about zero or negative. The work gives considerable advancement in the development of a practical method of determining the amount of evaporation from the ocean surface, applicable also to the transfer of other properties between ocean and atmosphere, such as momentum and carbon dioxide.

2. Studies of isentropic mixing in the ocean have been continued.

3. A study of the kinematics and dynamics of the waters in the Straits of Florida has been initiated.

BACTERIOLOGICAL DECOMPOSITION OF ORGANIC COMPOUNDS

HELEN NORRIS MOORE

The number of proteolytic organisms in sea water, and various media for their differentiation were investigated. The two media used contained 1.0% peptone, 5% gelatin, 1.5% agar, and 0.02% cystine, dissolved in (a) sea water or (b) 10% salt solution, both at pH 7.5. Sterile whole laked rabbit blood (providing protein rich in sulphur linkages) and a solution of bismuth citrate (to indicate hydrogen sulfide production) were added to each plate before pouring.

Sea water from various depths in Buzzards Bay and brine from chopped sealskin pelts were plated on these media and incubated at room temperature for from 2–5 days.

No samples grew on the 10% salt medium. The sea water medium showed growth of all sea water samples in 48 hours, indicating a stimulation possibly due to the bismuth or cystine or blood. No correlation between depth of sampling and numbers of hydrogen sulfide formers appeared.

COLOR CHANGES AND PIGMENTATION IN FLATFISHES

CLINTON M. OSBORN

During the summer of 1939 experiments were carried out concerning *three* aspects of pigmentary behavior in flatfishes (Summer Flounders, Winter Flounders and Sand Dabs).

1. The effects of artificial illumination on the production of pigment in normally unpigmented areas.

2. The effects of total blinding and semi-blinding on the rates and degree of background adaptation.

3. The reactions of melanophores of flounders to sympathetic and parasympathetic drugs.

A technique of subjecting the ventral surfaces of adult summer flounders to continuous diffuse light of constant intensity will be described. Both direct and reflected light have been used with success. Preliminary experiments on 22 animals indicate that illumination of the normally unpigmented ventral surface causes pigment (in apparently normal melanophores) to develop there. The first macroscopic appearance of ventral pigment followed 7 days of continuous illumination at the highest intensity used. Considerable melanin can be grown in 30 days, and extensive pigmentation occurred in a few fishes treated 7 weeks.

All of the flounders used in these experiments were in a physiological condition causing pigment dispersion in the melanophores on the dorsal surface. This was accomplished either by allowing these fishes to background-adapt to the black walls and ceiling of the experimental tank or by blinding fishes which previously had been black adapted. Vision is not essential, therefore, to the experimental development of ventral pigment.

Fishes appeared to experience discomfort from ventral illumination as manifested in repeated attempts to avoid it by coming to rest on their edges with the ventral surface against a vertical wall.

QUANTITATIVE STUDY OF THE FORAMINIFERA

FRANCES L. PARKER

It is believed that by establishing the relationship of the different genera and species of the foraminifera at the various depths and temperatures found along the east coast of the United States, that the study of samples from cores will be rendered much more exact. For this purpose a quantitative study of five different lines of samples

from the beach to the outer edge of the shelf, together with scattered samples from the slope, is being made.

Evidence has been found for several ecologic zones running parallel to the coast. Faunal differences have also been found between the more northern stations and those further south. The foraminifera of about half the stations have been counted and their precise relationship by percentage and abundance worked out in order to give as precise data as possible.

ECOLOGY OF SAND BEACH ORGANISMS

ROBERT W. PENNAK

In an attempt to establish certain ecological relationships of the microscopic Metazoa (especially the copepods) inhabiting their interstitial waters, four beaches in the vicinity of Woods Hole were studied between June 10 and July 22, 1939. Greatest emphasis was placed on a typical beach near Nobska Point; the other locations, differing from it considerably in morphology and exposure, were studied in order to ascertain the effects of heavy wave action, little wave action, and high particulate organic content on the distribution of the organisms.

Sand samples were collected vertically between the surface of the sand and a depth of 16 cm., and horizontally from the high tide line to below low tide level. In the laboratory the organisms were washed out of the sand and preserved for a quantitative and qualitative study to be carried out during the coming winter.

In addition, a series of measurements of the water content of the sand over the entire width of the beach was made. Dissolved oxygen and free carbon dioxide content of the capillary water were also frequently determined.

THE FORMATION OF THE PRIMARY FILM IN THE PROCESS OF FOULING OF SUBMERGED BODIES

AUSTIN PHELPS AND MARGARET HOTCHKISS

This work was initiated by the Bureau of Construction and Repair of the U. S. Navy Department. A detailed study has been made of the effect of the nature of the surface exposed and of the nature of the paint covering the surface upon the development of bacteria forming the primary film. A detailed study has also been made of the chemical nature of this film. A number of stations along the Atlantic seaboard have been selected for submerging painted surfaces for varying periods of time at different seasons of the year.

CHEMICAL INVESTIGATIONS

NORRIS W. RAKESTRAW

Work has been continuing on the decomposition and regeneration of nitrogenous organic matter in sea water. One paper, covering the results of the last two years, has recently been published. Work is now in progress to ascertain the effect of temperature and source of water on the nature of the decomposition cycle. A start has also been made to determine the part, if any, played by gaseous nitrogen. Contrary to the earliest investigations, indications have been found of the existence of intermediate nitrogen compounds between the formed organic matter and the ammonia resulting from decomposition.

An investigation of the changes in gaseous dissolved nitrogen in stored sea water has been continued, and nearly completed. The possibility of a slow fixation of gaseous nitrogen seems rather more likely than it did previously.

Work was completed on the problem of the helium and neon content of sea water and its relation to oxygen. The previous report of such correlation between the oxygen minimum and one of helium and neon was definitely disproved. A paper covering this work was published recently.

A comparison has been made between the oxygen, nitrate and phosphate concentrations at a number of deep sea stations to determine more accurately the relation in the neighborhood of the oxygen minimum. The results from a year's chemical survey of the line of stations between Woods Hole and Bermuda are also being correlated.

During the last summer Mr. Arnold N. Morton undertook an investigation of the growth of diatoms in artificial sea water prepared from highly purified salts. This work has not yet been completed.

A start has been made on the determination of the rate of oxygen consumption in deep waters, at the oxygen minimum and below. Due to the extremely low rate found the investigation will probably continue for a long time.

STUDIES ON THE BIOLOGY OF THE GULF OF MAINE AND OF THE PHYSIOLOGY OF DIATOMS

ALFRED C. REDFIELD

A report is in preparation on the distribution of chaetognaths in the Gulf of Maine in relation to the current systems of that body of water. A study is now in progress of the physiology and biological chemistry of algae under conditions of nutrient deficiency, a condi-

tion which must be of perennial occurrence during the life of marine phytoplankton in nature.

BACTERIOLOGY OF MARINE MUDS

C. E. RENN

The fine, inorganic materials of marine muds adsorb soluble and colloidal proteinaceous materials from decomposed plankton. This adsorption is very marked and rapid. In shallow, stirred waters the adsorbed materials are carried to the bottom in the sediments. By this mechanism a variable fraction of the organic matter of the sea becomes concentrated in the mud.

Under aerobic conditions it has been determined that the presence of adsorbing materials has little or no effect upon the rate at which decomposition of plankton materials takes place.

An efficient, inexpensive respirometer was designed and constructed to give continuous measurements of biological consumption of oxygen in muds and systems rich in organic matter that cannot be studied conveniently by standard chemical methods.

STUDIES ON FISHES

WILLIAM C. SCHROEDER

1. *The Deep Water Fauna around Cuba.* During March, April and May "Atlantis" made a second deep sea bottom trawling cruise around Cuba thus continuing the investigation of the fishes and other animals in this region started the previous year. Out of a total of 174 hauls, made in depths ranging from 315 to 2610 meters, 137 were successful. The gear consisted of 35 and 60 foot otter trawls, and 10 and 14 foot "Blake" trawls, the same types as were used last year.

Again good catches were made, with several hundred species of fish and a possible seven or eight hundred species of invertebrates, exclusive of foraminifera. New species will probably reach 25 or more, these being in addition to the 100-odd taken in 1938.

2. *Migrations of Gulf of Maine Cod.* From time to time progress was made in a report dealing with the migrations of cod living in this region.

3. *Fishes of the Western North Atlantic.* A general revision of the fishes of our Atlantic Coast was started this year by various ichthyologists scattered throughout the country. Dr. H. B. Bigelow and myself have agreed to work up the sharks and skates and also the Family Gadidae, the codfishes, and have assembled considerable data toward the completion of this report. We are also making a

revision of the Genus Mustelus and have examined nearly all the material in the Museum of Comparative Zoölogy, Cambridge, and in the National Museum, Washington.

INTERNAL WAVES

H. R. SEIWELL

Five deep anchor stations of approximately 27 hours duration each in the southern North Atlantic and Caribbean Sea, and one of 5 days duration, 150 miles northwest of Bermuda, were successfully completed during the year, and continuously repeated records of temperature at a series of fixed depths, between surface and 1100–1200 meters, obtained for internal wave investigations. At the localities sampled, temperature variations at fixed depths frequently exceeded 0.5° in 24 hours, apparently resulting from lunar diurnal and lunar semidiurnal vertical oscillations of the water particles.

As a result of the internal wave phenomenon, time variations of sea water properties at fixed depths may induce discrepancies of significant magnitudes in computed dynamic topographic and circulation patterns, as undertaken by the usual oceanographical procedure. Thus, it was desirable, as a first step, to complete a report, based on actual examples, which illustrated magnitudes of discrepancies to be expected in practical oceanographical investigations of the Western Sargasso Sea and of the Gulf Stream System off the American coast, and which offers appropriate suggestions for estimating significance of observed horizontal variations of sea water properties.

Actual analysis of the problem has been undertaken from both statistical and dynamical viewpoints. By the former, the establishment of dominating lunar diurnal and lunar semidiurnal frequencies, has permitted treatment of the geometrical properties of the derived harmonic coefficients of vertical oscillations so as to bring out detailed information on the nature of the phenomenon. In the dynamical treatment of the problem, computation of vertical displacements based on vertical distributions of density in the sea, has shown good agreement with observed values.

During the year at various times, I have been assisted by Kenneth Arnold, Andrew Stergion and Gladys Seiwell. The problem is partially supported by a grant from the Penrose Fund of the American Philosophical Society.

PHYSICAL OCEANOGRAPHY OF THE GRAND BANKS REGION AND LABRADOR SEA

FLOYD M. SOULE

Manuscript for the section on oceanography of U. S. Coast Guard Bulletin No. 28 (season of 1938) was completed during the months of January, February and part of March. This work included a quantitative consideration of the effect of a storm-produced, hypothetically uniform, vertical mixing of the upper 100 meters. The peripheral circulation in the upper layers of the Labrador Sea in 1938 was investigated by means of volume of flow, mean temperature, and heat transfer across four sections. Newly collected data on oxygen distribution along a longitudinal section through the northern part of the Labrador Sea were studied, adding information regarding the source of the bottom water of the Labrador Sea.

The months of April, May and June were spent on the oceanographic vessel of the International Ice Patrol Force, the U.S.C.G. Patrol Boat *General Greene*, supplying dynamic topographic charts of the Grand Banks region to the Ice Patrol cutters *Chelan* and *Champlain*. During this period four current surveys of the critical area were made, the resulting charts being referred to the 1000-decibar surface although at most of the oceanographic stations the temperature and salinity measurements extended to a depth of 1400 meters where the depth of water permitted. In this work 201 oceanographic stations were occupied. Between July 10 and July 15 the *General Greene* occupied 25 additional oceanographic stations from the surface to as near bottom as was practicable on an abbreviated post-season cruise in the Labrador Sea. The stations on this cruise were disposed in the form of a section from South Wolf Island, Labrador, to Cape Farewell, Greenland.

The available evidence collected by the International Ice Patrol regarding the existence, shape, and depth of a motionless surface in the Labrador Sea and the region immediately eastward of the Grand Banks was assembled and presented at the Seventh Triennial Assembly of the International Union of Geodesy and Geophysics in Washington. This evidence pointed to the existence of an approximately level motionless surface lying at a depth of about 2000 meters in the Labrador Sea and somewhat deeper (about 2000 or 2500 meters) east of the Grand Banks, and was contributed by patterns of flow, bottom temperatures, a volume transport balance, temperature-salinity correlations and a deep-water isentropic analysis.

Since September the rest of the year has been used in digesting

the data collected on the 1939 season and post-season cruises of the *General Greene* and in preparing for publication the oceanographic section of U. S. Coast Guard Bulletin No. 29 (1939 season).

STUDIES IN SEDIMENTATION AND IN SUBMARINE GEOLOGY

H. C. STETSON

Two trips were made on "Atlantis" in which cores were obtained from hitherto uncharted sections of the continental slope. With these, the first stage in the field work in the study of the Pleistocene history of the continental shelf and neighboring ocean basin has been completed. Most of the laboratory work has been finished and the report is under way. As has been previously stated this is being done in collaboration with Dr. J. A. Cushman, Miss Frances L. Parker and Dr. F. B. Phleger. The first part of Dr. Phleger's report has been published by the Geological Society and he is at present engaged in writing the second. Dr. Cushman and Miss Parker have been somewhat delayed by their duties in connection with the U. S. Geological Survey.

A chapter on the continental shelf was written for the book "Recent Marine Sediments" published by the Committee on Sedimentation of the National Research Council and a report on the shoals of Vineyard and Nantucket Sounds is in preparation from samples collected three years ago.

The Soil Mechanics Laboratory of the Harvard Engineering School and the American Society of Civil Engineers are conducting a program for the testing of different types of sedimentary deposits for foundation purposes. Through our assistance, sampling with various kinds of coring tubes was carried out in a pit in West Falmouth. The results of this and other tests, which Dr. M. Juul Hvorslev has kindly placed at our disposal, have considerable bearing on problems encountered in taking bottom cores at sea. With these data, it is planned to construct a coring tube which it is hoped will eliminate some of the undesirable features which all coring tubes at present possess.

A STUDY OF THE HYDROGRAPHY OF THE BERMUDA AREA

E. F. THOMPSON

The data for the Bermuda region of the Sargasso Sea have been examined. Particular attention has been given to the salinity-temperature correlation and seasonal variations of the current pattern

and other physical characters. While this work should help to give a better picture of the conditions in the Sargasso Sea, its chief purpose is as part of the coöperative Gulf Stream investigation.

DEPLETION AND REGENERATION OF BLOOD SERUM PROTEINS IN MARINE ELASMOBRANCHS AND TELEOSTS

ABBY H. TURNER

The study of blood serum proteins in different groups of fishes was continued in 1939, on the smooth dogfish, *Mustelus canis*, on the tautog, *Tautoga onitis*, and on a few other species, by determination of colloid osmotic pressure, refractive index of the colloid fraction, protein nitrogen (analyses by Helen Murphy), and water content of the muscles.

Results. Nine specimens of *Mustelus canis*, six of *Tautoga onitis* and one *Prionotus carolinus* withstood extensive bleedings from three to seven times. The experimental work leads to the following statements.

1. That the fish were suitable for study was shown by the close correspondence between the determinations on each first sample and values obtained in previous years on these species.

2. *Mustelus canis* and the teleosts show evidence of reserve protein supplies in that the protein of the serum falls less rapidly than the corpuscular volume. The protein nitrogen falls less than the colloid osmotic pressure indicating that proteins of higher molecular weights are retained preferentially.

3. Regeneration of proteins was shown in three instances, one dogfish, one tautog, and one robin, in all of which conspicuous rises in protein values occurred, except for the colloid osmotic pressure in the two teleosts. This last indicates again that proteins of the larger molecular weights, certainly in the teleosts, are more readily manipulated by the fish than the smaller ones which are associated more closely with the colloid osmotic level.

4. Depletion of serum proteins to a level of colloid osmotic pressure as low as one third or one fourth the original value was not followed by any perceptible edema. That this osmotic change was not without some influence was, however, shown in several instances by a rise in the percentage of water in the muscles. This was seldom conspicuous.

5. The evidence on the whole seems to relate the proteins more closely to the nutritive cycle than to the control of water balance between blood and tissues.

STUDIES ON THE NITROGEN CONTENT OF THE PARTICULATE MATTER IN THE SEA

THEODOR VON BRAND

A study of the nitrogen content of the particulate matter in the region of the oxygen minimum layer was made at seven stations (two from the Caribbean region, three from the slope water and two from the Sargasso Sea). Wherever possible closely spaced samples were analyzed from a region above the oxygen minimum layer, through the layer itself and a region below it. No indication was found that greater irregularities in the amount of particulate nitrogen occur in the region of the oxygen minimum. It should, however, be emphasized that conclusions from these findings can be drawn only with great reserve, since, so far, nothing is known about the C:N ratio of the particulate matter at different levels. Furthermore there is at the present time no way to decide how much of the particulate matter represents living organisms and how much dead material, or even residues from decomposition processes.

In addition six stations from the Cuban cruise were analyzed. Relatively high and uniform values were found at all levels.

STUDIES IN MARINE MICROBIOLOGY

SELMAN A. WAKSMAN

During the year 1939, eleven investigators in Marine Microbiology spent varying periods of time at the Oceanographic Institution. The work dealt with a variety of problems, which can be briefly summarized as follows:

1. The chemical nature of organic matter in the sea bottom and in decomposing algal material—Selman A. Waksman and C. M. Weiss.

2. Decomposition of organic matter in marine muds, with special emphasis on the liberation of the nitrogen in available forms—C. E. Renn.

3. Occurrence of denitrifying bacteria in the sea bottom—Blodwen Lloyd.

4. Occurrence of nitrite and nitrate forming bacteria in sea water and in the sea bottom—C. L. Carey.

5. The rate of oxidation of the dissolved organic matter in sea water—Claude E. ZoBell and Mrs. H. N. Moore.

VITAMIN A AND RETINENE IN SQUID EYE TISSUES

GEORGE WALD

All attempts to identify vitamin A in invertebrates have so far failed. This is interesting from an evolutionary viewpoint; and because the zooplankton, primarily invertebrate, form the channel through which carotenoid vitamin A-precursors supposedly flow from their ultimate source, the phytoplankton, into the marine invertebrates, many of which contain huge stores of vitamin A.

The high concentrations of vitamin A found in vertebrate retinas suggested an examination of squid eye tissues for this substance. A preliminary extraction of light adapted retinas with benzine yielded a greenish-yellow pigment, which, when tested with antimony chloride displayed the general carotenoid reaction, a deep blue color, due in this instance to sharp absorption bands at about 615 and 664 mμ. These bands are commonly specifically associated respectively with vitamin A and retinene. Further exhaustive extraction of these tissues yielded retinene alone, in relatively enormous quantities.

In vertebrate retinas, retinene is a specific intermediate between the visual pigment, rhodopsin, and vitamin A. Under the conditions of the present experiments, no retinene would have been found in a vertebrate retina. Its presence here suggests that the visual system of the squid is chemically closely related to that found in vertebrates, yet differs in arrangement in some still unknown manner.

THE CIRCULATION IN THE GULF OF MAINE AND DIRECT MEASUREMENT OF CURRENTS

E. E. WATSON

With the assistance of Helen Hay all charts of the dynamic isobaths for the 1933–34 survey have been prepared for publication, as well as others showing distribution of temperature and salinity. It is clear that for the spring and summer months the dynamic methods employed give substantially the same picture as that presented by Bigelow in 1924, so that the two presentations are mutually corroborative. For the winter months there is considerable evidence of a major change in the circulation of the Gulf, particularly across Georges Bank. The water from the Gulf moves directly across the Bank instead of peripherally around it as in the summer. Major changes take place in March and in September. The observations for Georges Bank are sparse, particularly on the south side, but the in-

vestigations of the Bank commenced in September should add to our knowledge of conditions there, and complete the picture of the circulation in the Gulf of Maine.

The recording current meter has definitely proved itself suitable for use at sea, either in deep water from "Atlantis" or in shallow water from "Asterias." During tests last August "Atlantis" was anchored in about 900 fathoms off Montauk Point. Current measurements were made down to 400 meters, but mainly at 200 meters, the level of the oxygen minimum layer. Owing to difficulties in keeping the ship anchored and the loss of the anchor itself the interpretation of the measurements obtained is uncertain. But valuable experience was gained in the use of the single insulated steel cable which supported the meter and in the operation of all parts of the measuring system. While use will suggest further improvements in the instruments the fundamental difficulty in deep sea current measurements from "Atlantis" now lies in the problem of anchoring the ship.

LIGHT PENETRATION OBSERVATIONS

LESTER V. WHITNEY

A photocell amplifier was adapted for measuring the angular distribution of underwater light intensity. After testing the apparatus near Woods Hole, a set of readings was then obtained from the "Atlantis" at the edge of the continental shelf. These observations, as well as the later ones taken from the "Asterias," were extremely satisfactory and are now being analyzed.

THE RATE OF OXIDATION OF THE DISSOLVED ORGANIC MATTER IN SEA WATER

CLAUDE E. ZOBELL

By determining the oxygen content of sea water before and after incubating in glass-stoppered bottles it was found that the bacterial oxidation of the organic matter of sea water from the Woods Hole region consumed from 0.5 to 1.5 cc. of oxygen per liter in 10 days at 22°C. Water samples collected from the oxygen minimum layer in the Sargasso Sea consumed only 0.46 cc. of oxygen per liter in 10 days at 22°. Untreated, silk filtered and sintered-glass filtered portions of a sample of surface water collected June 24 from Buzzards Bay consumed 0.86, 0.60 and 0.49 cc. of oxygen per liter respectively. These observations were repeated with similar results.

The average results of several determinations revealed that at 22°C. about 50% as much oxygen was consumed in 10 days as was

ultimately consumed by the bacteria in stored sea water after 60 days. After 20 days between 70% and 80% as much oxygen was consumed as in 60 days.

The rate of oxidation of organic matter in sea water as indicated by oxygen consumption by bacteria is independent of the oxygen tension within the examined ranges of 0.31 to 12.74 cc. of oxygen per liter.

During the first two days of incubation at 22° bacteria in stored sea water were found to consume an average of 14.2×10^{-12} cc. of oxygen per cell per hour. The rate dropped to 9.5×10^{-12} cc. of oxygen per cell per hour after five days and from the fifth to the tenth day of the experiment the bacteria were consuming an average of only 2.6×10^{-12} cc. of oxygen per cell per hour. The decreasing respiratory rate is attributed to the progressive utilization of the more readily oxidizable fractions of organic matter occurring in sea water leaving only the more refractory fractions.

Confirming observations made recently at the Scripps Institution of Oceanography it was found that nitrites appeared in most ammoniacal sea water solutions inoculated with 10 cc. of raw sea water collected from Buzzards Bay or Vineyard Sound provided the concentration of ammonium was low. More than 10 mgm. of ammonium per liter seemed to be inimical to the activities of the marine nitrifying bacteria although terrestrial nitrifiers tolerate over ten times this concentration of ammonium. There was no evidence that low concentrations of organic matter (10 mgm./1) inhibit nitrification provided the oxygen is not depleted from the water.

Progress was made in the perfection of a device for collecting samples of water from any depth for bacteriological analysis.