

XVI.—RESULTS OF THE EXPLORATIONS MADE BY THE STEAMER “ALBATROSS,” OFF THE NORTHERN COAST OF THE UNITED STATES, IN 1883.

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During the summer of 1883, the new United States Fish Commission steamer “Albatross,” Lieut. Z. L. Tanner, commander, continued the work of dredging in the region of the Gulf Stream, along our coast, from off Cape Hatteras to Nova Scotia.* She is, in construction, well adapted to do deep-sea work, and fully equipped with improved apparatus, and therefore was able to carry the dredgings much farther out to sea than the “Fish Hawk” had been able to in previous years. The stations most distant from the coast were more than a third of the way to the Bermudas. The greatest depth successfully dredged was in 2,949 fathoms, at station 2099, N. latitude $37^{\circ} 12' 20''$, W. longitude $69^{\circ} 39'$, August 2. Besides this, there were four successful hauls in 2,033 to 2,369 fathoms, and twenty-seven between 1,000 and 2,000 fathoms. Between 500 and 1,000 fathoms there were nineteen hauls, and in less than 500 fathoms, sixty-three, making a total of one hundred and sixteen stations. At nearly all the localities, except on the rocky bottoms off Nova Scotia, a large beam-trawl was used, and in most cases large quantities of specimens were obtained, even at great depths. The bottom temperatures between 1,000 and 2,000 fathoms were usually between 37° F. and 39° F., and rarely 40° .

The minimum temperatures at the bottom, in this region, are between

* It is but just to say that the unusual thoroughness and remarkable success of these explorations of the Gulf Stream region have been due to the great skill and untiring zeal and energy of Captain Tanner, who has personally superintended all our deep-sea dredging operations during the past five years. It is proper to add that his efforts have been well supported by the other officers associated with him.

The naturalists associated with the writer in this work in 1883 were: Prof. S. I. Smith, Mr. Sanderson Smith, Prof. L. A. Lee, Mr. Richard Rathbun, Mr. J. H. Emerton (also as artist), Mr. B. F. Koons, Prof. Edwin Linton, Mr. H. L. Bruner, Mr. J. E. Benedict (naturalist attached to the steamer), Mr. R. S. Tarr, W. E. Safford, ensign U. S. N., and others, more or less. Mr. Peter Parker, Mr. John A. Ryder, Dr. Theodore Gill, and R. H. Miner, ensign U. S. N., worked on the fishes. The parties who went out dredging on the the steamer varied from time to time. Usually only three or four naturalists, besides Mr. Benedict, could be properly accommodated on board. I took no part in this portion of the work, in 1883, not going out on the steamer at all.

36° and 37° F., even below 2,000 fathoms. But temperatures, practically identical, have often been taken in about 1,000 fathoms, or even less. Therefore the minimum temperatures may be considered as practically reached at 1,000 fathoms, off our coast. Below that, there is very little change. Accordingly, many of the special deep-sea species range from 1,000 fathoms or less to below 2,000 fathoms, in this region. Serial temperatures were also taken at various localities.

CHARACTER OF THE DEEP-SEA DEPOSITS.

Some very interesting and important discoveries were made in regard to the nature of the materials composing the sea bottom under the Gulf Stream at great depths. These observations are of great interest from a geological point of view, as they illustrate the kinds of sedimentary rocks that may be formed far from land and in deep water, and some of them are contrary to the experience of other expeditions and not in accordance with the generally accepted theories of the nature of the deposits so far from land. The bottom between 600 and 2,000 fathoms, in other regions, has generally been found to consist mainly of "globigerina ooze," or, as in some parts of the West Indian seas, of a mixture of globigerina and pteropod ooze. Off our northern coasts, however, although there is a more or less impure globigerina ooze, in such depths, at most localities beneath the Gulf Stream, this is by no means always the case. The "globigerina ooze" usually has the consistency of fine, sticky mud, commonly of a gray, dull olive-green or bluish color. When washed through a very fine sieve a variable, but often large, proportion remains on the sieve, composed chiefly of the shells of *Globigerina* and other foraminifera, of many kinds, but mostly minute species, which live at or near the surface of the sea and fall to the bottom when dead or disabled. With these are many larger forms, both of calcareous and sand-covered species, which live at the bottom. In many places there are large quantities of the brown, sandy, rod-like and triradiate species (*Rhabdammina*), in which the rays become about half an inch long. These are mingled with small shells, annelid tubes, fragments of echinoderms, otoliths of small fishes, &c., together with a variable proportion of true beach sand. The globigerina ooze, as found off our coast, even from below 1,000 fathoms, is always mixed with some fine siliceous and granitic sand, in which grains of quartz, feldspar, and mica can easily be distinguished under the microscope; in shallow water (100 to 400 fathoms) the sand is coarser, with the grains easily visible to the naked eye, but of the same nature, and frequently contains much clay-mud. In several instances the bottom between 500 and 1,200 fathoms has been found to consist of tough and compact clay, so thoroughly hardened that large angular masses, sometimes weighing more than 50 pounds, have been brought up in the trawl, and have not been washed away appreciably, notwithstanding the rapidity with which they have been drawn up through about two miles of water. In fact, these masses of

hard clay resemble large angular blocks of stone, but when cut with a knife they have a consistency somewhat like hard castile soap, and in sections are mottled with lighter and darker tints of dull green, olive, and bluish gray. When dried they develop cracks and break up into angular fragments. This material is genuine clay, mixed with more or less sand, showing under the microscope grains of quartz and feldspar with some scales of mica. More or less of the shells of *Globigerina* and other foraminifera are contained in the clay, but they make up a very small percentage of the material.*

LIST OF STATIONS OCCUPIED BY THE "ALBATROSS" IN 1883.

The following abbreviations are used to indicate the character of the bottom. They are the same as those used by the United States Coast Survey with a few additions desirable for greater precision:

Materials.	Colors.	Other qualities.
b. for barnacles. c. for clay. cns. for concretions. cr. for corals. F. for foraminifera. g. for gravel. M. for mud. o. for ooze. P. for pebbles. R. for rocks. s. for sand. sh. for shells. spg. for sponges. st. for stones.	bk. for black. bn. for brown. bu. for blue. db. for drab. dk. for dark. gn. for green. gy. for gray. lt. for light. ol. for olive. rd. for red. sl. for slate. wh. for white. yl. for yellow.	brk. for broken. cal. for calcareous. csa. for coarse. dia. for diatomaceous. fine. for fine. fer. for ferruginous. glb. for globigerina. hrd. for hard. lpy. for lumpy. rky. for rocky. sft. for soft. shy. for shelly. sml. for small. sps. for specks. sty. for sticky.

In the following list the character of the bottom is not always given as in the original record, for in some cases colors or other qualities have been omitted, when unimportant, for the sake of condensation. In other cases additions or alterations have been made based on the materials actually brought up in the dredge or trawl, often in large quantities:

Station.	Locality.		Fathoms.	Bottom.	Temp., F.		Hour.	Date.
	N. lat.	W. long.			Bot- tom.	Sur- face.		
OFF CHESAPEAKE BAY.								
	° ' "	° ' "			°	°		
2001	37 46 30	74 00 00	499	gn. M.				Mar. 22
2002	37 20 42	74 17 36	641	gn. M.		1 48		Mar. 23
2003	37 16 30	74 20 30	640			1 50		Mar. 23
2004	37 19 45	74 26 00	98	gn. M. sh.		1 51		Mar. 23
2005	37 18 11	74 27 30	78	M. s. sh.		1 50		Mar. 23
2006	37 19 11	74 20 00	492	M. fine. s.		1 50		Mar. 23
OFF CAPE HATTERAS.								
2007	35 17 00	75 13 00	15	fine. s.	1 68	1 56	8.00 a. m.	Apr. 27
2008	35 09 40	75 04 36	88	M. fine. s.	1 74	1 72	10.15 a. m.	Apr. 27

* This kind of material was encountered in much larger quantities during the past season (1884) than in 1883. See American Journal of Science for November, 1884.

Station.	Locality.		Fathoms.	Bottom.	Temp., F.		Hour.	Date.
	N. lat.	W. long.			Bot- tom.	Sur- face.		
OFF CAPE HATTERAS--								
continued.								
	° ' "	° ' "			°	°		
2009	85 29 85	74 46 45	591	-----	-----	1 69	8.45 a. m.	Apr. 28
2010	85 30 00	74 44 45	890	-----	-----	1 61	10.40 a. m.	Apr. 28
2011	86 38 30	74 40 10	81	s. brk. sh.	-----	1 48	9.00 a. m.	Apr. 30
2012	86 41 15	74 39 50	86	-----	-----	1 52	10.15 a. m.	Apr. 30
2013	86 45 80	74 25 30	888	gn. M.	-----	1 48	1 05 p. m.	Apr. 30
2014	86 41 05	74 38 53	373	s. brk. sh.	-----	1 47	6.35 a. m.	May 1
OFF CHESAPEAKE BAY.								
2015	37 81 00	74 53 30	19	fne. s. sh.	-----	-----	8.39 a. m.	May 5
2016	37 81 00	74 52 36	19	fne. s. sh.	45	45	9.06 a. m.	May 5
2017	37 80 48	74 51 29	18	fne. s. sh.	46	45	9.50 a. m.	May 5
2018	37 12 22	74 20 04	788	bu. M.	39	54	12.07 p. m.	May 7
2019	37 15 52	74 23 52	600	bu. M.	39	52	4.13 p. m.	May 7
2020	37 37 50	74 15 30	143	fne. s. M.	54	52	5.30 a. m.	May 21
2021	37 36 00	74 16 00	179	M. s.	45	54	7.00 a. m.	May 21
2022	37 32 00	74 13 20	487	M. s.	40	52	10.00 a. m.	May 21
2028	37 48 00	74 01 30	377	M. fne. s.	-----	56	3.15 p. m.	May 21
OFF MARYHA'S VINEYARD.								
2024	40 02 10	70 27 00	221	dk. gn. M.	40	49	5.51 a. m.	May 25
2025	40 02 05	70 27 00	239	M. fne. s.	40	49	7.20 a. m.	May 25
2026	40 04 00	70 28 50	131	gn. M. s.	48	49	9.00 a. m.	May 25
2027	39 58 25	70 37 00	198	bu. M. s.	43	52	12.21 p. m.	May 25
2028	39 57 50	70 32 00	204	bu. M.	41	52	2.05 p. m.	May 25
2029	39 42 00	70 47 00	1,168	gn. M.	38	53	5.18 p. m.	May 25
2080	39 29 45	71 43 00	588	bu. M.	-----	49	6.20 a. m.	May 26
2081	39 29 00	72 18 55	74	M. wh. s.	49	50	1.05 p. m.	May 26
2082	39 29 00	72 19 40	73	M. s. brk. sh.	47	50	2.10 p. m.	May 26
2083	39 32 30	72 18 35	379	gn. M.	41	49	5.00 a. m.	May 26
2034	39 27 10	69 56 20	1,346	glb. O.	38	72	8.55 a. m.	July 17
2035	39 26 12	70 02 37	1,362	glb. O.	-----	71	2.50 p. m.	July 17
2036	39 52 40	69 24 40	1,735	glb. O.	38	76	4.30 a. m.	July 18
2037	39 53 00	69 23 30	1,731	glb. O.	38	76	1.22 p. m.	July 18
2038	39 30 30	69 08 25	2,038	glb. O.	-----	76	2.32 p. m.	July 26
2039	38 19 26	68 20 20	2,369	glb. O.	-----	81	noon.	July 28
2040	38 35 13	68 18 00	2,226	glb. O.	-----	76	4.20 a. m.	July 29
2041	39 22 50	68 25 00	1,608	glb. O.	38	72	3.50 a. m.	July 30
2042	39 33 00	68 26 45	1,555	glb. O.	38	71	10.32 a. m.	July 30
2043	39 49 00	68 28 30	1,467	glb. O.	38	72	5.07 p. m.	July 30
2044	40 00 30	68 37 20	1,067	glb. O.	39	72	5.25 a. m.	July 31
2045	40 04 20	68 43 50	373	M. fne. s.	40	72	10.00 a. m.	July 31
2046	40 02 49	68 49 00	407	bu. M.	40	72	noon.	July 31
2047	40 02 30	68 49 40	389	bu. M.	-----	72	2.15 p. m.	July 31
2048	40 02 00	68 50 30	547	s. G. M.	-----	72	3.56 p. m.	July 31
2049	39 48 40	69 20 00	1,025	bu. glb. M.	39	71	3.35 a. m.	Aug. 1
2050	39 43 50	69 21 20	1,050	glb. O.	-----	72	9.15 a. m.	Aug. 1
2051	39 41 00	69 20 20	1,106	glb. O.	39	72	2.34 p. m.	Aug. 1
2052	39 40 05	69 21 25	1,098	glb. O.	-----	78	6.16 p. m.	Aug. 1
OFF GEORGE'S BANK.								
2053	42 02 00	68 27 00	105	bu. M.	-----	61	5.00 a. m.	Aug. 29
2054	42 03 30	68 28 00	105	bu. M.	-----	64	6.20 a. m.	Aug. 29
2055	42 32 00	68 17 00	99	M. crs. G.	-----	00	9.24 a. m.	Aug. 30
2056	42 01 30	68 01 00	97	fne. s. G.	-----	57	3.23 p. m.	Aug. 30
2057	42 01 00	68 00 30	86	s. B. brk. sh.	-----	57	4.26 p. m.	Aug. 30
2058	41 57 30	67 58 00	35	gy. s.	50	58	6.89 p. m.	Aug. 30
2059	42 05 00	67 46 15	41	bu. M. s.	-----	55	5.00 a. m.	Aug. 31
2060	42 10 00	66 46 15	123	s. B. brk. sh.	-----	55	7.10 a. m.	Aug. 31
2061	42 10 00	66 47 45	115	bu. M. s.	40	54	8.00 a. m.	Aug. 31
2062	42 17 00	66 37 15	150	s. G. B.	42	61	10.47 a. m.	Aug. 31
2063	42 23 00	66 23 00	141	s. crs. G. B.	46	57	1.20 p. m.	Aug. 31
2064	42 25 40	66 08 35	122	crs. s. G. B.	-----	56	4.32 p. m.	Aug. 31
OFF CAPE SABLE.								
2065	42 27 00	65 00 45	80	s. G. B.	44	55	7.00 p. m.	Aug. 31
2066	42 19 40	65 49 30	85	st. G. B.	43	54	5.00 a. m.	Sept. 1
2067	42 15 25	65 48 40	122	s. G. B.	46	56	7.05 a. m.	Sept. 1
2068	42 03 00	65 48 40	131	s. fne. O.	42	56	10.30 a. m.	Sept. 1
2069	41 54 50	65 48 35	101	s. st. G. Cr.	42	56	1.84 p. m.	Sept. 1
2070	41 55 30	65 47 10	113	P. coral	42	57	2.58 p. m.	Sept. 1
2071	41 56 20	65 48 40	113	P. coral	-----	57	4.10 p. m.	Sept. 1

Station.	Locality.		Fathoms.	Bottom.	Temp., F.		Hour.	Date.
	N. lat.	W. long.			Bot- tom.	Sur- face.		
OFF CAPE SABLE—con- tinued.								
	° ' "	° ' "			°	°		
2072	41 53 00	65 35 00	858	gy. M.	39	58	6.15 a. m.	Sept. 2
2073	41 54 15	65 39 00	593	gy. s.	40	58	10.41 a. m.	Sept. 2
2074	41 43 00	65 21 50	1,309	fne. glb. M.	40	69	6.42 a. m.	Sept. 3
2075	41 40 30	65 35 00	855	fne. glb. M.	39	58	3.41 p. m.	Sept. 3
2076	41 18 00	66 00 50	908	bu. glb. M.	-----	69	8.20 a. m.	Sept. 4
2077	41 09 40	66 02 00	1,255	bu. glb. M.	39	68	8.00 a. m.	Sept. 4
2078	41 12 50	66 12 20	499	gy. M. s.	40	68	1.40 p. m.	Sept. 4
2079	41 18 00	66 19 50	75	wh. s.	45	67	4.15 p. m.	Sept. 4
2080	41 13 00	66 21 50	55	gy. s.	46	67	5.10 p. m.	Sept. 4
2081	41 10 20	66 30 20	50	wh. s. P. B.	46	56	6.50 p. m.	Sept. 4
2082	41 09 50	66 31 50	49	crs. s. B.	46	55	7.40 p. m.	Sept. 4
2088	40 26 40	67 05 15	959	gy. M.	40	72	4.30 a. m.	Sept. 5
2084	40 16 50	67 05 15	1,290	bu. M. s.	40	78	9.09 a. m.	Sept. 5
OFF MARTHA'S VINEYARD.								
2085	40 05 00	70 34 45	70	bu. M.	50	68	6.56 a. m.	Sept. 20
2086	40 05 05	70 35 00	69	M. s.	52	67	9.20 a. m.	Sept. 20
2087	40 06 50	70 34 15	65	M. wh. s.	50	67	10.30 a. m.	Sept. 20
2088	39 59 15	70 36 30	143	yl. s.	48	68	12.40 p. m.	Sept. 20
2089	39 58 50	70 39 40	168	gy. s.	45	69	3.13 p. m.	Sept. 20
2090	39 59 40	70 41 10	140	s. brk. sh.	48	68	4.40 p. m.	Sept. 20
2091	40 01 50	70 59 00	117	gn. M.	49	69	5.30 a. m.	Sept. 21
2092	39 58 35	71 00 30	197	gn. M.	45	67	7.50 a. m.	Sept. 21
2093	39 42 50	71 01 20	1,000	F. s. M.	39	69	1.12 p. m.	Sept. 21
2094	39 44 30	71 04 00	1,022	F. s. M.	38	68	5.07 p. m.	Sept. 21
2095	39 29 00	70 58 40	1,842	glb. O.	-----	69	9.02 a. m.	Sept. 30
2096	39 22 20	70 52 20	1,451	glb. O.	37	69	2.07 p. m.	Sept. 30
OFF CHESAPEAKE BAY.								
2097	37 56 20	70 57 30	1,917	glb. O.	-----	72	5.80 a. m.	Oct. 1
2098	37 40 30	70 37 30	2,221	glb. O.	-----	72	1.08 p. m.	Oct. 1
2099	37 12 20	69 39 00	2,940	glb. O.	-----	82	5.30 a. m.	Oct. 2
2100	39 22 00	68 34 30	1,628	glb. O.	37	69	11.05 a. m.	Oct. 3
2101	39 18 30	68 24 00	1,686	glb. O.	37	67	4.31 p. m.	Oct. 3
OFF DELAWARE BAY.								
2102	38 44 00	72 38 00	1,209	glb. O.	39	62	-----	Nov. 5
2103	38 47 20	72 37 00	1,091	glb. O.	39	62	-----	Nov. 5
2104	38 48 00	72 40 30	991	bu. glb. M.	41	63	-----	Nov. 5
OFF CHESAPEAKE BAY.								
2105	37 50 00	73 03 50	1,395	glb. O.	41	63	-----	Nov. 6
2106	37 41 20	73 03 20	1,497	glb. O.	42	63	-----	Nov. 6
OFF CAPE HATTERAS.								
2107	35 19 30	75 15 20	16	fne. s. sh.	-----	76	-----	Nov. 9
2108	35 16 00	75 02 30	48	M. crs. s.	66	78	-----	Nov. 9
2109	35 14 20	74 59 10	142	bu. M.	50	70	-----	Nov. 9
2110	35 12 10	74 57 15	516	bu. M.	40	75	-----	Nov. 9
2111	35 09 50	74 57 40	938	gn. M.	-----	76	-----	Nov. 9
2112	35 20 50	75 18 00	15	s. bk. sp.	73	70	-----	Nov. 10
2113	35 20 30	75 19 00	15	s. M.	72	70	-----	Nov. 10
2114	35 20 00	75 20 00	14	s. M.	72	70	-----	Nov. 10
2115	35 49 30	74 34 45	848	M. fne. s.	39	78	-----	Nov. 11
2116	35 45 23	74 31 25	888	M. fne. s.	39	77	-----	Nov. 11

In many instances we have also dredged pebbles and small, rounded boulders of granite and other crystalline rocks from beneath the Gulf Stream in deep water. These, I suppose, have been carried to that region by shore-ice floating off in great quantities from our northern coasts in winter and spring, and melting where the warm Gulf Stream water is encountered. The coarser sands and gravel are probably carried there in the same way, but the fine sand, in part at least, probably

floats out to this region after drying on the beaches during ebb tide, by reason of the adherent air and repellent action toward the water. The clay mud, with much of the fine sand, is probably carried out from the shallower water as suspended sediment. But some of the clay may result from the local decomposition of feldspathic rocks and sand at the bottom of the sea.

FAUNA OF THE DEEP WATER.

The deepest localities were all rich in animal life of many kinds.* A considerable number of interesting fishes were obtained, many of them new to our fauna. Some of these are new genera and species of great interest.

Very interesting additions to our collections were made in nearly every class of marine invertebrates, including many undescribed species and genera, some of which are of great morphological importance, while many of the described species were previously known only from distant regions on the European side of the Atlantic, in the Arctic or Antarctic regions, off the coast of South America, in the West Indies, or even in the Indian or Pacific Oceans. Thus our knowledge of the distribution of the deep-sea forms, both geographically and in depth, has been greatly increased. Some of these deep-sea species were first described as fossils from the European tertiaries. Moreover, a considerable number of our shallow-water species have been found to have a much greater range in depth than was anticipated, many of them going down below 500 fathoms, while some even go below 1,000 fathoms.

On the first trip of the "Albatross" from Wood's Holl, which was made July 16 to 19, four successful hauls were made with a large trawl, in 1,346 to 1,735 fathoms, on the 17th and 18th of July, two each day, besides the soundings and temperature determinations, including series of temperatures at various distances from the surface. On this trip about one hundred and five species of Invertebrates were obtained, not including the Foraminifera and other minute forms. There were among them fourteen species of Anthozoa; two of Hydroids; twenty-two of Echinoderms; thirty-eight of Mollusca; fifteen of Crustacea; one of Pycnogonida; ten of Annelida; one of Bryozoa; two of Sponges.

ANTHOZOA.

The Anthozoa were abundant, both in individuals and species, in most of the dredgings. From below 1,000 fathoms there were numer-

*An account of the Crustacea was published in the July number of the American Journal of Science by Prof. S. I. Smith, who has also published a detailed account of that group, with figures, in the Fish Commission Annual Report, part x. The writer has published a detailed paper on the Mollusca, with five plates, in the Trans. Conn. Acad., vol. vi, and also a brief general account of the work of the season in the American Journal of Science, vol. 28, p. 213, with descriptions of new species of Echinoderms and Anthozoa. Some of the new fishes have been described by Messrs. Gill and Ryder.

ous species, many of them of great interest. About forty species were taken, altogether, belonging to all the principal groups. Several were undescribed, while others are new additions to our fauna, though previously obtained elsewhere by the "Blake" or "Challenger." It was also a source of satisfaction to us that we rediscovered, in larger numbers, the few remaining species that the "Blake" and "Challenger" had discovered off our coast, but which the Fish Commission had not previously dredged.

The Pennatulacea were among those of greatest interest, and of these several fine species occurred, among which were two large and handsome species of the rare and curious genus *Umbellula*. In this genus there is at the summit of the tall, slender stem a close cluster of large, flower-like, deep red, orange-red, or purplish-red polyps, each with eight long, pinnate tentacles. The flexible stem is often 2 feet or more in length, and terminates at the base in a long, hollow, muscular bulb, which serves as an anchor when inserted into the mud. The first known species of this genus was brought up on a sounding line from deep water, off the coast of Greenland, early in the last century, and one of the two specimens was described by Ellis, and the other by Mylius with rude but characteristic figures. These specimens seem to have been lost. From that time it remained unknown until within a few years, and was often a source of doubt and perplexity to the systematists. The modern deep-sea explorations, and especially those of the "Challenger," have brought to light several additional species, and proved that the genus inhabits all the oceans in deep water. But no specimens of the genus had been taken on the North American coast before last year, though a small one had been dredged in the West Indies by the "Blake." One of our species appears to be *U. Guntheri* K lliker (fig. 3), first dredged on the other side of the Atlantic by the "Challenger;" the second and more common was apparently new (*U. Bairdii* V., fig. 2). It differs from the former in having longer and perfectly smooth polyps, with lanceolate clusters of zooids running up between them. It is 2 feet high, with the polyp-bodies over an inch in length. Both occurred in 1,731 to 2,033 fathoms, and sometimes together. The handsome, small, dark red *Pennatula aculeata* (fig. 7) has been taken many times, both by the "Albatross" and "Fish Hawk," and often in great numbers, as many as 100 to 200, and in one case 494 specimens in a single haul. Like most of the Pennatulacea it is brilliantly phosphorescent. It ranges from 100 to 1,255 fathoms, but is most abundant between 150 and 300 fathoms. A much larger and finer species (*P. borealis*, fig. 8), usually considered rare, but frequently brought in by our halibut fishermen from the northern banks, was dredged several times in 192 to 1,255 fathoms. It grows to the height of 18 inches or more, and is often 4 or 5 inches broad across the pinnae. Its color is usually bright orange-red, varying to brownish red and to light orange. A large, handsome and very remarkable new species for which it is necessary to constitute a

new genus, if not also a new family, was taken once, in 1883, in 843 fathoms, but two better specimens were taken, in 1884, in 991 and 1,073 fathoms. This I have named *Benthoptilum sertum* (fig. 4). It has the general form of a large *Pennatula*, with short, thick, fleshy, oblique pinnae, from which spring several rows of numerous large and very long, soft, fleshy polyps, without calicles and without spicula, each group forming a bouquet-like cluster of flower-like polyps, which in life are blood-red.

The singular club-shaped genus, *Kophobelemnon*, was represented by two species. One of these, which was undescribed (*K. tenue* V., fig. 5), is long, slender, and smooth, with a number of large polyps. It was taken in 499 to 2,369 fathoms, and in considerable numbers in some localities. The other and smaller rough species (*K. scabrum* V.) was previously known from a single specimen taken by the "Blake" in 1880. It occurred in 788 fathoms, but was taken more abundantly in 1884. A handsome new species, from 6 inches to a foot high, and slender, with many spiculate flower-like polyps in a row along each side on the upper half, was dredged in many localities by the "Albatross" in 1,467 to 2,369 fathoms. It belongs to the genus *Scleroptilum* (*S. elegans* V., fig. 6). This genus was previously known only from a related species taken off Japan by the "Challenger." Many of our specimens had a new species of Ophiuran (*Hemieuryale tenuispina* V., fig. 55) clinging closely to them, with its long, slender arms, which are provided with rough-tipped spines, closely coiled around the coral, which, like its commensal, is bright orange in color.

This Ophiuran is similar in habits to the *Astrophytons*, but, unlike most of the latter, the arms do not branch. All of this family habitually live clinging to Aleyonaria of various kinds, and generally agree in a most remarkable manner in color, and frequently, also, in the rough ornamentation of the surface, with the branches of the gorgonians to which they cling. This indicates a protective adaptation, both of color, form, and ornamentation, running through a large group, and inhabiting all the oceans, both in shallow and deep water. Two simple-armed species of this group, with similar habits, were also taken by us, one of which (*Astronyx Loveni*) lives clinging to several slender Pennatulacea, including *Distichoptilum gracile* V., *Anthoptilum grandiflorum* V., and *A. Murrayi* K. Another (*Astrochele Lymani* V., fig. 53) lives in large numbers on the bushy gorgonian coral, *Acanella Normani* V., with which it agrees in its orange or salmon-color. The two species of *Anthoptilum* referred to grow in long, stout, wand-like forms, with numerous large, naked, flower-like polyps in oblique rows. *A. grandiflorum* is much the larger, growing over 2 feet high and an inch in diameter, with many hundreds of polyps. It was dredged in 302 to 1,106 fathoms, but was first described by me in 1879 from many large specimens brought in by the Gloucester halibut fishermen from off Nova Scotia, on the deep-water banks. It was afterward described by Kölliker under a new name (*A. Thomsoni*) from specimens dredged by the "Chal-

lenger" off Buenos Ayres. *A. Murrayi* K. was first taken by the "Chalenger" off Nova Scotia. The "Albatross" dredged it in 640 to 1,362 fathoms. Other tall, wand-like species are *Funiculina armata* V., which is very slender, and *Balticina Finmarchica*, fig. 11. The latter frequently grows to the length of a yard and is about an inch in diameter. Many of the specimens have the round, stony axis stripped bare at the end, and sometimes in other places, for a longer or shorter distance, by accidental injuries. Nearly always these naked places are occupied by a peculiar species of Actinian (*Actinauge nexilis* V., fig. 22), which starts like ordinary young Actinians, with a flat base, but the sides of the base spread out thin and wrap around the axis of the coral till they meet on opposite sides, when they coalesce by a firm suture, inclosing the coral in a sort of tube or sheath, and when several of them start near together their bases mutually coalesce where they come in contact, thus forming a continuous covering over the dead coral. This Actinian grows to a rather large size, and the weight of a cluster, often of five or six, and in one case nine, at the top of the tall, slender axis causes it to bend over, so that they are pendulous on the nodding summit of the coral. By certain writers this denuded condition of the axis of this species has been supposed to be normal, or at least constant, but I have seen numerous specimens that are perfect to the tip. Several other deep-sea Actinians from this region have the same habit of growth, inclosing the denuded axis of various species of Gorgonians. One of the most abundant of these is *Sagartia Acanellæ* V., fig. 25, which thus incloses denuded portions of the bush-coral, *Acanella Normani*. It has the same orange or salmon color as the coral on which it lives.

The Gorgonacea or "bush corals," are well represented, at great depths, by several handsome species, some of them 2 or 3 feet high, and nearly all belonging to genera that are peculiar to the deep sea, for which they are specially adapted by a peculiar modification of the base, which divides into a number of divergent, root-like branches, sometimes becoming much divided and slender, but more commonly flat and irregular. These penetrate, like roots, into the soft mud and thus give a secure anchorage on bottoms where no solid foundation could be had for species that adhere only to solid objects by a flat expansion of the base, as in nearly all shallow-water species. The root-like base is characteristic of the genera *Acanella*, *Lepidisis*, *Dasygorgia* and *Lepidogorgia* found in our region, and of many others, found elsewhere in deep-sea dredging. Most of these corals are orange, orange-red, or salmon-color in life, some of them varying to red or to orange-brown. One of the most elegant of these, dredged in 1,346 to 1,362 fathoms, is *Dasygorgia Agassizii* V., first discovered by the "Blake." It is a plumose, much branched coral, with the terminal twigs very slender, while the main branches are spirally arranged. Its axis is slender, calcareous, and iridescent, and its root-like base is divided into short, flat, irregular branches. Its polyps are prominent, relatively large, rather far apart,

and obliquely seated on the branches. It belongs to the family *Ohryso-gorgiæ*, recently established by the writer for this and several other related deep-sea genera, nearly all having a brilliantly iridescent axis, and most of them with spiral branches.

We also dredged, in 858 to 1,735 fathoms, another allied new species, representing a new genus in this family. I have called it *Lepidogorgia gracilis*. It grows in the form of a very slender, tall, round, unbranched stem, about 3 feet high. The axis is iridescent, and the root is divided into many divergent branches, which are stony, white, round, and much branched, and when detached look like branching corals of a very different nature. The polyps are large, prominent, obliquely seated, secund and far apart along the stem, which is covered with a thin layer of small oblong scales. *Lepidisis caryophyllia* V. is also a coral that grows in the shape of a tall simple stem, a yard or more high, but its axis is divided into joints, the longer ones white, calcareous, and hollow, alternating with brown, short, horny ones. Its polyp-calicles are spinose and very long and clavate, and when the tentacles are, as usually seen, rolled up in a ball at the end, they resemble cloves in shape, a character to which the name refers. It was often taken in 1,098 to 1,735 fathoms, and its dead, stony joints must be abundant on the bottom, for they afford attachment for many other creatures of various kinds. The smaller and much branched, bush-like, orange-brown coral, *Acanella Normani* V., is the most common of all the corals. It has been dredged in a great many localities, both by the "Fish Hawk" and "Albatross," in 225 to 1,300 fathoms, often in great numbers, several hundreds sometimes coming up in a single haul. It grows about a foot high, and is often nearly as broad as high, its branches growing out three or four together, in close whorls, from the horny joints. It is decidedly phosphorescent. Many other creatures, such as Actiniæ, hydroids, barnacles, worms, and Ophiurans of several species are frequently attached to it, so that in this way it is a valuable aid to us in bringing up these abyssal creatures. One peculiar Ophiuran, *Astrochele Lymani* V., occurs in great numbers on this coral, which is its regular home. It twines its long slender arms, which bear numerous clusters of small hooks, closely around the branches of the coral, and it cannot be easily removed without breaking the arms. A dozen or more frequently occur on a single coral, and are often accompanied by *Ophiacantha millespina* and other species having similar habits.

The *Acanthogorgia armata* V. is a large and much branched gorgonian with a horny axis, and long, clavate, spinose calicles. Some fine living specimens were taken in 407 and 640 fathoms. When living it was pale orange, or salmon-color, but it quickly turns either dark brown or black in alcohol or when dried. On the outside of Brown's Bank, off Southern Nova Scotia, at several stations, the "Albatross" dredged, in 101 to 131 fathoms, a number of good specimens of the great bush-coral, *Prim-*

noa lepadifera, thus accurately fixing one of its localities. It is often brought in by the Gloucester fishermen.

Among the Alcyonacea there were a few interesting forms. One of these, *Anthomastus grandiflorus* V. (fig. 12), grows somewhat in the form of a mushroom, with a broad, rounded top and a stout stem, which may either be attached to stones by a flat base, or penetrating the mud it may branch and divide into many curious little bulb-like expansions to form an anchorage. When full grown, it becomes large and hemispherical, often 4 to 5 inches broad, with a short, broad stem, while a number of very large, flower-like polyps are scattered over the top. Smaller specimens have but few of the large polyps, which are often an inch and a half across the tentacles, but there are many minute zoöids on the surface between the polyps. Its color is dark red, or purplish red. It has been dredged in considerable numbers by the "Fish Hawk" in 410 to 458 fathoms, and by the "Albatross" in 858 to 1,395 fathoms. It was also obtained previously, of large size, by the Gloucester fishermen, from the outer banks off Nova Scotia. More recently, it has been redescribed from the Norwegian coast under the name of *Sarcophyton purpureum* Kor. & Dan.

There were also two large species allied to *Alcyonium*. One of the latter (fig. 13), common in 1,290 to 1,608 fathoms, almost always starts on a joint of *Lepidisis caryophyllia*, but its thin expanding base, after surrounding the coral, descends deeply into the mud, in a hollow, bulb-like form, firmly inclosing a ball of mud for an anchorage, a habit similar to that of several of the large Actinians.

There are several species of cup-corals living in deep water off our northern coast. Several of these are large and handsome species. The largest and most common, which we have also taken in considerable numbers every year on the "Fish Hawk," in 164 to 787 fathoms, is *Flabellum Goodei* V (fig. 14). It has a strongly compressed form, often with flat sides, and is very fragile. Large specimens are often 3 or 4 inches across the longest diameter. The animal is orange, with the lips and tentacles purplish red or brown. A second species of *Flabellum* (*F. angulatum* Moseley, fig. 15) was taken last season. It is a beautiful species, with a broad, cup-shaped calicle, somewhat hexagonal in outline. It was dredged several times this year, in 906 to 1,467 fathoms, and was originally discovered by the "Challenger," off Nova Scotia. The third species is a handsome coral (*Caryophyllia communis*, fig. 16) of which a number of fine, large, living specimens were dredged in 1,098 to 1,106 fathoms. It is narrow, cup-shaped at summit, but terminates in a rather acute base, which is turned to one side more or less decidedly. It was originally described as a fossil from the Italian tertiary formation. Another very fragile cup-coral, interesting on account of its remarkable habit of restoring itself, after being broken, by budding out from every fragment, so that most of the specimens have a larger or smaller frag-

ment of the dead parent coral adhering to its base, is *Dasmosmilia Lymani* (fig. 17). It was taken in 57 to 1,091 fathoms.

The Actinians are represented in deep water by several very large species, some of them handsomely colored. Several hundreds often come up in a single haul of the trawl, making a bushel or more in bulk. As most of these secrete from their surfaces a large amount of slimy mucus, their presence in such numbers is often a nuisance, as the slime obscures and injures rarer and more delicate things. An orange or pale red species, *Bolocera Tuediæ*, living mostly in 150 to 640 fathoms, is among the most common and most slimy. It has a smooth body, often 3 or 4 inches in diameter, with numerous very large light orange-red tentacles, 2 or 3 inches long and about as large as a man's fingers. These tentacles cannot be retracted and are very easily detached, and then resemble peculiar worms, for they retain the power of motion for some hours. They also have powerful stinging organs, or "nettling threads," which are able to poison the human hand severely, especially between the fingers, when the skin is softened by prolonged handling of the wet specimens, so that for those persons who are sensitive to such poisons they render the handling of the contents of the dredge rather unpleasant.

A very singular, large, soft, pinkish Lernean crustacean (*Anthecheres Dübenii* Sars, fig. 167-8) lives parasitically in the stomach of this Actinian, with which it agrees in color. It is not uncommon. A large, bright orange, scaly annelid, over 2 inches long (*Polynöë aurantiaca* V.), lives as a commensal among the tentacles.

Another common red or orange Actinian, taken in 55 to 616 fathoms, but most abundant in 150 to 400 fathoms, is *Actinauge nodosa* (fig. 20), which grows quite as large as the preceding, but has very numerous and smaller, retractile, red or orange-brown tentacles; vertical rows of tubercles cover the firm body, while just below the tentacles there is a broad zone which, like the tentacles, secretes an abundance of mucus, which is highly phosphorescent, so that when irritated the upper end of the body is illuminated, looking something like a large torch in the dark. In the deep-sea mud it has a bulbous base, but in less depths it attaches itself by a flat base to stones and shells, or clasps its base around worm-tubes and branches of corals.

Another very large and much handsomer species of this genus, with the same phosphorescent character and similar habits, is *Actinauge longicornis* V. (fig. 21), which has been taken many times in 100 to 325 fathoms. It often becomes 3 or 4 inches broad across the body, and 5 or 6 high, while the long, slender, tapered, pale pink tentacles, banded with purple, may be 3 or 4 inches long, and when fully expanded they may fill a space 10 or 12 inches in diameter, or the size of an ordinary water bucket. The body is white or pink, and has a somewhat parchment-like appearance. It bears rows of small warts. A still larger and very common species, in 60 to 640 fathoms,

is *Actinostola callosa* V. (fig. 24), which often becomes 5 or 6 inches across the body, and is usually somewhat higher than broad. It has a large number of short, thick tentacles, usually deep orange in color, while the body is lighter, varying to salmon or pale flesh-color, and has a smooth leathery texture and warty surface. This and the two preceding, when living on the deep-water muddy bottoms, have the habit of firmly inclosing a large ball of mud, often 2 or 3 inches in diameter, in the base. This is done by the basal disk first spreading out and then descending into the mud, when its edges contract so as to produce a hollow bulb, often with only a small central opening below. This bulb serves as an anchorage in the mud, but it is probable that all these species, at first, when very young, adhere to bits of corals, worm-tubes, shells, or some other solid substance, by a flat base, as usual with Actinians in shallow water, and that the base gradually becomes bulbous when it grows beyond its small support, for we often find young specimens thus attached, and have observed the bulb in all stages of formation. In some cases one half the base would be flat, and adherent to a shell, while the other half would have the bulbous form, inclosing mud. Moreover, when these same species inhabit hard bottoms, covered with shells and stones, as often happens, large specimens occur broadly attached by their flat bases, so that this must be regarded as a special adaptation suited to the peculiar conditions of muddy bottoms, but not yet become a permanent character of the genera, nor even of the species, so far as we have been able to discover.

Within the hollow bulbs, mixed with the mud, or next to the base itself, we usually find a number of chitinous pelicles, which have been secreted by the basal disk and cast off from time to time. This is not confined to either of the several genera that have bulbous bases, but is common to all. It indicates that the same ball of mud, or portions of it, at least, must be retained for a long period, or perhaps through life, for it is probable that individuals thus anchored in the mud do not move about at all, but ever afterwards remain fixed. Indeed, I have good evidence that some large individuals of *A. nodosa* attached to stones and shells remain fixed in the same place for years, without any disposition to creep about, and perhaps they may lose this power, more or less, as they grow old, though they certainly have it while young, as do most shallow-water species. The formation of the basal bulb in these Actinians, and in the *Alcyonium* above mentioned, throws much light on the probable origin of the specialized muscular basal bulb of the Pennatulacea.

A remarkable new genus (*Gondul mirabilis*) has been recently described by Koren and Danielssen,* which is attached by an adherent base, as in *Alcyonium*, but has the polyps arranged on bilateral oblique ridges, as in many Pennatulacea, and with four axial tubes,

* Bergen's Museum, Nye Alcyonider, Gorgonider og Pennatulider til Norges Fauna, p. 19, pl. 10, 1863.

much as in the latter, while the spicula also resembles those of this group. This may represent a primitive type from which the Pennatulacea have been derived. It is only necessary to suppose that the attached base of such a form may have become bulbous and more specialized, on account of the exigencies of muddy bottoms, as in the case of our Alcyonium and Actinians, when it would become a true member of the Pennatulacea. It might, of course, be urged that it is a degraded form, derived from the Pennatulacea, but this is not probable. At any rate, it is evident that the Pennatulacea, as a group, are adapted specially for life on the soft muddy bottoms of the deep sea, and probably were originally developed there from simpler attached forms of shallow-water origin.

The bulbous bases of the large Actinians are often useful to us in dredging, because they may inclose various small shells, &c., with the mud, and some of our new discoveries have been obtained only from this source. They are also very useful to us as bringing up the most perfect samples of the mud of the bottom, with precisely the same composition that it had when undisturbed, for the bulb is often so nearly closed that none of the mud can wash out, while the contents of the dredge and trawl and of the sounding cup are more or less washed on the way up, and the finer parts may be largely lost.

Another very large and handsome species of Actinian, first discovered in 1880, but one which does not descend to great depths, inhabiting only the warm zone, in 60 to 115 fathoms, is *Urticina perdis* V. (fig. 19). When in full expansion, it is often over a foot across, with its very numerous long, slender, translucent tentacles spread out in every direction. The body is smooth and curiously mottled with shades of lighter and darker brownish, yellow, and pale flesh-color, something like the feathers of a partridge, to which the name alludes. It is one of the few deep-water species that thrives well in confinement. We have kept large individuals in aquaria all summer, without special care. It is very active, constantly changing in form, and very voracious. The temperature of the water in which it naturally lives is similar to that of the harbor at Wood's Holl in summer, while most of the other species, coming from greater depths, live in and require much colder water than can be provided without special means of cooling.

We often keep deep-sea species, of different groups, alive for a few hours or days by keeping them in water cooled down in the ice-box on the steamer, in cases where it is desirable to bring them ashore with their natural colors and appearance for descriptions and figures. But in most cases they never recover from the injury received by being drawn up through the warm upper stratum of Gulf Stream water, which is usually above 70 degrees, and although they sometimes remain alive for a day or two, they seldom show any activity, and usually die within a few hours. The Crustacea are nearly always quite dead when brought on deck, for, excepting the hermit-crabs, they are injured by the rough

treatment and crushing that they receive in the trawl, as well as by the heat of the upper waters. The same is true of the more delicate species in all of the groups. But the Mollusca having strong shells; some of the Echinoderms; and all the large, tough-skinned Actinians seem to be injured or killed by the heat alone. It is probable, therefore, that but few of the more delicate deep-sea animals will ever be seen alive by man, and still fewer in a healthy living condition.

HYDROIDA.

The Hydroids are few in species, and not numerous individually in the deeper dredgings. But at moderate depths, especially near George's and Brown's Banks, a considerable number of northern and mostly well known European species were obtained. Several interesting species also occurred, some of them frequently, in 100 to 300 fathoms, off the southern coast of New England. Some of these are undescribed. The most abundant is a species of *Tubularia* with coarse, yellow stems (*T. indivisa*?). A new species of *Cladocarpus* (*C. flexilis* V., fig. 29), with tall, slender, pinnate, yellowish stalks is also very common. A large and rather coarse hydroid, *Calicella plicatilis*, fig. 30, is also rather common.

ECHINODERMATA.

The Echinoderms were among the most abundant and interesting of the deep-sea animals. About one hundred species were dredged by the "Albatross," many of which are new to our coast, though previously dredged on the European side, or in the Caribbean Sea and still more distant regions. Others are undescribed forms. Among the Holothurians, besides several species of *Trochostoma* and allied forms, there were two gigantic species, belonging to a peculiar deep-sea family of which many species were brought to light by the "Challenger" expedition. These occurred in large numbers at several stations, mostly between 1,000 and 1,500 fathoms, in some cases more than a barrelful of one of them coming up in a single haul. The largest and most singular one was a new species of *Bentho-dytes* (*B. gigantea* V., figs. 31, *a*, *b*), a very large, massive species, flat below and convex above, sometimes 18 inches long and 5 or 6 broad, having a gelatinous, translucent appearance, but with a firm cartilaginous texture when fresh. The cartilage-like walls of the body are very thick, often an inch or more, and the visceral cavity is very small in proportion. Owing to the dense and impervious, cartilage-like tissues, this species is very difficult to preserve in alcohol,* the interior decaying before the fluid can penetrate the tissues, even when the visceral cavity is cut open. This has been dredged in 924 to 2,033 fathoms.

* During the season of 1884 this and other large gelatinous species (Cephalopods, &c.) were preserved in much better condition by the use of ice-cold alcohol, kept in tanks in the ice-room ready for immediate use.

From its peculiar appearance the sailors on the "Albatross" called this species "boxing gloves."

The second was also a new form, *Euphronides cornuta* V. (figs. 32-33a), related to *E. depressa* of the "Challenger" expedition. It has a large, conical, median posterior elevation, double at the summit, and two pairs of large, elevated, teat-like anterior tubercles. To the latter character the name refers. In form it is not unlike *B. gigantea*, but it is smaller, narrower, less massive, and has a much thinner, reddish brown, or purplish brown, spiculate integument, without the cartilaginous character of the latter. To this the sailors gave the name of "overshoes," which it somewhat resembles in form and color. It has been taken in 855 to 1,735 fathoms.

A large, brown, undescribed species of *Synapta* (*S. brychia* V.), with large anchors, was discovered in 938 fathoms. This genus has generally been considered as entirely confined to shallow water.

Of Echini, we obtained two of the curious species having flexible shells (*Phormosoma placenta* and *P. uranus*). The former was taken in many localities and in considerable numbers. *P. uranus* has often occurred in 568 to 1,080 fathoms. Some of the specimens are 8 to 9 inches in diameter, and of a rich purplish color, an unusual color for deep-sea animals. *P. placenta* ranged from 458 to 1,230 fathoms. Other interesting species, not previously dredged by us, and characteristic of the greater depths, were *Pourtalesia Jeffreysii*, in 843 to 1,555 fathoms; *Aërope rostrata*, in 1,395 to 1,608 fathoms; *Aceste bellidifera*, in 1,395 to 1,467 fathoms; *Urechinus Naresianus*, in 1,309 fathoms; *Salenia varispina*, in 547 fathoms.

The *Echinus Norvegicus* was taken in large numbers in 1,043 to 1,255 fathoms, while *Brissopsis lyrifera* and *Schizaster fragilis* were very frequently dredged this season, the former in 938 to 1,555 fathoms, the latter in 100 to 239 fathoms.

The star-fishes were very numerous in the deep dredgings and are represented by many interesting species. One of the most abundant star-fishes was a fine, new, orange-red species of *Zoroaster*, of large size, with slender spinose arms (*Z. Diomedæ* V.). About two hundred specimens of this occurred at station 2035. It was taken at many stations, in 1,000 to 1,600 fathoms. The most common genus, as usual in very deep water, was *Archaster*, of which numerous species occurred. Many of these are very large and handsome forms, and are generally buff, salmon, orange, or orange-red in color. Several are unlike those species from less than 500 fathoms, taken by the "Fish Hawk." A large, new, orange-colored *Archaster*, with a very large madreporic plate (*A. grandis* V.) occurred in great numbers at several stations, in very deep water, often associated with *Zoroaster Diomedæ* and *Benthopecten spinosus*. It has a small or moderate-sized, flat disk, closely covered with fine paxillæ, with long, rather flat, tapering arms, having two rows of small marginal spines on each side. In several instances I have taken from the

stomach of this star-fish specimens of sea-urchins (*Brissopsis lyrifera* and *Aceste bellidifera*) 1 to 2 inches in diameter, but partially crushed.*

A smaller and very distinct new species of this genus (*Archaster septus* V.), from 368 to 858 fathoms, has two regular, divergent rows of marginal spines all around, while the rather swollen marginal plates are covered with small, sharp spinules, and similar spinules cover the lower side. The adambulacral plates project strongly into the grooves and bear very convex groups of slender, tapering spines. The disk is rather small and the tapering arms moderately elongated.

A large and handsome new *Archaster* (*A. robustus* V.), remarkable for its long, high, squarish arms and smoothish appearance, was taken at several localities, in 938 to 1,467 fathoms. Its marginal plates are closely covered with small scale-like spinules, but bear no marginal spines. The disk is small and the arms long. It is sometimes over a foot in diameter. Another new and very elegant species of this genus (*A. formosus* V.) was taken sparingly at several stations, in 1,467 to 1,608 fathoms. This species has a rather broad, flat, pentagonal disk, with large, distinct, hexagonal paxillæ, while the arms rapidly narrow and have only one or two rows of paxillæ distally. Their tips are slender and terminate in a thickened apical plate. There are no marginal spines.

A very interesting new form, taken in many localities, is related to *Archaster* and *Astropecten*, closely resembling some of the spinose species of these genera in general appearance. It represented a new genus (*Benthopecten spinosus* V.). The flat dorsal surface is closely covered with tessellated, angular plates, having single, definite, small pores for solitary branchial papulæ between them, while there are no true paxillæ, the small spinules arising singly, or two or three together, directly from the plates. The marginal plates, above and below, bear single large, sharp spines, the five largest ones occupying the central interbranchial plates, on the upper margin. The disk is of moderate or rather small size, but the arms are long and tapered. It occurred in 855 to 1,917 fathoms, in 1883, but is most abundant in 1,200 to 1,500 fathoms.

Among the most interesting of all the star-fishes were two species of the remarkable genus *Brisinga*. One of these (*B. elegans* V.), taken in many localities in 1883 and 1884, in 906 to 2,021 fathoms, sometimes in large numbers, has often been obtained and preserved nearly entire. It is a handsome species with very long, slender, finely-tapered arms, usually eleven or twelve in number, but varying from nine to thirteen.

* In one case I also found in its stomach a fresh specimen of the common surface barnacle (*Lepas anatifera*), which is often found in large numbers attached to floating timber, &c., in the Gulf Stream. This *Lepas* unquestionably sank to the bottom and was swallowed by the star-fish (living at the depth of 1,395 fathoms) before decomposition had begun. This illustrates well the dependence of the deep-sea life on the surface fauna.

The small disk and the basal, slightly swollen portion of the arms are covered with small sharp spinules, arranged in small clusters or standing singly, but not forming definite transverse groups on the basal part of the arms. The marginal spines are long and very slender, and mostly stand in a single row. The other (*B. costata* V.) is a coarser species, which usually comes up broken into numerous fragments, by spontaneous division. In this species the spinules and pedicellariæ form large and prominent transverse ridges or ribs on the swollen basal part of the arms, as well as on the distal portion. It resembles the *B. coronata* Sars, in general appearance. It was taken during the last two seasons in 991 to 2,021 fathoms.

The curious little pentagonal star-fish, described by Wyville Thomson (Voyage of the "Challenger," p. 378, Figs. 97, 98), as *Porcellanaster cœruleus* (figs. 40, 41), was taken in considerable numbers at many localities, in 1883 and 1884, in 816 to 1,917 fathoms. Its cœrulean color is due only to the bluish mud, with which its large stomach is usually filled, showing through the translucent integument. The real color is buff or pale salmon.

Among the large and showy forms of star-fishes is a new species of *Solaster* (*S. abyssicola* V.), which is bright red or orange in color, and often becomes over a foot in diameter. It has a broad disk and usually eight or nine arms. It has rather small rounded clusters of spinules on moderately elevated paxillæ, both above and beneath. The spinulation is coarser and the paxillæ larger, more elevated, and less crowded than in *S. endeca*, of the shallow waters.

The Ophiurans were abundantly represented by many species, some of which were previously undescribed and others unknown from this region. Several of them are of large size and conspicuous. Among these one of the largest and most abundant was *Ophiomusium Lymani*, of which many hundreds or even thousands were often taken in a single haul in 900 to 1,100 fathoms. It has occurred at many localities in 238 to 2,033 fathoms. Another almost equally large species of the same genus (*O. armigerum* Lym.) also occurred abundantly at several stations in 1,731 to 2,369 fathoms. A handsome species, remarkable for its large and distinct, symmetrically arranged dorsal scales (*Ophioglypha bullata*), has been taken in considerable numbers in 1,608 to 2,574 fathoms. A smaller flattened species (*O. lepida* Lym.) occurred in vast numbers at several stations, both in 1883 and 1884. It seems to be very abundant at about 1,500 fathoms, and is widely diffused in 428 to 2,574 fathoms. Our perfect specimens generally, if not always, have small, slender spinules scattered over the disk, which was not the case with the original types described by Lyman. The spinules are easily rubbed off. A large species of *Ophiochiton* (*O. grandis* V.) was taken in 888 fathoms. This genus had not been taken before in this part of the Atlantic. Numerous species of *Ophiacantha*, which is a very common and characteristic deep-water genus, were taken, among which were several that

were undescribed and others not before known from this region. The species of simple-armed *Astrophytonidæ*, taken by the "Albatross," have been referred to on previous pages [pp. 8, 10]. They are often found clinging to the Pennatulacea and Gorgonians, in large numbers, in company with the various species of *Ophiacantha*.

The very common species, *Antedon dentata*, was the only crinoid obtained, with the exception of fragments and young of *Rhizocrinus* (fig. 57). Of the former we also took a few young specimens, in the attached or stemmed condition (fig. 58).

A fine species of stalked crinoid belonging to the genus, *Benthoocrinus*, was dredged in 1884, in 2,021 fathoms, off Chesapeake Bay.

CRUSTACEA.

The Crustacea were very numerous and included many new forms of great interest. According to the report of Prof. S. I. Smith* there were fifty-seven species of deep-water Decapod Crustacea, besides fifteen shallow-water ones. Of these he has described nineteen as new. At the single haul in 2,949 fathoms six species were taken, while thirteen occurred below 2,000 fathoms, and twenty-nine below 1,000 fathoms.

The twenty-nine species taken below 1,000 fathoms include twenty-one Caridea, or true shrimp, two Eryontidæ, three Galatheidæ, one Paguroid, one Lithodes, and one Brachyuran belonging to the Dorippidæ.

"It is interesting to compare these results with the lists of the fauna of the North Atlantic below 1,000 fathoms, given by the Rev. Dr. Norman in the presidential address to the Tyneside Naturalists' Field Club, published last year. In Dr. Norman's lists only twelve species of Decapoda are recorded, none of them from as great a depth as 2,000 fathoms, and of these twelve species seven were known only from the 'Blake' dredgings of 1880."

In the course of subsequent studies Professor Smith has added a few more species to the list.

The deep-sea crustacea are neither degraded in structure nor small in size. Among them are representatives of all the higher groups, while many of the species are remarkable for their great size. A true crab (*Geryon quinquedens* Smith, fig. 156), common in 105 to 816 fathoms, is one of the largest crabs known, for the massive body is often 5 inches long and 6 broad. It is dark red in color. The great spiny spider-crab (*Lithodes Agassizii* Smith, fig. 151), first described from the "Blake" collection, but also taken in 1882 and 1883 by the Fish Commission, measures over 3 feet across the outspread legs, while the body is 7 inches long and 6 broad, and covered with long, sharp spines. It ranges from 410 to 1,255 fathoms. Several of the shrimp are nearly a foot long, not including the antennæ, which, like the legs, are often remarkable for their great length and slenderness.

* Report of the United States Commissioner of Fish and Fisheries, Part X, for 1882 (published 1884), p. 345, and American Journal of Science, vol. 23, p. 53, July, 1884.

The following, according to Professor Smith, are some of the more interesting forms: "A new genus of Brachyura, allied to *Ethusa*, 1,496 to 1,735 fathoms; an Anomuran belonging to A Milne-Edwards' new genus *Galacantha* [= *Munidopsis* Whiteaves], 1,479 fathoms; two species of *Pentacheles* (fig. 152, a genus of Eryontidæ allied to *Willemæsia*), between 843 and 1,917 fathoms; a stout Palæmonid (*Notostomus*, fig. 160), 6 inches long and intense dark crimson in color, 1,309 to 1,555 fathoms; a gigantic *Pasiphaë* (fig. 158), 8½ inches long, 1,342 fathoms; three species of a remarkable new genus allied to *Pasiphaë*, and also to *Hymenodora*, and some other genera of Palæmonidæ, which shows that *Pasiphaë* is closely allied to the Palæmonidæ; a large Penæid, a foot in length, referred to the little-known genus *Aristeus* (fig. 159); and a large *Sergestes*, 3 inches in length."

"A striking characteristic of the deep-sea crustacea is their red or reddish color. A few species are apparently nearly colorless, but the great majority are some shade of red or orange, and I have seen no evidence of any other bright color. A few species from between 100 and 300 fathoms are conspicuously marked with scarlet or vermilion, but such bright markings were not noticed in any species from below 1,000 fathoms. Below this depth orange-red of varying intensity is apparently the most common color, although in several species, very notably in the *Notostomus* already referred to, the color was an exceedingly intense dark crimson."

I have in former articles repeatedly called attention to the prevalence of salmon, orange, and scarlet colors among the deep-sea animals of various groups, and have insisted that these are protective colors in consequence of the peculiar nature of the light transmitted to them through a vast thickness of sea-water. This view necessarily implies that a certain amount of sunlight is thus transmitted. The existence of well-developed eyes in the deep-sea fishes, cephalapods, crustacea, &c., may well be regarded as positive evidence of the existence of a certain amount of light even at the greatest depths explored. According to Prof. S. I. Smith there were sixteen species of decapod and schizopod crustacea taken by the "Albatross" at depths below 2,000 fathoms, eight of them ranging downward to 2,949 fathoms, and all these species had normal faceted eyes. Nine of them had dark-colored eyes, similar to allied shallow-water species, and not much smaller; four had small black or dark eyes; one had light-colored eyes larger than usual in the shallow-water species of the same genus; and nine had small light-colored eyes.

Professor Smith has also called attention to the remarkably large size and small number of the eggs of many of these deep-sea crustacea, their eggs being often ten, fifteen, and sometimes even more than three hundred times larger than those of allied shallow-water species.

"The large size of the eggs is a marked feature in many of the deep-water Decapoda. The eggs of *Eupagurus politus* from 50 to 500 fathoms, are more than eight times the volume of those of the closely allied and

larger *E. bernhardus* from shallow water, and in *Sabinea princeps*, from 400 to 900 fathoms, they are more than fifteen times as large as in *S. septemcarinata*, from 25 to 150 fathoms. The most remarkable cases are among the deep-water genera. *Galacantha rostrata* and *G. Bairdii*, from between 1,000 and 1,500 fathoms, have eggs 3^{mm} in diameter in alcoholic specimens, while in the vastly larger lobster they are less than 2^{mm}. The largest crustacean eggs known to me are those of *Parapasiphaë sulcatifrons* (fig. 162), a slender shrimp less than 3 inches long, taken between 1,000 and 3,000 fathoms. Alcoholic specimens of these eggs are fully 4 by 5^{mm} in shorter and longer diameter, fully ten times the volume of the eggs of *Pasiphaë tarda* from 100 to 200 fathoms, more than three hundred and fifty times the volume of those of a much larger shallow-water *Palæmon*, and each one more than a hundredth of the volume of the largest individual of the species. From the peculiar environment of deep-water species it seems probable that many of them pass through an abbreviated metamorphosis within the egg, like many fresh-water and terrestrial species, and these large eggs are apparently adapted to producing young of large size, in an advanced stage of development, and specially fitted to live under conditions similar to those environing the adults."

"Among the Schizopoda there are two large species of *Gnathophausia*, one over 4 inches in length, and a *Lophogaster*, all from below 2,000 fathoms. One of the most interesting Schizopods is a small *Thysanoessa* (a genus of Euphausidæ) from 398 to 1,067 fathoms, of which one female was found carrying eggs. The eggs are carried in an elongated and flattened mass beneath the cephalothorax, are apparently held together by some glutinous secretion, and are attached principally to the third pair of peræopods (antepenultimate cephalothoracic appendages)."

One of the Schizopoda of frequent occurrence is *Thysanopoda Norvegica*, taken at the surface, and also apparently from 150 to 239 fathoms, in the trawl-wings.

"The Amphipoda from deep water are comparatively few in number, and have not yet been carefully examined, but among them is one specimen of the gigantic *Eurythenes gryllus* Boeck (*Lysianassa Magellanica* Milne-Edwards), probably the largest of all known Amphipoda. This specimen, which is over 4½ inches long, and very stout in proportion, was taken in 1,917 fathoms, north latitude 37° 56' 20", west longitude 70° 57' 30". The few previously known specimens came from Cape Horn, Greenland, and Finmark, and have apparently all been taken from the stomachs of fishes. This species and its occurrence in the extreme Arctic and Antarctic seas, has been much discussed, and is the subject of a long memoir by Lilljeborg, but the apparently anomalous distribution is explained by its discovery in deep water off our middle Atlantic coast."

Other Amphipods are *Themisto bispinosa*, apparently from 373 to 1,348 fathoms, in trawl-wings; and *Epimeria loricata*, in 168 to 239 fathoms.

The Cumacea and Isopoda are each represented by several species,

but these groups have not yet been fully examined. Among the Isopods, one of the largest and most common is *Syscenus infelix* Harger (fig. 164), which is orange in color. Another singular species is *Astacilla granulata* Harger (fig. 165).

The Copepoda and Ostracoda are very abundant, both in the lots obtained in the trawl-wings and in the surface collections. Very many fine species were noticed, but they have not yet been reported upon by Mr. Rathbun, who has charge of these groups. He has studied a number of interesting and novel forms of Lerneans found parasitic on several of the deep-sea fishes. A representative of this group (*Antheaoheres Dubenii* Sars, figs. 166, 167), which lives in the stomach of the large sea-anemone (*Bolocera Tuediæ*) has been referred to on a previous page [p. 12].

The Cirripeds were represented in deep water by several species of *Scalpellum* and allied genera, most of them of small size; one of these (*S. Strömii*) occurs frequently on the deep-sea gorgonian corals. Two or three species of this group live upon the large crab, *Geryon quinquedens*, some of them on the exterior and some in the gill-cavity. A large species of *Scalpellum*, allied to *S. regius* W. Thomson, was taken several times in deep water on Brown's Bank, off Nova Scotia; and large clusters of *Balanus Hameri* were dredged on the shallower parts of that bank.

PYCNOGONIDA.

The Pycnogonida were well represented by two or three very large species of *Colossendeis* and other genera, in 900 to 1,500 fathoms. Some of the largest of these (*C. colossea* Wilson, fig. 169) measured nearly 2 feet across the outstretched legs. Nine of them were taken at one haul in 1,106 fathoms. It is orange-colored in life.

ANNELIDA.

The Annelida are well represented at all depths, but yet they appear to be relatively much less numerous below 500 fathoms than in shallower water. In 100 to 300 fathoms they are usually abundant. The most conspicuous species, as well as one of the most abundant, is *Hyalinæcia artifex* V. (figs. 177-179a), which inhabits and drags about a large, quill-like, free tube, often 8 to 10 inches long, open at both ends, and so translucent as to show the large iridescent annelid within it. This is frequently taken in very large numbers, several thousands coming up in a single haul, in 150 to 640 fathoms. Two species of Actinians (*Sagartia abyssicola* and the young of *Actinauge nodosa*) are very often attached to these tubes, and also various hydroids and sponges.

There are also two or three large species of *Leodice* (*L. polybranchia* V., fig. 180, *L. vivida*, &c.), which inhabit irregular, rough, parchment-like tubes, very common in 100 to 300 fathoms. *Nothria conchyphila*

V., which constructs flat, free tubes, about 2 inches long, out of broken bivalves, often occurs in vast numbers in the warm zone.

A large and conspicuous, smooth, orange-red scaly annelid (*Polynoë aurantiaca* V., fig. 173), lives as a commensal among the tentacles of *Bolocera Tuediæ*; and another species of this group (*P. Acanella* V., fig. 172, a-c), is very abundant among the branches of *Acanella Normani*. It has a dark purple proboscis and finely spinulose scales. Numerous small species of many genera have been taken at great depths.

Several other interesting deep-sea annelids are illustrated on the plates (figs. 172-190).

GEPHYREA.

Several large and remarkable species of Gephyrea have been taken in deep water, but they are not yet determined. Among them there is a large strongly sulcated species (fig. 192), taken in 707 to 1,060 fathoms, which is often 3 to 5 inches long and nearly an inch in diameter, in alcohol. Another equally large species, from 858 to 1,168 fathoms, is covered with large warts or verrucæ. Both of these appear to be species of *Phascolosoma*. There is a large *Priapulus* (fig. 191, a) from 1,000 fathoms, and a small one from 1,060 fathoms. A large *Thalassema* occurred in 1,600 fathoms.

NEMERTEANS.

The nemertean worms are not common in deep water, and but few species have been taken in our deep-water dredgings. The largest and most interesting one is a bright orange species, which grows to the length of 10 feet or more, and is about a third of an inch in diameter. It occurred in 192 fathoms, and is identical with *Macronemertes gigantea* Verrill, originally from the Gulf of Maine. *Cerebratulus luridus* V. (fig. 195) occurred in 64 to 192 fathoms.

MOLLUSCA.

The Mollusca were very numerous and proved to be of even greater interest than those previously taken by the "Fish Hawk." The number of species of Mollusca added to the fauna of this region by the "Albatross" in 1883 was more than 150, of which over 80 were undescribed.*

Four new forms of Cephalopods were taken, including two new genera. One of these, from 2,949 fathoms, is an Octopod (*Eledonella pygmaea* V.), allied to *Eledone*, but peculiar in having the suckers singularly enlarged and altered in form on the hectocotylyzed arm (fig. 64). Another, from 1,731 fathoms, is a small squid (*Leptoteuthis diaphana* V., fig. 62), remarkable for its slenderness and transparency and for its

* Most of these new species are described by the writer in the Transactions of the Connecticut Academy, vol. vi, 1884, with figures.

very elongated head. The others are species of *Octopus*, from 142 and 1,290 fathoms.

Of Gastropods many new forms occurred. One of the most remarkable is a large shell, from 1,395 to 2,594 fathoms, the living ones only from below 2,000 fathoms, constituting a new genus (*Benthodolium abyssorum* V., fig. 84, *a*, *b*), allied to *Dolium*, but having an operculum, and in form somewhat resembling *Buccinum*. Its animal and dentition are, however, like *Dolium*. There was also a thin and delicate *Buccinum* (*B. abyssorum* V., fig. 80) of good size, the live ones ranging from 906 to 1,309 fathoms. Several interesting new forms of *Sipho* occurred. These are mostly small species, but some of them are of good size, as *S. profundicola* V. (fig. 81), living in 1,525 to 2,574 fathoms.

The curious and very beautifully sculptured shells belonging to the genus *Seguenzia* were among the most interesting forms. Two species were taken living. One of these is *S. formosa* Jeffreys (fig. 88), the other is a closely related new species, *S. eritima* V. (fig. 89). They both occurred several times in 1,290 to 2,033 fathoms. The possession of these species, with the animal preserved in alcohol, enabled me to study the dentition, and thus ascertain the zoological affinities of the genus. It proves to belong to the Tænioglossa, somewhere near *Aporrhais* and *Fossarus*, but evidently represents a new family (*Seguenziæ* V.). It has no relationship whatever with Trochidæ, where it had been put by Boog-Watson and by Dall, nor with *Solaridæ*, where it was located by Jeffreys and others. The resemblance to these widely diverse groups is confined entirely to the shell, which is, however, very peculiar.

The Toxoglossa, as usual in deep water, were relatively very numerous, and included several handsomely sculptured new species belonging to *Pleurotomella* and allied genera. The largest of these is *P. Bairdii* (fig. 68), which is the largest member of this group known off our coast. It occurred living in 1,537 to 2,021 fathoms. Another remarkable and elegant species is *P. Catherinæ* (fig. 76, *a*), from 843 to 2,033 fathoms. *P. Benedicti* (fig. 70, *a*), from 1,290 fathoms; *P. Emertoni* (fig. 74), from 1,917 fathoms; and *P. Bruneri* (fig. 75), from 1,608 to 2,033 fathoms, are also handsome shells, with the elegant and delicate sculpture and translucency characteristic of many deep-sea shells.

The Chitons or Polyplacophora are very scarce in deep water, perhaps owing to the small number of suitable objects to which they can adhere, for even the small limpets are generally found in worm-tubes, empty skate's eggs, or other similar places. Only five species of Chiton have been taken below 60 fathoms by us, and most of these also live in shallow water and do not go very deep. One was a very interesting new species (*Euplacophora Atlantica* V., figs. 102, 102*a*) belonging to a group not known before from the Atlantic. It is remarkable for the very broad anterior girdle.

The Rhiphidoglossa are well represented in deep water by several handsome species belonging to the Trochidæ, such as *Calliostoma Bairdii*

V. & S. (fig. 96), *Margarita regalis* V. & S. (fig. 97), *M. lamellosa* V. & S. (fig. 98), and by several small species of *Cyclostrema*. A more peculiar group includes curious small limpet-shaped shells, not distantly allied to *Fissurella*, but imperforate at tip. Of these we now know 10 species from our deep dredgings. These belong to the genera *Addisonia*, 1 species; *Cocculina*, 6 species; *Lepetella*, 1 species; *Propitidium*, 2 species.

The Tectibranchs are relatively abundant in deep water, one of the shell-less species, *Koonsia obesa* V. (fig. 107), grows to a very large size, some examples being 4 to 5 inches long and 3 broad. A large and handsome new *Scaphander* (*S. nobilis* V., fig. 106) was taken alive in 1,058 to 1,309 fathoms.

The Scaphopods are much more numerous in deep than in shallow water, and are abundantly represented by several species of *Dentalium*, *Siphodentalium*, and *Oadulus* (fig. 126). *D. solidum*, from 843 to 1,309 fathoms, grows to the length of 3½ inches. *Oadulus grandis* V. and another allied new species (*O. princeps* V.) are remarkably large representatives of this genus. The former lives in 816 to 1,537 fathoms, the latter in 1,525 to 1,594 fathoms.

Of Heteropoda, eight species were taken, including at least six species of *Atlanta* (figs. 110, 111). Part of these were only dredged as dead shells, but others were taken alive at the surface. Two transparent species of *Firola* (fig. 112) and *Firoloides* were common at the surface, associated with *Sagitta*, which it somewhat resembles in shape. All these species, except one, and most of the twenty-three Pteropods have long been known from the more tropical parts of the Atlantic, but not from so far north.

The bivalves or Lamellibranchs are relatively less abundant than in shallow water, and are less peculiar; but they include numerous species of the Anatinidæ and Corbulidæ (especially the genus *Næra*), the Nuculidæ, including the genera *Nucula*, *Leda*, *Yoldia*, *Glomus*, *Malletia*, &c.; and the Arcidæ, including *Arca* and *Limopsis*. The Lucinidæ are also well represented by several species of *Cryptodon* (or *Axinus*) and other genera. Among the most peculiar forms are *Pholadomya arata* (figs. 133, 134), *Mytilimeria flexuosa* (fig. 132), *Verticordia cœlata* (fig. 131, a), and *Poromya sublevis* (fig. 128). Several species of *Pecten* and *Amussium* also occur, most of them with delicate, translucent, and elegantly sculptured shells (figs. 141, 142).

Of the Brachiopoda we took two deep-sea species, both new to our coast, but known on the European side. These are *Waldheimia cranium*, in 1,362 fathoms, and *Discina Atlantica*, in 1,251 to 1,467 fathoms.*

The accompanying tables will give an idea of the number and bathymetrical distribution of the different groups of Mollusca.

The writer's published list† of the Mollusca taken in 1880 to 1883 by

*An additional species was obtained in 1884: *Atrella gnomon*, in 1,525 to 1,594 fathoms.

†Transactions Connecticut Academy, vol. vi, p. 263, 1884.

the "Fish Hawk" and "Albatross," off our northern coast, exclusive of those dredged only in shallow water, included 380 species and 21 named varieties. But of these, at least 42 are pelagic species, taken either alive at the surface or dead at the bottom, viz: Cephalopoda, 2; Tænioglossa, 1; Ptenoglossa, 1; Nudibranchiata, 4 (2 live also in shallow water); Heteropoda, 8; Pteropoda, 24; Lamellibranchiata, 3 (2 live also in shallow water). Possibly a few other species, now considered as deep-water forms, may be pelagic, for it is difficult to tell at what depths free-swimming species of Cephalopods are taken, unless they occur in the stomachs of the deep-sea fishes. Many small Gastropods, &c., living habitually on floating *Fucus* and *Sargassum*, are caught with these sea-weeds in the trawl, on its way up or down, and mingling with the shells from the bottom may give rise to errors of this kind. Thus some of the species of *Rissoa*, *Cingula*, *Cithna*, &c., may not really live at the depths recorded, but at the surface. There were also a considerable number of minute, undetermined species not included in the list. During the season of 1884 about 40 species, of which about 25 were undescribed, were added to this list. These are largely from the deepest dredgings.

Of the 343 species* and 20 named varieties in my published list of 1883, regarded as living at the bottom, 89 are also shallow-water forms, living habitually in less than 60 fathoms, in this region. A considerable number, considered as deep-water species on this part of the coast, occur in shallow water north of Cape Cod, and some of them may eventually be found to occur in the cold belt off Martha's Vineyard in 25 to 60 fathoms. Of the shallow-water species, 63 occur also between 200 and 500 fathoms, and 18 below 1,000 fathoms. Some of these have a remarkable great range geographically, as well as in depth. Of the 273 species and varieties regarded as belonging to the deep-water fauna in this region, 143 have occurred in the comparatively warm zone, between 60 and 200 fathoms. A considerable number of these have been taken only in the more southern dredgings, off Chesapeake Bay and Cape Hatteras, and some of them only in depths not much exceeding 100 fathoms, where the Gulf Stream has the greatest effect. In this zone occur species belonging to southern genera, such as *Dolium Bairdii* (fig. 83), *Marginella borealis* (fig. 79), *Solarium boreale* (figs. 95, 95a), *Avicula hirundo*, &c.

The number that occupy the zone between 200 and 500 fathoms is 123, while 118 inhabit the depths between 500 and 1,000 fathoms, and 96 have been taken between 1,000 and 2,000 fathoms. Although but five of our dredgings have been in more than 2,000 fathoms,† we are able to

* More recent studies of the 1883 shells have added several species to the list, mostly from the deeper localities. They are included in the accompanying list.

† During the season of 1884 other series of dredgings were made in the same region in depths below 2,000 fathoms. From these a large number of additional species of Mollusca and other groups were obtained.

enumerate 34 species from between 2,000 and 3,000 fathoms, which is a much greater number than had previously been recorded from such depths in the North Atlantic.

The species and varieties already described as new from the 1883 collections are 76, as follows: Cephalopoda, 4; Gastropoda, 58; Solenoncha, 4; Lamellibranchiata, 10. The total number of species of Mollusca added to the fauna of this region by the Fish Commission dredgings since 1880 is over 275.

The different groups of Mollusca differ greatly in the relative proportion of deep and shallow water species, as shown by the following tables. Thus the deep-water Cephalopods are 23, against 4 shallow-water and surface species. The Gastropods exclusively deep water are 166, against 38 of shallow-water origin. The shallow-water Lamellibranchs, however, seem to have a much greater tendency to range into deep water, for of these there are but 68 deep-water species and varieties, associated with 46 shallow-water ones.

TUNICATA.

On the upper part of the Gulf Stream slope, at the depths of about 65 to 125 fathoms, in localities where the bottom is of compact sand and gravel, it is often well covered with various sponges, hydroids (*Tubularia*, *Cladocarpus*, &c.), and large, rough groups of a coarsely wrinkled ascidian, which appears to be identical with *Cynthia partita* Stimpson. This species occurs abundantly in shallow water on stones, piles, &c., from North Carolina to Vineyard Sound, often forming, in such situations, large, irregular clusters. A few other species, not yet studied, also occur, though less commonly, on the hard bottoms in 100 to 125 fathoms. At the northern stations, off Nova Scotia, where the bottom is often stony, many of the well-known northern forms occur, such as *Boltenia Bolteni*, *Ascidia complanata*, *Cynthia pyriformis*, &c. In the deeper waters, where the bottom is usually of soft mud and sand, or ooze, ascidians are not very common, though several undetermined species of *Molgula* and allied forms have been taken. One species of *Molgula*, which was taken in 1,608 fathoms, is about an inch in diameter, soft, flattened, and covered with a thick coat of foraminifera.

The most interesting ascidian taken by us is a new species of the curious, long-stemmed genus, *Culeolus*, first discovered by the "Challenger." It is peculiar to deep water, and a species very closely allied to our own was dredged by the "Challenger" off the coast of Japan. I have named our species *Culeolus Tanneri* (figs. 144, 145, a. b.),* in honor of our accomplished commander.

* *Culeolus Tanneri* Verrill, sp. nov. Stem long, slender, somewhat decreasing in size from the base to the summit. Body irregularly pear-shaped, the lower end tapering to a conical form, where it joins the stem, while the stem itself can be seen extending upward about 15 to 20^{mm} along the dorsal margin, where it forms, for that distance, a rounded midrib terminating in a prominence in one specimen and at a de-

Several fine species of *Salpa*, some of them of great size, often occurred in abundance in our trawl, but they belong to the surface fauna, and will be mentioned more particularly under that head.

BRYOZOA.

The Bryozoa collected have not yet been carefully studied. They are usually not abundant in deep water, owing mainly to the absence of favorable objects for attachment. Whenever we have met with bowlders or hard concretions in deep water we have generally found a number of species of Bryozoa adhering to them. On the hard, spongy bottoms, in 65 to 125 fathoms, several species commonly occur, mixed with the hydroids and sponges, or adhering to ascidians, shells, pebbles, &c. One of the most interesting of these is a slender species of *Salicornaria*.

On the stony bottoms off Nova Scotia, in about 100 fathoms, large numbers of well-known northern species were taken. On stones and hard concretions, taken at station 1124, in 640 fathoms, there are several species, among which are *Ocellularia scabra*, *Discopora ovalis*, and a *Tubulipora*. The two latter also occurred on stones from 234 fathoms, with *Membranipora Flemingii* and other species. The curiously branched form, *Kinetoskias* (or *Bugulopsis*) *flexilis* V., occurred in 194 fathoms.

SPONGES.

The sponges obtained in this region have not yet been studied. Those from deep water are not very numerous, but some of them are of great interest. One large handsome, vase-like, vitreous sponge, resembling *Holtentia*, was taken at station 2067, in 122 fathoms, off Nova Scotia. A thin, felt-like species, belonging to the same group, occurred in 640 to 780 fathoms. A large, coarse-fibered, felt-like *Phakellia*, growing in semicircular or funnel-shaped fronds, was taken in 640 fathoms, together

pression in another. The dorsal margin is nearly straight, but swells out a little in the middle, and is subcarinate, with a row of small scattered papillæ along the ridge. The distal end is large, rounded, swollen, and bordered on each side by a distinct keel, which is covered with several crowded rows of prominent, rough, though soft papillæ, which merge into a large, triangular patch of similar but larger papillæ, situated on the dorsal side near the distal end, where the dorsal carina meets the lateral ones; the papillæ in this cluster are large, stout, tapering to a point, and covered on all sides with minute, conical spinules. The lateral rows of papillæ extend back to about the middle of the body on the ventral side, where they meet, thus inclosing a large ovate area, near the middle of which the large cloacal-opening is situated. This opening is bilabiate, each lip bordered with one or two rows of elongated, rough papillæ, like those of the lateral carinæ. The oral opening is very large, in expansion nearly round, the proximal side sometimes bending inward, leaving a sinus on either side of it; the margin is thickened and revolute, bordered by a row of small tapering papillæ. The whole surface of the test is covered by minute, granule-like or conical elevations, which are rather close over the dorsal parts, less numerous beneath. Color dull yellowish gray, the stem dark brown.

Length of the stem of one specimen, 155^{mm}; its diameter near the base, 2^{mm}; length of body, 70^{mm}; greatest diameter, 400^{mm}; diameter of mouth, 8^{mm}. Station 2041, in 1,608 fathoms, 1883.

with a slender pinnate species of *Cladorhiza* (*C. abyssicola* Sars ♀). The large, stout, clavate, species (*C. grandis* V., fig. 1), occurred occasionally. It is not uncommon in 100 to 200 fathoms off Nova Scotia. The curious slender-stemmed *Stylocordyla longissima* G. O. Sars, was dredged on muddy bottoms several times in 407 to 1,423 fathoms. *Dorvillia echinata* Verrill, which forms large, harsh, spiculate balls, attached to the mud by long root-spicules, occurred in one instance.

On the hard bottoms in 65 to 125 fathoms several irregularly lobed and branched species, belonging to *Chalina*, *Isodictya*, *Halichondria*, &c., occurred in great abundance. With these there were large numbers of hard, rigid, sparingly branched and rather strong stems of an unknown sponge, composed of long closely-united siliceous spicules.

FAUNA OF THE NORTHERN WATERS.

One trip, stations 2053 to 2084, was made to the northern waters, during which a number of hauls were made, both in shallow and deep water, on and near Brown's Bank, off Cape Sable, Nova Scotia, and off the southern slope of George's Bank, August 29 to September 5. On the southern border of Brown's Bank a rough, hard bottom, covered with stones and large barnacles, was found in 108 to 113 fathoms (stations 2069 to 2071), on which the great bush-coral (*Primnoa lepadifera*) appeared to be abundant, and several good specimens of it were obtained by the use of tangles and grapples, but the bottom was too rough for the trawl. Various other well-known northern and Arctic species, most of them already discovered in the same region by our former explorations, were obtained from the cold-water localities, many of which were in moderate depths. Great clusters of the large barnacle (*Balanus Hameri*) were dredged in abundance in 80 to 120 fathoms on Brown's Bank. It was usually associated on these rough, stony bottoms with *Balanus porcatus*. Among the more prominent of the northern Echinoderms taken in these northern waters were *Solaster endeca*, *Crossaster papposus*, *Lophaster furcifer* (fig. 49, a), *Ophiacantha spectabilis*, and several new species of *Ophiacantha* enumerated in the general list.

One interesting Arctic shell was added to the American fauna on this occasion. This is a limpet-like species (*Piliscus commodus* Midd.) previously known from the extreme northern coasts of Europe and Asia, from Iceland, and from Alaska. It was dredged in the same region as the *Primnoa*, in 150 fathoms, and lives clinging closely to the rocks. Doubtless other additions to our northern fauna will be found among these northern dredgings when they shall have been carefully studied.

On the hard bottoms, covered with barnacles, &c., in about 100 fathoms, off Nova Scotia, several northern species of sponges were obtained, mostly of *Halichondria*, *Chalina*, and allied genera. Among these were *Chalina oculata*, *Polymastia robusta*, &c.

The fauna in the deep-water localities dredged on the same trip (stations 2072 to 2078, 2083, 2084) did not differ essentially from that found at corresponding depths off Martha's Vineyard.