General sketch of the expedition of the "Albatross," from February to May, 1891. Vol. XXIII, No. 1 February, 1892

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Bulletin of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. XXIII. No. 1.

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II.

GENERAL SKETCH OF THE EXPEDITION OF THE "ALBATROSS," FROM FEBRUARY TO MAY, 1891.

BY ALEXANDER AGASSIZ.

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WITH TWENTY-TWO PLATES.

CAMBRIDGE, U. S. A.:
PRINTED FOR THE MUSEUM.
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No. 1. — *Reports on the Dredging Operations off the West Coast of Central America to the Galapagos, to the West Coast of Mexico, and in the Gulf of California, in Charge of* ALEXANDER AGASSIZ, *carried on by the U. S. Fish Commission Steamer "Albatross,"* LIEUT. COMMANDER Z. L. TANNER, U. S. N., *Commanding.*

II.*

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ROUTE OF THE EXPEDITION.

WE left Panama on the 22d of February, and returned there after an absence of twenty days. During our first trip, the route extended from Panama to Point Mala, and next to Cocos Island ; from there we ran in a southerly direction, then northwesterly to Malpelo Island, and back to the hundred fathom line off the Bay of Panama, where we spent several days trawling off the continental plateau of the Bay.

After coaling, we left Panama, and reached Galera Point, where we began our second line, across the Humbolt Current to the southern face of the Galapagos. We spent a few days at the Galapagos visiting Chatham, Charles, Duncan, and James Islands, and then steamed for Acapulco, making casts of the trawl, and of the surface and the submarine townets, at various points.

After a few days' delay at Acapulco to coal the ship, we left that port on the 15th of April for our third cruise, into the Gulf of California, and steamed as far as Cape Corrientes without attempting to do any trawling. The character of the bottom, as indicated on the charts, promised nothing different from what we had dredged off Acapulco, and on the line from there to the Galapagos Islands. We made one haul off Cape

* I. Calamocrinus Diomedæ, a new Stalked Crinoid. Memoirs Mus. Comp. Zoöl., Vol. XVII. No. 2, 1892. 96 pp. With 32 plates.

Corrientes, bringing up nothing but mud and decomposed vegetable matter. This induced us to keep up the Gulf of California, till we were off the Tres Marias. From that point until we reached Guaymas, on the 23d of April, we carried on our usual operations with the trawl, the tow-net, and the Tanner net.

In the afternoon of the same day I parted from the ship with great regret, but more than satisfied with the results of this expedition.

The more I saw of the "Albatross," the more I became convinced that her true field is that of exploration. She is a remarkably fine sea boat, and has ample accommodation for a staff of working specialists such as would be needed on a distant expedition. The time will soon come when the Fish Commission will hardly care to continue to run her, and I can conceive of no better use for so fine a vessel than to explore a belt of 20° of latitude north and south of the equator in the Pacific, from the west coast of Central America to the East Indian Archipelago.

The success of the "Albatross" thus far has depended entirely upon the zeal, energy, intelligence, forethought, and devotion of Captain Tanner, if I may judge of the past by the present. He never spares himself, and he is always ready to make the most of the time at his disposal for the benefit of the special object he has in charge. He looks after every haul of the trawl himself, and will not allow any one else to jeopard in any way the material of the vessel, or the time it requires to make a haul. That responsibility he assumes himself, and it constitutes his daily work. In looking over the records of the "Albatross" during her voyage from New York to San Francisco, I am struck with the amount of work which has been accomplished. It would be but a just return to Captain Tanner, if Congress would make the necessary appropriations to work up and publish, not only all that he has brought together on that cruise, but also what has been left untouched thus far of the immense collections made from the time he first commanded the "Albatross." In his cruises off the east coast of the United States and in the Caribbean, to say nothing of his explorations in the Gulf of California, on the coast of California, on the coast of Alaska, and in the Bering Sea, he has accumulated in the "Albatross" endless most interesting material, which no other ship could have got together unless she had another Tanner in command.

My cordial thanks are due to Colonel Marshall McDonald, the United States Fish Commissioner, for having given me the opportunity to join the "Albatross" on this extended cruise, and for his kindness in urging the President to allow the vessel to be detailed for this work. To Mr.

Richard Rathbun, of the United States Fish Commission, I must also express my thanks for the care, interest, and patience with which he attended to the endless details connected with the fitting out of the "Albatross" for her voyage. Since the arrival of the collections at Washington, he has taken full charge of their care and distribution to the specialists who will write reports on the results of the expedition.

I can hardly express my satisfaction at having had the opportunity to carry on this deep-sea work on the "Albatross." While of course I knew in a general way the great facilities the ship afforded, I did not fully realize the capacity of the equipment until I came to make use of it myself. I could not but contrast the luxurious and thoroughly convenient appointments of the laboratory of the "Albatross" for work by day and by night with my previous experiences. The constant assistance of Messrs. C. H. Townsend and N. B. Miller in the care of the specimens was most welcome, giving me ample time to examine the specimens during the process of assorting them, and to make such notes as I could between successive hauls, while paying some attention also to the work of the artist, Mr. Magnus Westergren. He found his time fully occupied, and we have in this trip brought together a considerable number of colored drawings, giving an excellent general idea of the appearance of the inhabitants of the deep waters as they first come up. These drawings can be used to great advantage with the specimens in making the final illustrations intended to accompany the reports of the specialists who have kindly undertaken the task of working up the different groups.

Stations occupied by the "Albatross," February to May, 1891.

During this cruise of the "Albatross," we occupied in all eighty-four Stations where the trawl, tangles, and tow-nets were used, and in addition five Stations at which the surface and submarine tow-nets alone were in use. Forty-four Stations, Nos. 3353 to 3397, with three tow-net Stations, were occupied on our first trip. Stations Nos. 3398 to 3423, as well as three others, were occupied during our second trip, from Panama to Acapulco via the Galapagos, and in the Gulf of California we occupied Stations Nos. 3424 to 3437, and three tow-net Stations.

The following record gives the work done at each Station: —

RECORD OF SUBMARINE TOW-NET STATIONS OF THE UNITED STATES FISH COMMISSION STEAMER "ALBATROSS."*

March and April, 1891.

Serial Number.	DATE.	TIME.	POSITION.		TEMPERATURES.		Depth in Fathoms.	Character of Bottom.	Depth at which towed, in Fathoms.	Time in Minutes.	REMARKS.
			Latitude North.	Longitude West.	Surface.	Bottom.					
	1891.	h. m.	° ′ ″	° ′ ″	°	°					
3282 Dr.	March 7	8 50 A.M.	6 21 0	80 41 0	75	35.8	1793	gn. M.	200	15	
"	" 7	9 53 A.M.	6 21 0	80 41 0	75	35.8	1793	gn. M.	200		Hauled up straight from 200 fathoms in 10 minutes; from 100 fathoms, in about 5 minutes. About 60 miles from the 100 fathom line.
"	" 7	10 23 A.M.	6 21 0	80 41 0	75	35.8	1793	gn. M.	100		
3388 Dr.	" 9	10 31 A.M.	7 6 0	79 48 0	73	36.2	1168	gn. glob. Oz.	400	17	Young Eryoneicus in upper part of net. 15 miles from 100 f. line, and 25 miles from nearest land.
2619 Hyd.	" 11	8 25 A.M.	7 31 0	78 42 30	68	36.5	1100	gn. glob. Oz.	300	19	
"	" 11	9 44 A.M.	7 31 0	78 42 30	68	36.5	1100	gn. glob. Oz.	1000 / 1482 †	16	Drifted into 1482 f. Atolla in upper part of net.
2627 Hyd.	" 25	6 49 A.M.	0 36 0	82 45 0	81	36.0	1832	gy. glob. Oz.	1770 / 1739 †	20	
2628 Hyd.	" 26	9 14 A.M.	*South.* 0 13 0	84 52 0	81	—	—	——	204	20	Towed awhile from 200 f. to surface, to fill upper part of net. About 250 m. from the Galapagos.
3414 Dr.	April 8	6 57 A.M.	*North.* 10 14 0	96 28 0	82	35.8	2232	gn. M.	100	20	350 miles from land.
"	" 8	7 47 A.M.	10 14 0	96 28 0	82	35 8	2232	gn. M.	200	10	
"	" 8	8 49 A.M.	10 14 0	96 28 0	82	35.8	2232	gn. M.	300	20	
"	" 8	10 30 A.M.	10 14 0	96 28 0	82	35.8	2232	gn. M.	300	15	
——	" 9	10 4 A.M.	12 34 0	97 21 0	82	—	—	——	175	8	About 300 miles S. E. of Acapulco. Depth.‡
——	" 9	8 3 P.M.	13 33 30	97 57 30	83	—	—	——	175	10	About 250 miles S. E. of Acapulco. Depth.‡
——	" 11	8 45 A.M.	16 32 0	99 42 0	80	—	—	——	300	20	About 30 miles S. E. of Acapulco. Depth.§
——	" 16	10 10 A.M.	17 39 30	102 11 30	76	—	—	——	175	15	About 120 m. N. W. of Acapulco. Depth over 2,000 f.
3436 Dr.	" 22	1 22 P.M.	27 3 40	110 53 40	72	37.2	905	bn. M. bk. Sp.	800	15	Surface about 75 miles S. W. of Guaymas, half-way across Gulf of California. New Bougainvillia, Periphylla.
2637 Hyd.	" 22	7 21 P.M.	27 20 0	110 54 0	71	38.0	773	bn. M. bk. Sp.	700	15	About 50 miles S. W. of Guaymas. Nettastoma.
3437 Dr.	" 23	5 31 A.M.	27 39 40	111 0 30	70	40.0	628	bn. M. bk. Sp.	600	15	Shoaled water and dragged on bottom.
2638 Hyd.	" 23	7 26 A.M.	27 38 0	111 4 0	72	39.2	622	bn. M. bk. Sp.	500 / 570 †	15	

* Tanner tow-net at all Stations except Station 3282, March 7.
† Depth varying between these points.
‡ Between two Stations, over 2,000 fathoms.
§ Between two Stations, about 500 fathoms.

RECORD OF DREDGING AND TRAWLING STATIONS OF THE UNITED STATES FISH COMMISSION STEAMER "ALBATROSS."

Serial Number.	DATE.		TIME.	POSITION.		TEMPERATURES.		Depth in Fathoms.	Character of Bottom.	REMARKS.
				Latitude North.	Longitude West.	Surface.	Bottom.			
	1891.		h. m.	° ′ ″	° ′ ″	°	°			
	Feb.	22	8 0 P.M.	—	—	—	—	—	—	
3353	Feb.	23	8 56 A.M.	7 6 15	80 34 0	73	39.0	695	gn. M.	Surface tow-net.
3354	"	23	1 25 P.M.	7 9 45	80 50 0	78	46.0	322	gn. M.	
3355	"	23	3 1 P.M.	7 12 20	80 55 0	81	54.1	182	bk. G. Sh.	
3356	"	23	7 30 P.M.	7 9 30	81 8 30	83	40.1	546	sft. bl. M.	Surface tow-net. 15 miles from Mariato Point.
3357	"	24	6 17 A.M.	6 35 0	81 44 0	83	38.5	782	Modern Greensand.	Surface tow-net.
3358	"	24	11 38 A.M.	6 30 0	81 44 0	83	40.2	555	Mode n Greensand.	
3359	"	24	2 4 P.M.	6 22 20	81 52 0	83	42.0	465	Rky.	
3360	"	24	5 20 P.M.	6 17 0	82 5 0	83	36.4	1672	fne. bk. dk. gn. S.	Surface tow-net.
3361	"	25	7 33 A.M.	6 10 0	83 6 0	82	36.6	1471	gn. Oz.	
3362	"	26	7 20 A.M.	5 56 0	85 10 30	84	36.8	1175	gn. M. S. rky.	Intermediate net of Chun and Peterson.
3363	"	26	4 37 P.M.	5 43 0	85 50 0	83	37.5	978	wh. glob. Oz.	Surface tow-net.
3364	"	27	6 58 A.M.	5 30 0	86 8 30	81	38.0	902	yl. glob. Oz.	
3365	"	27	1 30 P.M.	5 31 0	86 31 0	85	37.0	1010	yl. glob. Oz.	Surface tow-net.
3366	"	27	8 4 P.M.	5 30 0	86 45 0	84	37.0	1067	yl. glob. Oz.	
3367	"	28	6 38 A.M.	5 31 30	86 52 30	82	57.1	100	Rky.	
3368	"	28	7 21 A.M.	5 32 45	86 54 30	82	58.4	66	Rky.	Surface tow-net.
3369	"	28	8 7 A.M.	5 32 45	86 55 20	82	62.2	52	Nullipore or rky.	
3370	"	28	10 3 A.M.	5 36 40	86 56 50	84	54.8	134	Rks. & S.	At Cocos Island. Surface tow-net at night.
3371	March	1	7 49 A.M.	5 26 20	86 55 0	82	39.0	770	glob. Oz.	
3372	"	1	5 51 P.M.	4 49 0	86 11 20	84	38.8	761	gy. glob. Oz.	8 P. M. Surface tow-net.
3373	"	2	10 33 A.M.	4 2 0	84 58 0	82	36.6	1877	br. M. bk. sp.	
3374	"	3	10 35 A.M.	2 35 0	83 53 0	80	36.4	1823	gn. Oz.	

RECORD OF DREDGING AND TRAWLING STATIONS OF THE UNITED STATES FISH COMMISSION STEAMER "ALBATROSS." — *Continued.*

Serial Number.	DATE.		TIME.	POSITION. Latitude North.	POSITION. Longitude West.	TEMPERATURES. Surface.	TEMPERATURES. Bottom.	Depth in Fathoms.	Character of Bottom	REMARKS.
	1891.		h. m.	° ′ ″	° ′ ″	°	°			
3375	March	4	6 36 A.M.	2 34 0	82 29 0	77	36.6	1201	gy. glob. Oz.	Surface tow-net. In trawl swimming Holothurian, Periphylla, Atolla, and Eryoneicus.
3376	"	4	4 27 P.M.	3 9 0	82 8 0	78	36.3	1132	gy. glob. Oz.	
3377	"	5	8 38 A.M.	3 56 0	81 40 15	77	38.0	764	M.	
3378	"	5	11 45 A.M.	3 58 20	81 36 0	78	55.9	112	brk. sh.	
3379	"	5	2 15 P.M.	3 59 40	81 35 0	78	—	52	Rks.	
3380	"	5	4 51 P.M.	4 3 0	81 31 0	79	37.2	899	Rks.	In trawl, Periphylla, Atolla.
3381	"	6	8 38 A.M.	4 56 0	80 52 30	77	35.8	1772	gn. M.	Siphonophore clinging to wire rope.
3382	"	7	10 46 A.M	6 21 0	80 41 0	75	35.8	1793	gn. M.	Submarine tow-net. 8 : 30 P. M., Surface tow-net.
3383	"	8	6 51 A.M.	7 21 0	79 2 0	74	36.0	1832	gr. glob. Oz.	Atolla in trawl, Periphylla, Nauphanta, fragments of Drymonema.
3384	"	8	1 20 P.M.	7 31 30	79 14 0	74	42.0	458	gn. S.	Stomobrachium in trawl.
3385	"	8	3 7 P.M.	7 32 36	79 16 0	72	45.9	286	gn. M.	
3386	"	8	4 54 P.M.	7 33 12	79 17 15	73	48.0	242	fne. gy. S.	
3387	"	8	7 21 P.M.	7 40 0	79 17 50	74	56.4	127	fne. gy. S.	Surface tow-net.
3388	"	9	6 41 A.M.	7 6 0	79 48 0	73	36.2	1168	gn. glob. Oz.	Submarine tow-net. In trawl, Stomobrachium. In tow-net, open part, Periphylla.
3389	"	9	2 10 P.M.	7 16 45	79 56 30	74	48.8	210	gn. M.	
3390	"	9	4 25 P.M.	7 26 10	79 53 50	74	62.6	56	fne. gy. S. G.	
3391	"	9	7 15 P.M.	7 33 40	79 43 20	73	55.8	153	gn. M.	
3392	"	10	6 30 A.M.	7 5 30	79 40 0	73	36.4	1270	hard.	Rhabdamina bottom.
3393	"	10	1 21 P.M.	7 15 0	79 36 0	74	36.8	1020	gn. M.	
3394	"	10	5 43 P.M.	7 21 0	79 35 0	73	41.8	511	dk. gn. M.	

Serial Number.	DATE.	TIME.	POSITION. Latitude North.	POSITION. Longitude West.	TEMPERATURES. Surface.	TEMPERATURES. Bottom.	Depth in Fathoms.	Character of Bottom.	REMARKS.
	1891.	h. m.	° ′ ″	° ′ ″	°	°			
3395	March 11	2 20 P.M.	7 30 36	78 39 0	70	38.5	730	Rky.	
3396	" 11	5 15 P.M.	7 32 0	78 36 30	70	47.4	259	hrd. gy. M. S.	
3397	" 11	6 32 P.M.	7 33 0	78 34 20	71	57.3	85	stf. gn. M. brk.	Surface tow-net.
3398	" 23	3 16 P.M.	1 7 0	80 21 0	84	36.0	1573	gn. Oz.	Surface tow-net, off Galera Point.
3399	" 24	6 37 A.M.	1 7 0	81 4 0	80	36.0	1740	gn. Oz.	Siphonophore on wire. Phæodaria fragments. Surface tow-net.
			South.						
3400	" 27	6 10 A.M.	0 36 0	86 46 0	81	36.0	1322	lt. gy. glob. Oz.	Surface tow-net, March 25, pelagic Holothurian.
3401	" 28	4 45 A.M.	0 59 0	88 58 30	82	44.0	395	glob. Oz.	
3402	" 28	7 13 A.M.	0 57 30	89 3 30	82	42.3	421	R. glob. Oz.	
3403	" 28	10 19 A.M.	0 58 30	89 17 0	82	43.3	384	fne. gy. S. bk. Sp.	
3404	" 28	1 16 P.M.	1 3 0	89 28 0	83	43.2	385	R.	
3405	" 28	3 42 P.M.	0 57 0	89 38 0	83	60.0	53	P. Co. Sh.	Tangles. (3404–3406)
3406	April 3	6 47 A.M.	0 16 0	90 21 30	81	41.3	551	R.	
3407	" 3	10 48 A.M.	0 4 0	90 24 30	81	37.2	885	glob. Oz.	Tangles.
			North.						
3408	" 3	4 7 P.M.	0 12 30	90 32 30	83	39.5	684	glob. Oz.	Tangles.
3409	" 3	7 24 P.M.	0 18 40	90 34 0	82	42.3	327	bk. S.	Tangles. Surface tow-net. Off Bindloe Island, 4 miles west. (3409–3410)
3410	" 3	8 48 P.M.	0 19 0	90 34 0	82	44.2	331	bk. S.	
3411	" 4	7 35 A.M.	0 54 0	91 9 0	82	36.2	1189	yl. glob. Oz.	
3412	" 4	6 11 P.M.	1 23 0	91 43 0	82	38.0	918	R.	9 P.M., surface tow-net, 5 m. off Wenman Islands.
3413	" 5	8 34 A.M.	2 34 0	92 6 0	82	36.0	1360	glob. Oz. dk. Sp.	At noon, surface tow-net.
3414	" 8	11 14 A.M.	10 14 0	96 28 0	82	35.8	2232	gn. M.	Submarine tow-net and surface tow-net.
3415	" 10	9 39 A.M.	14 46 0	98 40 0	82	36.0	1879	br. M. glob. Oz.	

RECORD OF DREDGING AND TRAWLING STATIONS OF THE UNITED STATES FISH COMMISSION STEAMER "ALBATROSS." — *Continued.*

Serial Number.	DATE.		TIME	POSITION.		TEMPERATURES.		Depth in Fathoms.	Character of Bottom.	REMARKS.
				Latitude North.	Longitude West.	Surface.	Bottom.			
	1891.		h. m.	° ′ ″	° ′ ″	°	°			
3416	April	11	9 46 A.M.	16 32 30	99 42 40	81	40.5	419	fne. br. M.	
3417	"	11	11 44 A.M.	16 32 0	99 48 0	82	40.6	493	gn. M.	
3418	"	11	2 57 A.M.	16 33 0	99 52 30	82	39.0	660	br. S. bk. Sp.	
3419	"	11	5 59 P.M.	16 34 30	100 3 0	81	39.0	772	gn. M. bk. Sp.	Surface tow-net.
3420	"	12	7 48 A.M.	16 46 0	100 8 20	82	39.6	664	dk. gn. M.	
3421	"	12	11 32 A.M.	16 47 20	100 0 10	82	42.9	388	dk. gn. M.	
3422	"	12	12 35 P.M.	16 47 30	99 59 30	83	53.5	141	gn. M.	
3423	"	12	1 31 P.M.	16 47 30	99 59 20	83	56.0	94	gn. M.	
3424	"	18	11 18 A.M.	21 15 0	106 23 0	76	38.0	676	gy. S. bk. Sp. Glob.	
3425	"	18	2 14 P.M.	21 19 0	106 24 0	76	39.0	680	gn. M. & S.	
3426	"	18	3 45 P.M.	21 21 0	106 25 0	76	51.2	146	Rky.	
3427	"	18	4 3 P.M.	21 22 15	106 25 0	75	51.2	80	Rky.	
3428	"	18	6 40 P.M.	21 36 30	106 25 0	76	48.1	238	dk. gy. S. Glob.	
3429	"	19	5 39 A.M.	22 30 30	107 1 0	73	37.0	919	gn. M. Glob. Oz.	
3430	"	19	3 27 P.M.	23 16 0	107 31 0	73	37.9	852	bk. S.	
3431	"	20	6 33 A.M.	23 59 0	108 40 0	70	37.0	995	lt. bro. M. Glob.	
3432	"	20	2 38 P.M.	24 22 30	109 3 20	70	37.8	1421	br. M. bk. Sp.	
3433	"	21	6 34 A.M.	25 26 15	109 48 0	69	36.5	1218	br. M. bk. Sp.	}
3434	"	21	10 14 A.M.	25 29 30	109 48 0	70	36.4	1588	br. M. bk. Sp.	} Surface tow-net.
3435	"	22	8 56 A.M.	26 48 0	110 45 20	70	37.3	859	br. M. bk. Sp.	}
3436	"	22	3 10 P.M.	27 34 0	110 53 40	72	37.2	905	br. M. bk. Sp.	Submarine tow-net and surface tow-net.
3437	"	23	5 4 A.M.			70	40.0	628	br. M. bk. Sp.	Submarine tow-net dragged on the bottom. About 50 miles south of Guaymas.

Topography of the Bottom in the Panamic Region.

There can be no more striking contrast than exists between the topography of the two sides of Central America. The Atlantic side[1] with the great inland seas of the Gulf of Mexico and Caribbean, and the great submarine banks extending from Yucatan, Honduras, and Venezuela, while on the Pacific side (Plate III.) the continental slope is steep, the 2,000 fathom line often coming within 100 miles of the coast line. (See Plates V. to IX.) The 100 fathom line, with the exception of the stretch forming the Bay of Panama, and a comparatively narrow continental shelf along a part of the shore from Costa Rica to Tehuantepec, is within a few miles of the shore as far as the southern entrance of the Gulf of California, where it broadens out again to take in the Tres Marias group of islands. The 500 and 1,000 fathom lines are parallel with the 100 fathom line, forming a very abrupt slope from Ecuador to the Gulf of California, except along the stretch between Cape Mala and Tehuantepec, where the distance between those curves is somewhat greater (Plate III.), but still so slight as not to alter materially the prevailing steepness of the continental slope. In this same stretch the 1,500 fathom line is from three to four times as distant from the 1,000 fathom curve as it is off the coast line extending from Panama to Ecuador, and from Tehuantepec to Cape Corrientes; at the mouth of the Gulf of California, the 1,500 fathom line extends across the opening of the Gulf of California, coming in again close to Cape San Lucas.

The rise upon which Malpelo (Plate VI.) is situated is bounded by the 1,500 fathom line (Plate III.), and separated by a channel with over 1,700 fathoms of water from the Columbian and Ecuadorian coasts. And again the same curve forms a gigantic comma-shaped figure, taking in Cocos Island (Plates III. and V.) and the Galapagos group; it is separated from the 1,500 fathom line off Mariato Point by over 1,600 fathoms, and from the Malpelo Bank and Ecuadorian coast by over 1,800 fathoms. (See Plate III.) The course of the 2,000 fathom line shows how very uniform is the depth of the floor of the Pacific beyond the 1,500 fathom curve. The rise to the Galapagos is most gradual close to the islands, and the different islands of the Revilla Gigedo group, varying in distance from 300 to 500 miles from Cape San Lucas, form steep peaks suddenly rising from a comparatively level oceanic floor of an average depth of about 2,000 fathoms (see Plate III.), which is nearly the

[1] See Figs. 55–59, Three Cruises of the "Blake."

general depth between them and the mainland. This flat floor also extends farther to the southeast towards the 1,500 fathom line from which the Galapagos rise begins, and in the direction of the Costa Rica coast. The slope from the 1,000 fathom line to the 1,500 and 2,000 fathom line is much more gradual between Costa Rica and Tehuantepec than farther north along the coast of Mexico as far as the Gulf of California (Plate III.).

Our knowledge of the hydrography of the Galapagos is still quite incomplete. (See Plates IV. and VIII. to XII.) There are unfortunately no soundings between James and Albemarle, or between Indefatigable and Albemarle, to indicate the probable depth of the ridges connecting them.

Nothing likewise is known of the depth of the channels between Abingdon and Bindloe and Tower, and no soundings exist to show how far to the westward the deep valley (of over 800 fathoms) separating Bindloe from Indefatigable extends (Plate X. Fig. 2), as there are no soundings between either Bindloe or Abingdon and Albemarle. There seems little doubt that the northernmost islands, the isolated rocks of Culpepper and Wenman, are themselves separated by comparatively deep water (Plate XII. Figs. 1, 2), and in turn separated from the northeastern group of islands, Abingdon, Bindloe, and Tower, by a tongue of the ocean of at least 1,000 fathoms in depth, and from sixty to seventy miles in width. From a careful examination of the soundings thus far made, it seems probable that the 100 fathom line connects Indefatigable, Duncan, Barrington, and Charles, (see Plate IV., as well as the line between Charles and Indefatigable, Plate XI. Fig. 1,) and that there is also a connecting ridge inside that same depth between those islands and Albemarle to the southeast of Cape Woodford on Albemarle, or a wider plateau of which Duncan Island is one of the culminating summits.

A comparatively shallow connection may also exist between Cape Nepean on James Island and Albemarle in the direction of Cowley Island, Narborough itself being only separated from Albemarle by a channel less than 75 fathoms in depth (Plate IV.). The soundings between Chatham, Barrington, and Hood are so few in number that we are not yet able to decide whether these southeastern islands, Chatham and Hood (Plate XI. Figs. 2, 3), are not perhaps connected by a ridge connecting Hood and Macgowen Reef (Plate IV.), and also uniting them with the great plateau which the islands of Barrington, Charles, Indefatigable, Duncan, Albemarle, Narborough, and perhaps James, have gradually built up. But it may be that the tongue of deeper water extending between Hood and Chatham (287 fathoms) runs towards Barrington, and also separates that island from Chatham (Plate XI. Fig. 2).

On account of the small number of soundings, no attempt has been made to draw curves of depth on the chart of the Galapagos (Plate IV.).

The structure of Albemarle, made up of a series of at least five volcanic centres, with the adjacent Narborough, gives us an indication of the probable appearance of the central and western group of islands were they still active so as finally to become connected and form a huge island, with James, Indefatigable, Jarvis, Duncan, Barrington, and Charles as the culminating points of the plateau formed by the 100 fathom line. We may therefore look upon the Galapagos Islands as a group of volcanic islands, gradually built up by successive flows of lava upon a huge mound, itself perhaps raised by the same agencies from the floor of the ocean; more active local flows in the same region having at special points built up more rapidly the northern group of islands, Wenman and Culpepper, and the two other groups of islands we have recognized.

Character of the Bottom Deposits.

We dredged frequently in most characteristic Globigerina ooze. On one occasion the trawl came up literally filled with masses of a species of Rhabdamina closely allied to R. lineata.

It is interesting to note that, at two localities not far from the coast off Mariato Point, we came across patches of modern greensand similar in formation to the patches discovered off the east coast of the United States by the earlier dredgings of the Coast Survey, of Pourtalès, and of the "Blake." (See page 5, Stations 3357, 3358.)

Nearly everywhere along our second line of exploration, except on the face of the Galapagos slope, we trawled upon a bottom either muddy or composed of Globigerina ooze, more or less contaminated with terrigenous deposits, and frequently covered with a great amount of decayed vegetable matter. We scarcely made a single haul of the trawl which did not bring up a considerable amount of decayed vegetable matter, and frequently logs, branches, twigs, seeds, leaves, fruits, much as during our first cruise.

I was struck, while trawling on our second line between the Galapagos and Acapulco, to observe the great distance from shore to which true terrigenous deposits were carried. There was not a station there occupied of which the bottom could be characterized as strictly oceanic.

At our most distant points from shore, the bottom specimens invariably showed some trace of admixture of terrigenous material. A very fine mud was the characteristic bottom we brought up, often very sticky, and enough of it usually remained in the trawl, even when coming up from depths of over 2,000 fathoms, materially to interfere with the assorting of the specimens contained in our hauls. This mud continued all the way from the Galapagos to Acapulco, and up to the mouth of the Gulf of California, where it became still more of an impediment to dredging, so that little work was done until we passed the Tres Marias. Even then the trawl was ordinarily well filled with mud, and with it came up the usual supply of logs, branches, twigs, and decayed vegetable matter.

On going farther north, into the Gulf of California, the nature of the bottom did not change materially from what it had been along the coast from Acapulco to Cape Corrientes; it was the same viscid mud, mixed occasionally with Globigerinæ and masses of vegetable matter. So we found the trawling most difficult from the weight of the mud brought up, but occasionally a haul was made which more than repaid us for the time spent on the less productive ones.

In the dredgings of the "Blake" in the Gulf of Mexico, off the West Indies, and in the Caribbean, my attention had already been called to the immense amount of vegetable matter dredged up from a depth of over 1,500 fathoms on the lee side of the West India Islands. But in none of the dredgings we made on the Atlantic side of the Isthmus did we come upon such masses of decomposed vegetable matter as we found on this expedition. There was hardly a haul taken which did not supply a large quantity of water-logged wood, and more or less fresh twigs, leaves, seeds, and fruits, in all possible stages of decomposition.

Temperature Sections in the Panamic District.

The temperature sections taken by the "Albatross" during this cruise give us a fair sketch of the temperature of the currents running north parallel with the Mexican coast, of the counter current running towards the Gulf of Panama, of a branch of the Humboldt Current running from the coast of Peru and deflected by the Galapagos to the northward, the main branch of the current running south of the Galapagos and forming a great westerly current running nearly at right angles from the coast of Central America past the Galapagos, and becoming the Equatorial Current of the Pacific.[1]

[1] The Peruvian stream, the bulk of which flows westerly south of the Galapa-

A transverse section of the Mexican Current from Mariato Point to Cocos Island (Plate V.) shows the water to be considerably warmer near the mainland than about half-way across to Cocos Island. At the 1,000 fathom line, the 60° curve is found at a depth of more than 100 fathoms, while at Station 3361, at a depth of 1,471 fathoms, nearly the half-way point, the 60° curve has risen to a depth of 50 fathoms from the surface, to sink to 75 fathoms and rise to 25 fathoms again at Station 3362 at a depth of 1,175 fathoms, and at Station 3364 in 902 fathoms, towards Cocos Island, the surface belt becoming again decidedly warmer near the island. The curve of 45° temperature corresponds nearly with the 300 fathom line, rising near the mainland and falling somewhat at Cocos Island. The 40° curve in its turn corresponds practically with the 600 fathom line except near the mainland, where there seems to have been a colder body of water.

The bottom temperature of 36°.4 between 1,600 and 1,700 fathoms shows a free connection with the oceanic floor, and the temperatures on the ridges indicated by the soundings, the one near the mainland (42°), the other near Cocos Island (38°), show that they are not parts of an oceanic barrier, but are probably short ridges parallel with the mainland and the general trend of Cocos Island.

A temperature section run across the westerly Panamic current in a southeasterly direction from Cocos Island (Plate VI. Fig. 1) shows remarkably uniform temperature curves of 60°, 45°, and 40°. The 60° curve, after leaving the shores of Cocos Island, rises to about the 45 fathom line, the water as we go south gradually becoming warmer, and at Station 3375, about 100 miles southwest of Malpelo, the 60° curve is down to the 75 fathom line. The 45° curve barely rises above the 300 fathom line near Cocos, and at Station 3375 falls somewhat below it. The 40° curve is nearly parallel with the 520 fathom line; so that going south from Cocos Island the body of water above the 500 fathom line is considerably warmer than in the section from Cocos Island to the mainland.

gos, divides off Ecuador, one branch, the westerly, extending to the eastward of the Galapagos, the other flowing into the Bay of Panama. The westerly branch meets the eastern equatorial set, and the eastern branch meets north of the Bay of Panama both the easterly equatorial set and the Mexican branch of the California Current. There is thus found off the Bay of Panama, from the coast of Costa Rica and in a southerly direction, and northerly in the triangle between the Galapagos, Point Mala, and Acapulco, a most complicated system of currents and counter currents. These currents had a marked effect on the ship's course, and frequently set us one day thirty or forty miles east, the next day as many miles in a westerly direction.

In the section from Station 3375 towards Malpelo and to the Pearl Islands in the Bay of Panama (Plate VI. Fig. 2), the water becomes somewhat colder as we approach Malpelo and as far as Station 3,381 in 1,772 fathoms, where the temperature gradually rises again (the 40°, 45°, and 60° curves) towards the Bay of Panama, although the surface temperature has been gradually diminishing from 84° off Cocos Island to 77° off Malpelo, to become as low as 73° off the mouth of the Bay of Panama in 1,168 fathoms, to rise again to 75° in the shallow water of the bay itself.

The three temperature sections of Plate VII. Figs. 1, 2, 3, from Station 3392 to Caracoles Point, on the east shore of the Bay of Panama, and to Point Mala, and from Station 3383, fifty miles to the south of Caracoles Point, to Panama, show an increase of temperature as we rise above the continental slope to the heated waters of the bay, and close to Point Mala on its western face.

In the temperature section from Galera Point to Chatham Island (Plate VIII.) we find the 60° curve but little below the 50 fathom line, showing plainly that it is from the southern current that the cold water comes which occupies the upper strata of the Bay of Panama. The 45° curve rises above the 300 fathom line close to the mainland, to fall nearly 50 fathoms below it on the slope of Chatham Island. The 40° curve is below the 600 fathom line near the mainland, but rises to that line off Galera Point, to fall again nearly to 675 fathoms on the Galapagos slope.

It will be noticed that the upper belt of 50 fathoms varies considerably in temperature, ranging near Galera Point fully 20° in less than 50 fathoms, and in comparatively short distances more than 17°, the surface temperature varying from 80° to 84° on the way to Chatham, and the temperature at the 50 fathom line from 59°.1 to 64°.3.

The bottom temperature is fully half a degree colder below 1,300 fathoms than it is in the sections from Mariato Point to Cocos, and southerly from that island the colder water of the bottom, 36°, extends to the western face of the continental slope off the Bay of Panama as far as Point Mala, as is seen in the sections of Plate VII. Figs. 1 and 2.

The temperature of the upper strata rises somewhat as we approach the Galapagos, the 60° curve being found at a depth of 75 fathoms (Plate VIII.) off Chatham Island.

In the temperature section run in a northwesterly direction from the Galapagos to Acapulco (Plate IX.) we obtained the deepest soundings of our cruise, the temperature at a depth of 2,232 fathoms, somewhat more than half-way between Culpepper and Acapulco, falling to 35°.8, the temperature being below 36° in the whole of the great basin extending between the northerly slope of the Galapagos and the continental slope off Acapulco. The surface temperature was 83° off Chatham, it fell to 81° off James, and varied between 81° and 83° to fall to 81° again about half-way to Acapulco, to rise to 84° and fall to 80° off Acapulco. The 60° curve rises among some of the Galapagos Islands almost to the 50 fathom line, but falls rapidly below the 100 fathom line between Abingdon and Wenman, retaining that depth nearly to Station 3414 in 2,232 fathoms (Plate IX.), showing the presence of a large mass of warm water flowing eastwardly. From that point it rises rapidly above the 50 fathom line to a short distance off Acapulco, where the water close to the shore becomes warmer again. The 45° curve follows nearly the line of the 60° curve, reaching for a great part of its length the line of 350 fathoms. But the 40° curve shows more markedly than the 45° curve the influence of the warmer body of water moving eastward, and again as markedly that of the colder belt close to the Mexican mainland. It reaches well below the 600 fathom line for more than two thirds its length, extending for a considerable distance to 630, and even to 650 fathoms.

A comparison of the temperature curves of Plates VIII. and IX. will show in the one case the large belt of warmer water flowing east in the greater part of the oceanic basin extending between the Galapagos and Acapulco, and the comparatively colder water flowing north in the oceanic valley extending between Cape San Francisco (Galera Point) and the Galapagos.

The few temperatures taken between the different islands of the Galapagos are interesting as showing the southern islands, Chatham, Hood, and Charles, to be somewhat within the influence of the colder Humboldt Current (Plate XI. Figs. 2, 3, 5), while that which sweeps north of Chatham across the central islands is somewhat warmer (see Plate X. Figs. 1–4), and the upper belt of temperatures is still warmer between Abingdon and Wenman Islands (Plate XII.).

The mixing of the cold and warmer currents flowing between the different islands is plainly indicated by the temperature section from Indefatigable Island to Bindloe (Plate X. Fig. 2), where the 60° curve is at about the 50 fathom line, the 45° at the 300 fathom line, and the 40° curve at the 600 fathom line, while between Abingdon and Wenman the 60° curve is below the 100 fathom line, the

45° curve at about the 350 fathom line, and the 40° curve at the 650 fathom line, indicating a much larger body of warm water between Abingdon and Wenman (Plate XII. Fig. 1) than between Indefatigable and Bindloe, while farther south, near Chatham (Plate XI. Figs. 2, 3, 4), the upper belt of temperatures indicated are the coldest, the 60° curve being above the 50 fathom line.

The temperatures were all taken during February, March, and April of 1891. The sections of the first lines, Panama to Cocos, to Malpelo, and back again to Panama, were taken during the last of February and the beginning of March; those from Galera Point and the Galapagos during the latter part of March and beginning of April; and the line from the Galapagos to Acapulco from the 3d of April to the 12th.

The soundings and temperatures taken during our trip up the Gulf of California indicate free connection with the Pacific, (see the bottom temperatures of Stations 3424 to 3437 in the Gulf of California, page 8, and Hy. 2635, page 17, the deeper stations having practically the same temperature as the oceanic temperatures off Acapulco,) the 1,500 fathom line sweeping across the opening of the gulf with a rapid rise to the 1,000 fathom line running parallel to the two coasts, and a very flat bottom along the central part of the Gulf of California to the line where the 1,000 fathom curve cuts across the gulf off Topolobampo, the bottom rising again gradually along the centre of the gulf to the 500 fathom line, which extends north of Guaymas. The rapid decrease of the surface temperatures as well as that of the upper belt of water to 100 fathoms, within the Gulf of California, is very marked. See the record, on page 8, of Stations 3424 to 3437, and Hy. 2635, page 17.

The accompanying table shows the serial temperatures taken at the different Stations. The position is given in the list of Stations occupied, on pages 4 to 8.

Serial Number.	TEMPERATURE. Of the Air.	At the Surface.	At Fathoms. 25	50	100	200	300	400	500	600	700	800	900	1000	At Bottom.	Depth in Fathoms.
	° F.	°	°	°	°	°	°	°	°	°	°	°	°	°	° F.	
Hy. 2609	79	81	67.2	63.2											57.7	127
Dr. 3356	80	83	68.4	65.9	58.5	52.9	44.9	48.7							40.1	546
" 3357	80	83	74.4			51.8	46.1	43.0	41.0						38.5	782
" 3361	81	82	76.9	59.0	55.0	50.5	46.8	43.6	41.9	40.2	38.3	38.9	37.5	36.5	36.6	1471
" 3362	80	84	71.8		55.8	51.3	46.7				39.1		37.3	36.8	36.8	1175
" 3364	79	81	71.4	58.9	54.4 *	48.8 *	44.9 *	42.8 *	41.0 *						38.0	902
" 3366	83	84	73.7	58.9	55.8	50.9	45.9	44.7	41.5	40.4	38.8				37.0	1067
" 3367	81	82	72.4	69.0											57.1	100
" 3372	85	84	74.4	58.8	55.0	49.1	44.9	42.5	41.0						38.8	761
" 3373	83	82	77.7	60.9	55.9	49.7	44.4	41.9		38.9	38.0	37.5	37.1	37.0	36.6	1877
" 3374	81	80	74.8	61.1	56.6	51.3	45.8	42.3	40.9	39.4					36.4	1823
" 3375	76	77	66.7		58.0	54.2	46.6	43.8	40.9	39.9	38.9	38.0	37.6	37.2	36.6	1201
Hy. 2613	77	77	69.9	59.9	57.7	50.8	45.6	43.3	40.9	39.7	38.8		37.3		36.5	1181
Dr. 3381	78	77	70.9	59.3	55.4	51.5	46.7	42.8	40.5	39.4	38.6	37.7	36.4	36.0	36.0	1772
" 3382	77	75	67.7	61.1	55.3	49.9	45.8	42.8	41.1	39.4	38.8	38.1	36.7	36.3	36.0	1793
" 3383	75	74	63.2	63.4	56.4	49.1	45.0	43.3	41.3	39.6	39.4	39.0	37.4	37.0	36.0	1832
" 3387	77	75	65.8	64.0											56.4	127
" 3388	75	73	64.0	60.9	56.1	49.0	45.5	43.4	43.1	39.8	39.2	38.1	37.7	37.2	36.2	1168
" 3392	76	73	63.0		55.9	49.8	45.0	43.2	40.5	39.7	38.6		37.3	36.8	36.4	1270
Hy. 2619	72	68	65.0	61.8		48.9	45.5	42.6	41.1	40.1	38.7	37.8			36.5	1100
Dr. 3396	77	70	64.5	62.4	55.9										47.4	259
Hy. 2624	77	80		59.1	58.1	56.4	45.6	43.1	41.9	41.0					39.0	724
" 2626	79	80	68.9	60.7											57.5	90
Dr. 3398	84	84	68.8	64.4	59.0	53.8	45.1	42.9	42.0	40.3	39.5	39.0	38.4	37.0	36.0	1573
" 3399	79	80	72.7	65.7	56.1	50.0	44.9	43.0	41.4	40.1	38.9	38.0	37.6	36.7	36.0	1740
Hy. 2627	80	81	71.4	64.3	56.8	49.2	44.8	42.5	41.9	40.2	38.7	38.2	37.7	37.1	36.0	1832
" 2629	85	83	69.9	63.7	56.2	50.1	45.0	42.4	41.8	40.3	39.2	38.6	37.8	36.8	36.0	1488
Dr. 3401	81	82	70.1	63.7	56.6	50.0	46.1								44.0	395
" 3406	79	81	73.5	59.9	57.9	53.9	45.0	42.3							41.3	551
" 3411	79	82	71.8	67.8	61.5	54.0	46.8	43.0	41.3	40.8	39.8	38.9	38.1	37.5	36.2	1189
" 3414	81	82	81.9	72.1	59.5	51.8	47.8	44.4	42.0	40.8	39.6	38.8	38.1	37.8	35.8	2232
" 3415	84	82	77.4	56.8	54.3	49.4	45.3	43.1	41.0	39.5	38.8	37.9	37.0	36.8	36.0	1879
Hy. 2631	79	80	72.5	59.6	54.2	49.5	44.5	42.6	41.1	39.8	38.7	38.2	37.9	37.2	35.8	1823
" 2635	72	74	65.4	59.0	54.6	49.8	44.8	42.2	41.1	39.8	38.7	38.1	37.6	37.0	36.0	2022
Dr. 3435	72	70	65.6	59.2	54.1	49.8		41.8	40.3	39.3	38.5				37.3	859

* These stations are all 50 fathoms deeper than the column in which they are placed.

Specific Gravity of the Ocean in the Panamic District.

During the present cruise of the "Albatross," a few observations of the specific gravity of the water were taken.

On February 23, at a depth of 546 fathoms, the specific gravity was as high as	1.027300
While on the surface it was only	1.025700
On February 24, at the surface, Station 3357	1.024700
" " at 600 fathoms " "	1.026912
" 25, at the surface, Station 3361	1.024712
" " at 1,000 fathoms, " "	1.027512
" 26, at the surface, Station 3362	1.024726
" " at 1,000 fathoms " "	1.027120
" 27, at the surface, Station 3365	1.024900
" " at 900 fathoms " "	1.027100
March 1, at the surface, Station 3371	1.024568
" 7, at the surface, Station 3382	1.026160
Cocos Island, at the surface	1.024600
Off Malpelo " "	1.025960
At the Galapagos, off Chatham, at the surface	1.025726
" " Wreck Bay, " "	1.025926
" " at Charles Island, at the surface	1.026126
" " at Duncan Island, " "	1.026126
" " at Indefatigable Island, at the surface	1.025926
" " off Wenman, at the surface	1.025926
April 6, at the surface	1.026912
" 8, at the surface, Station 3414	1.026112
" 11, off Acapulco, at the surface	1.026712
On the trip of the "Albatross" to these waters from San Francisco, the specific gravity of the sea water at the surface, reduced to 60°, off San Francisco, was	1.026160
It gradually increased to	1.026960
And diminished again, near Acapulco, to	1.026520
From Acapulco towards Panama, it gradually decreased to	1.025920
And off Panama passed through streaks as low as	1.024600
On a former trip from Panama to the Galapagos and to Acapulco, the specific gravity in Panama Bay was	1.026160
March 6, 1888, in Lat. 3° 22′ N., Long. 86° 5′ W., on the way to the Galapagos, the surface water had a specific gravity of	1.025726
Off Hood's Island, " " " " " "	1.028316
Off James Island, " " " " " "	1.027916
In Lat. 8° 10′ N., Long. 95° 9′ W., the surface water had a specific gravity of	1.026316
Off Acapulco, the surface water had a specific gravity of	1.026924

The lines limiting the areas of specific gravities given on the chart by Buchanan in the narrative of the "Challenger" will have to be modified as far as they relate to the Panamic District. According to the observations of the "Albatross," the specific gravities are too high off Panama.

Observations on the Pelagic Fauna by the "Challenger," and by Th. Studer in the "Gazelle."

Having always been more or less interested in pelagic faunæ, and having paid considerable attention to its vertical distribution during my earlier cruises in the "Blake," I was naturally anxious to reconcile the conflicting statements and experiences of the naturalists of the "Challenger" and "Gazelle" on one side, and my own observations on the other.

The subsequent observations of Chierchia, of Chun, and of Hensen, and their discussion, have only increased the interest in the problem of the bathymetrical range of the pelagic fauna. Before giving an account of the work accomplished towards the solution of the problem by the present trip of the "Albatross," I will rapidly give the results obtained since the "Blake" experiments.

It should be remembered that Studer's[1] statements were based entirely upon the assumption that the deep-sea Siphonophores, or their fragments, collected by him while in the "Gazelle" from the sounding line, actually came from the depths to which they were attached when the line reached the deck; so that, for instance, a fragment of Siphonophore coming up to the surface at the 650 fathom mark, or any other depth, indicated to Studer that the specimen was collected at that depth. From these observations Studer concluded that "auch die tiefen Wasserschichten nicht unbewohnt sind," and that they did not come from higher levels, the tow-nets of the "Gazelle" having frequently been lowered to a depth of 200 fathoms without bringing up any Siphonophores. He considers that the depth at which the Siphonophores occurred was a definite one, limited by the temperature, — a depth of from 800 to 1,500 fathoms, with a temperature of 2° or 3° Centigrade. The experiments of the "Challenger," on the other hand, consisted in sending open tow-nets down to various depths, and by a differentiation of the contents of the nets at different depths assuming that the changes in the catches were due to the several bathymetrical ranges of the species obtained. As the nets used by the "Challenger" were open tow-nets, all of which, on their way to the surface, passed through the upper and most

[1] Zeitschr. f. Wiss. Zool., XXXI., p. 1, 1878.

populous stratum of the ocean, it is evident that no great degree of accuracy in determining the bathymetrical range of the pelagic fauna could be claimed for this method of towing. From the mode of making the observations, the catch of all the hauls must have contained representatives of the fauna of the upper belts of water, regarding the geographical range and the composition of which we know as yet but little.

Observations on the Pelagic Fauna by the "Blake."

In spite, however, of the objections urged above, both Murray and Studer contended that, in addition to the deep-sea and pelagic faunæ, there was what might be called an intermediate fauna with characteristic species, having nothing in common with the other two; while I maintained, on the other hand, from my experiments in the "Blake," that there was no such intermediate fauna, but that the pelagic fauna might descend to a considerable depth during the daytime to escape the effects of light, heat, and the disturbing influence of surface winds, and that this surface fauna on the Atlantic side of the United States, off shore in deep water, did not descend much deeper than 150 to 200 fathoms, or some point not far distant from that level, depending of course to some extent upon the latitude of the observation; the lower bathymetrical limits of the pelagic fauna very probably coinciding with the limits to which the action of the heat of the sun, of light, and of other disturbing elements of the surface extended.

The experiments I made on the "Blake"[1] were carried on with the Sigsbee gravitating trap, which worked successfully, and tested the contents of a vertical column of water of any desired height. The only drawback of the original apparatus was its small size. The machine subsequently used by Hensen for his quantitative experiments worked on the same principle, of filtering the whole of a vertical column of water, and examining the results.

Observations on the Pelagic Fauna by the "Vettor Pisani."

The next observations made were those of the "Vettor Pisani."[2] Lieutenant Chierchia devised a net which he asserted could be sent down

[1] Bull. Mus. Comp. Zoöl., Vol. VI. Nos. 8 and 9, and Three Cruises of the Blake, Vol. I. p. 36.

[2] G. Chierchia, Collezioni per Studi di Scienze Naturali fatte nel Viaggio intorno al Mondo dalla R. Corvetta Vettor Pisani, Commandante G. Palumbo. 1885.

closed, then opened when it had reached the requisite depth, and after towing horizontally for a time closed by means of a propeller similar to the one adopted by Commander C. D. Sigsbee, U. S. N., for closing the water cups in use on the "Blake." Unfortunately, as experience has shown, all the experiments made by the "Vettor Pisani" are vitiated by the imperfect method of closure of the rim of the net, and the danger that it may open or close again and again on its way up to the surface should the hoisting be in the least irregular.

On the 31st of May, at a depth of 1,800 meters, a small net was attached below the thermometer, and tripped at the same time as the thermometer turned free of the propeller; but on examination of the figures of the net in use given on Plate X. by Chierchia, there is no doubt that he is correct in stating, "Anche in questo caso non si può asserire che tutta la quantità di animali trovati appartenga agli ultimi strati ove pescò il retino." So that this experiment at least proves nothing, the partly open net having passed through the upper 250 or 200 fathoms, where there is abundant life.

On the 5th of June the same experiment was again made on the "Vettor Pisani," at a depth of 1,000 meters; but there is nothing to show that, in the surging of the ship and the hauling up, the valves of the net have not opened and closed many times on its way to the surface. The same objection may be made to the haul of the 12th of June, at a depth of 2,300 meters.

The experience which all have had who have dredged at sea, of bringing up fragments of so called deep-sea Siphonophores, was of course also that of the "Vettor Pisani." Chierchia on the 24th of January, 1884, at a depth of 900 meters, let down the wire only, and brought up tentacles of Siphonophores. To insist, as he and Studer have done, that the depth at which these animals lived may be inferred from the length of the rope let out by which they reached the surface, is simply to ignore the fact that the wire rope on its passage upward through the pelagic belt of the fauna may catch anything within those limits. It will be seen that Hensen fully concurs with me in considering the bathymetrical data obtained by collections from the wire rope or the sounding line as of no value.

The fact that the "Albatross" on her last expedition brought up these so called deep-sea Siphonophores, from depths of less than 200 fathoms, in the open tow-net, which had not been sunk below that depth, ought to dispose of the argument of the wire rope catches as meaningless.

The two charts of Zootalassographia given by Chierchia for the Atlantic and Pacific show at a glance the general character of the surface fauna at the various localities at which the "Vettor Pisani" used the tow-net, and also in the Pacific chart the contents of the deep-sea net, and the depths to which it was lowered. But, as I have stated above, there is no proof as yet that the fauna and flora reported by the "Vettor Pisani" as living at the depths indicated by the record did actually live at those depths. We may leave out of consideration the catches of Siphonophores on the dredging and sounding wires, as well as a large number of hauls at depths of 100 to 400 meters, depths which are not in question; and as regards the contents of the self-closing net in use on the "Vettor Pisani," sent to depths in one case as great as 4,000 meters, it would add nothing to the discussion of the greatest depth at which pelagic animals are found, owing to the untrustworthiness of the working of the net. Of course, the same objections hold equally good to the results claimed from the contents of tow-nets sent to depths varying from 1,000 to 2,300 meters.

Observations on the Pelagic Fauna by the Prince of Monaco.

In a German translation by Marenzeller[1] of the notices of the pelagic work of the yacht "Hirondelle" scattered through the Comptes Rendus, will be found an account of the experiments of the Prince of Monaco. Off Monaco he lowered a trap to a depth of 1,200 meters from the surface and 300 meters from the bottom, and obtained a species of Paralepis.

The Prince of Monaco has invented a number of most ingenious pieces of apparatus for collecting the surface fauna and that which may live at intermediate depths, but neither his apparatus nor that of Fol, who has experimented in the same locality, has been sufficiently tested to enable us to judge of its value.[2] Fol's apparatus, from his own account in "La Nature," is very sensitive to the rising and falling of the ship. The Prince of Monaco discarded the use of the Chun-Petersen net, as he found more or less gaping of the mouth frame, after it was supposed to have closed, during the whole of its ascent to the surface.

[1] Zur Erforschung der Meere und ihrer Bewohner, gesammelte Schriften des Fürsten Albert I. von Monaco, von E. v. Marenzeller, 1891.

[2] His large pelagic beam-trawl, if I may so call it, in use on the "Hirondelle," should prove a valuable machine for collecting surface animals.

The closing net of the "Hirondelle" for deep-sea pelagic work is a somewhat complicated and expensive piece of apparatus,[1] but appears to have worked well, although special data are not at hand regarding the exact depths of its working; and as is sufficiently clear, results obtained in the Mediterranean, or any closed sea like it, as the Baltic, or close to the shores of any mainland, cannot be correlated with those of the open sea, far from the disturbing factors at those localities.

Observations on the Pelagic Fauna by Dr. C. Chun.

The next experiments were those of Dr. Chun, who, under the auspices of the Naples Zoölogical Station, made an expedition to the Ponza Islands. Dr. Chun and the engineer Petersen applied to a tow-net an apparatus for closing it, similar to the propeller in use on our thermometers and water cups. Chun towed to a depth of 1,300 to 1,400 meters, but never at any great distance from the mainland or from the islands of the Gulf of Naples, and came to the conclusion that the pelagic fauna existed all the way to the bottom.[2]

In a notice of Chun's memoir on the results of this expedition, I questioned the conclusions to which he had arrived, and quote the following *résumé* from the American Journal of Science[3]: —

"Unfortunately, this expedition, interesting as its results are, does little towards settling the subjects under discussion, because neither the distance from shore nor the depths investigated were great enough to eliminate the disturbing effects of close proximity to land, as it was near the continental slope, on the very edge of which Dr. Chun trawled with the tow-net. The results are further vitiated from the fact that they have been carried on in a closed sea where the conditions of temperature are strikingly different from those of the Atlantic, and where at a depth of about 500 fathoms we find already the lowest temperatures of the deepest part of the Mediterranean. The minimum seasonal differences of temperature between that and the surface cannot be contrasted to oceanic conditions."

On his trip to the Canary Islands, his second pelagic fishing expedi-

[1] Compte-Rendu des Séances du Congrès Internat. de Zoologie, Paris, 1889, pp. 133–159.

[2] Bibliotheca Zoologica. I. Die pelagische Thierwelt in grösseren Meerestiefen und ihre Beziehungen zu der Oberflächenfauna, 1887.

[3] A. Agassiz, in Am. Jour. of Science, Vol. XXXV. p. 421, May, 1888.

tion,[1] Chun was provided, as he says, with a line for pelagic fishing of a length of 1,600 meters.

During the journey Chun made seven casts, at depths varying from 500 to 1,600 meters. The casts are certainly not numerous enough to furnish a basis for a general theory. Two of the casts were at depths of 500 and 1,000 meters, not very distant from Cape Finistère, while another cast of 500 meters was made off Funchal, and the cast of 1,600 meters was made between Teneriffe and Gran Canaria, where he speaks of making a pelagic haul at a depth of 1,600 meters with a line only 1,600 meters long. He must, of course, have lowered his net vertically, and Chun can hardly expect any one practised in dredging or towing to accept the depth he gives as the correct bathymetrical limit at which the two specimens he brought up were collected. Furthermore, all of these casts except one, perhaps, are open to the objection of having been made at comparatively small distances from land; and, taking Chun's own account, the casts of 500 meters, say 250 fathoms, contain, judging from his list, about the same amount (somewhat less) of pelagic material as was found in our "Albatross" hauls with the tow-nets at depths of about 200 fathoms.

Furthermore, he says: "kam es bei den früherhin im Mittelmeer angestellten Versuchen gelegentlich vor dass durch den starken seitlichen Druck, welche die sich auslösenden Drähte auf den mit einem Schraubengewinde versehenen Messingstab ausübten, ein Öffnen und Schliessen des Netzes nicht erfolgte, anderseits blieb nach dem Schluss des Netzes gelegentlich ein schmaler, etwa fingerbreiter Spalt zwischen den beweglichen Hälften des Rahmens frei."

I need not say that an opening of half an inch wide and nearly two feet long at the mouth of the net will, in its ascent through a distance of 200 fathoms of the upper belt of the pelagic fauna, suffice to sift into the bag enough material to vitiate all accurate conception of what lives *below* that belt. In his expedition to the Canary Islands, these defects were said to be remedied by Chun, and the modified net was used by him during his voyage at depths of 500, 1,000, and 1,600 meters. But Hensen is of the opinion that the modified net is still defective, and that its results cannot be relied on. There seems to be no reason why these self-closing nets should not be placed serially on a line, as are thermometers, and then we may expect to get accurate results. If this be impracticable, we can, at any rate, use the nets at the same locality at

[1] Untersuchungen über die pelagische Fauna der Canarischen Inseln, von Carl Chun, Sitzungsb. d. König. Preuss. Akad. d. Wiss. zu Berlin, XXX., 1889, p. 519.

different depths, as I attempted to do on the "Blake," and have done more successfully on the present trip on the "Albatross." It is important to give at the same time the depth of the bottom and the distance from land, both most essential factors, to which neither Chun nor Hensen has paid sufficient attention.

In discussing the value of Chun's observations made on his way to the Canaries, we should remember that of the three casts with the closing net one was taken at a moderate distance off shore from Cape Finistère. The only strictly oceanic cast was his No. V., Lat. 34° 18′ N., Long. 15° 34′ W., and even that, if plotted, will be found remarkably close to the bank extending in a northeasterly trend from Madeira. This bank as marked is inside the 1,500 fathom line, and has many points the depths of which are near 500 fathoms. But leaving this out of consideration, his catch at that point consisted only of a single Copepod[1] and a Phaeodaria, and even these may have come from near the bottom. At any rate, we can hardly consider such a catch as indicating the presence at that depth of an abundant pelagic fauna.

As for the work accomplished by Chun at the Canaries, that strikes me as vitiated by the same disturbing factors to which I have already alluded. It can certainly not be called oceanic. The most distant of the Canary Islands is not more than 225 nautical miles from the coast, and the nearest less than forty, so that the pelagic fauna is under the influence, of all the disturbing elements of a coast line within a short distance. The very fact that so much surface pelagic material accumulates around the islands is the best evidence of this. We are therefore still left, so far as the distribution in depth of the pelagic fauna is concerned, to the few observations I made on the "Blake" (*pace* Haeckel), to that one of Chun mentioned above, to those of Hensen in the "National" expedition, and to those of the last expedition on the "Albatross." I am leaving out as not conclusive those of the "Vettor Pisani." The positive results of all these hauls clearly indicate that the bulk of the pelagic fauna is limited to a depth not exceeding 200–250 fathoms, and that then it rapidly decreases.

[1] The material collected by Chun was worked up by Claus in Arbeiten aus dem Zoöl. Inst. d. Univ. Wien, IX., 1890, I. p. 1. Of the new species described, "Die Gattungen und Arten der mediterranen und atlantischen Halocypriden," six said to have been collected at 1,500 and 1,000 meters were also collected at the surface. No less than nine species have a wide geographical distribution, and those brought up from deep water in the proximity of land or near the Canaries of course add nothing to our knowledge of their oceanic bathymetrical distribution.

But until our reports give us the exact depth of the bottom, together with the results of the tow-nets from the so called intermediate deep-sea pelagic life, there is nothing to show that the contents of the nets may not have come from a belt of water close to the bottom, about which there has as yet been no discussion.

The occurrence of animal life within a moderate distance of the bottom is a question which is not to be confounded with that of the lower limit in depth of the pelagic fauna. These two zones may meet at depths of 500 to 700 fathoms, under favorable conditions of distance from shore, and give the impression of a continuous fauna from the surface to the very bottom. Undoubtedly a great deal of the confusion which has arisen regarding the lower limits of the pelagic fauna is due to differences in our understanding of what we call deep water. To a deep-sea dredger the limits of the bulk of the pelagic fauna, whether it turn out to be 200, or 250, or even 300 fathoms, is naturally shallow water. To one who has been accustomed to tow merely on the surface, 50 to 100 fathoms are already deep water, and depths below that seem enormous.

This last expedition of Chun — which made one oceanic cast! — marks, so Haeckel states, the greatest progress in marine biology since the "Challenger" expedition.[1] Yet he discards the results obtained from the oceanic hauls of the "Blake," which are the only accurate ones made up to the time when Hensen entered the field. He also considers Hensen's work worthless, probably because for over three months he explored the surface of the Northern Atlantic as it had not been done before. Unfortunately, Hensen's results do not chime with Haeckel's preconceived ideas, and they are naturally condemned because they do not show below 200 fathoms the existence of a populous pelagic fauna, which Haeckel had decided ought to exist down to great depths, and which he assumes the catches made by the defective net in use in the "Vettor Pisani" and those of the open nets of the "Challenger" to have conclusively proved. Taking all these positive results, as Haeckel is pleased to call them, and adding to them the equally fictitious statements regarding the presence of an intermediate pelagic fauna, based upon the fact that the so called deep-sea Siphonophores were found on the sounding wire and dredging rope of various expeditions, he gets a formidable array of incomplete data, brought together by defective methods. Upon these grounds he bases results for which more recent investigations, carried on with improved machinery, furnish as yet no

[1] I need not say that Chun makes no such ridiculous claim for his few experiments as are put forth by Haeckel.

proof. The later results are of course, as Haeckel says, in absolute contradiction to former experiences. Hence their great value, and the burden of proof is not upon the recent explorers, but upon those who build castles in the air based on the incorrect data obtained by the earlier expeditions. They have got to show that what they obtained from these great depths did not come from the upper belt of the pelagic fauna, from 250 or 300 fathoms in depth, up to the surface.

The Pelagic Fauna and the "National" Expedition.

It is a great merit of Hensen's [1] explorations, that he was the first to see that the quantitative measurements of the pelagic fauna could only be reached by the examination of the contents of a vertical column of water. This, if examined from the point of its minimum density upwards to the surface, will very nearly represent the total amount of life which lives in any given locality. We may by thus fishing upwards get at any locality practically all that is characteristic of it, whether the fauna has congregated at the surface or near it, or at any other part of the pelagic faunal belt, owing to the peculiar conditions of light, heat, wind, and weather.

In the "National" expedition in charge of Hensen,[2] the Plankton fishing hauls were limited to depths of 200 to 400 meters, and, if I understand the statements of Dr. Brandt [3] correctly, several hauls were made at the same spots to determine the vertical distribution of the pelagic organisms. A modification of the Petersen-Chun net was also used in the "National" expedition, and according to Hensen and Brandt there are still found in very considerable depths between the surface and the bottom "noch Organismen leben allerdings sehr viel weniger als in den oberen, von Licht durchstrahlten Wasserschichten." The number of indviduals decreased very materially the deeper the net was sunk, and there was also a rapid decrease in the number of species. Only Copepods and certain Radiolarians (Phaeodariæ) were found living at depths of 3,500 meters. Five casts from 3,500 to 2,000 meters contained nothing except Copepods and Phaeodariæ. Nearer the surface, from 2,000 to 1,000 metres, Sagittæ were added to the above groups, besides

[1] Hensen, V., Ueber die Bestimmung des Plankton's. Fünfter Bericht der Kommission zur wiss. Untersuchung der deutschen Meere in Kiel. 1887.

[2] Die Plankton Expedition von Victor Hensen, 1891.

[3] K. Brandt, Verhandl. d. Gesell. f. Erdkunde, Berlin, 1889, p. 515. Ueber die biologischen Untersuchungen der Plankton-Expedition.

single individuals of Siphonophores, Craspedote Medusæ, Ostracods, Amphipods, Decapods, Salpæ, Doliolum, and young fishes. Eleven casts from 1,000 to 600 meters gave similar results, only the diversity was still further increased by the presence of Schizopods, Pteropods, Alciopidæ, and Tomopteridæ. How far these animals were the dead or recently dead carcasses of the mass of pelagic life living nearer the surface is of course not known, and, while hauling up from great depths through the column of water lying below the 200 fathom pelagic belt, we might expect a goodly number of such finds among the presumed inhabitants of the depths at which the self-closing net was operated.[1]

It must be remembered that, while many of the pelagic animals are most delicate, and decompose after death with great rapidity, yet when sinking from the surface towards the bottom these dead or dying organisms, soon reach a belt of water in which the low temperature as compared to the surface would prevent any very active decomposition, and the cold itself of the lower belts may be one of the causes of the limitation in depth of the bathymetrical range of the pelagic fauna. Moseley has found by experiment that a Salpa would take about four days to reach the bottom in a depth of 2,000 fathoms.

A few Velellæ, no Physalia, but a few Porpitæ, were met with, while Diphyes occurred in nearly all the hauls, either with the surface or with the vertical net. About twenty casts were made to determine the occurrence of organisms near the bottom, but owing to the failure of the sounding machine and its uselessness it was impossible to tell what the depth was, as the Sigsbee machine was not, according to Krümmel and Brandt, constructed according to specification, and gave out after the fifth trial; and hence no data of the depth of the bottom accompany the casts for the determination of the intermediate fauna.

To those of us who have been accustomed to fish for the pelagic fauna along the course of the Gulf Stream and off the east coast of the United States, it seems incredible, as is asserted by Hensen, that the pelagic fauna of the Atlantic is much poorer than that of the North Sea or the Baltic.

The success of the Plankton expedition in making their best surface hauls on the lee side of the ship is not a new experience to old fishermen. In all our dredging expeditions the lee side of the ship naturally has invariably been used to catch floating pelagic stuff, and the tow-net is always placed on that side. The floating tow-net of the "Hirondelle,"

1 There being no description of Hensen's self-closing net, we cannot judge of the value of his results as settling the existence of a deep-sea intermediate fauna.

a pelagic trawl, seems to have escaped the notice of Brandt and Hensen, and a huge tow-net has been in use by the "Albatross" for many years.

I find it difficult to agree with Hensen's statement that it "is nonsense to think one can run the tow-net at a given depth horizontally, and that it is therefore mere waste of money to equip for this object." Certainly no one will claim to have towed along a mathematical line. All the variables which enter into the question as to the depth at which the net has been towed, — the speed of the vessel, the weight of the rope, its resistance as well as that of the net, and the shot which loads the extremity of the line, — undoubtedly make it a most intricate mathematical problem. But practically there is no such impossibility in keeping the tow-net within a very moderate distance of the required depth, and making constantly a careful record of the angle at which the line tends from the dredging boom. In our practice the net is first lowered vertically to the required depth, then the line is let out gradually, so that its length plus a small amount, taken from logarithmic tables, will represent the hypotenuse and catenary of the triangle along the base of which the net moves with a given speed which is carefully regulated by the angle of the rope. The shot used to sink the rope and net is a 200 pound shot, and a 60 pound shot at the end of the net halyards. This is about the weight of the wire rope to a vertical depth of 300 fathoms. The Tanner dredging quadrant angle-indicator[1] is in constant use to regulate the speed, and we feel satisfied from our extended practice that the difficulty of keeping the tow-net, say for fifteen or twenty minutes, at or near a given depth is comparatively slight, although the constant mathematical calculation of the exact position of the net is wellnigh impossible. The elements of error in estimating the height of the column of water passed through by the tow-net while towing vertically are equally great, and the same variables which Hensen enumerates as impossible of satisfactory reduction apply equally well to the rigid mathematical calculation of the height of the column through which the tow-net has passed. And yet he must be perfectly satisfied with his approximate measurement of that vertical column.

Hensen evidently does not think it of importance to limit the towing to a short column; his net closes after travelling 250 meters, and of course everything in that column is filtered through his net. Hensen has called attention to the danger of Chun's net opening on its way down, and also closing so that it would bring up nothing, leaving it

[1] Plate XXVIII., Appendix A, Report of the Commissioner of Fish and Fisheries for 1883, Washington, 1885.

uncertain whether the result was due to there being nothing at certain depths or to the action of the net itself.

While it is true that we made no volumetric or quantitative measurements of the material obtained by the tow-net, yet as we invariably used the same large pan, filled to about the same height, for the washing out of the contents of the tow, and as this water was then carefully examined in smaller dishes, it was not a difficult matter to make comparisons, which, though not quantitatively accurate as those of Hensen, yet differed sufficiently to show us a degree of variation in the quantity of pelagic animals far greater than that admitted by him. Hensen very justly says (p. 71): "Da sich die Massen im Ocean bei zu dieser Tiefe (400 m.), wenngleich mit abnehmender Dichte vertheilen, so ist es unzweifelhaft, dass dort selbst bei grossen Fängen die Dichte des Planktons nur gering ist." He adds in a note: "Die Bestimmung, wie die Massen nach der Tiefe zu abnehmen, erfordert genauere Analyse der gemachten Fänge, als bisher ausgefürt werden konnte; *die Hauptmasse findet sich meistens an der Oberfläche.*" The italics are mine.

It seems to me as if Hensen had himself given here an excellent reason for the value of fishing horizontally or in limited vertical ranges, neither of which he considers of any value.

Hensen's views regarding the depth at which the so called deep-sea Siphonophores exist are as follows: "Das Vorkommen von Fangfäden an Lothleinen [or also dredging wires] ist an und für sich überhaupt kein Beweis, den diese Leine geht zweimal durch die Oberfläche und kann hier alles fangen."

The discussion of Hensen regarding the accumulation of pelagic animals along extended rows I cannot understand. That such winrows exist near the shores he himself admits; that they are due near the coast to the greater or less interference of the complicated shore tidal currents seems to me self-evident. The action of counter currents and eddies complicated by the action of the prevailing winds is so well known to collectors at special localities that at certain stages of tide and wind one may feel sure of finding these accumulations at given points. That such winrows also occur on the track of great oceanic currents has been my experience in the Caribbean and Gulf of Mexico, in the Gulf Stream from 150, 200, or 250 miles from the coast, and that there they are also probably due to similar eddies and counter currents acted upon by the prevailing winds.

The Gulf Stream, with its ever fluctuating belts of currents, its rips, and the great Equatorial Current off Panama, with its bands of colder and warmer water, its velocities from little or nothing to five or six knots, and its endless counter currents and eddies, did produce such winrows on several occasions at great distances from the shore, — over 600 miles. That these accumulations of pelagic animals on the surface are intensified on calm, brilliant days, goes without saying. How far they retreat below the surface when they disappear, we do not yet know. Such accumulations continue sometimes for a whole season on the surface. We have had at Newport Salpæ rendering surface fishing absolutely useless for more than six weeks, and again Ctenophores have been as great pests for as long a period, later in the fall.

The most extraordinary winrows I have met were off the Tortugas, about 150 miles to the northward, where the surface of the Gulf of Mexico for a whole day's steaming swarmed with Globigerinæ. It was a dead calm. Again, steaming from the Tortugas to Key West, a distance of sixty miles, outside the reef, we kept in sight a long comparatively narrow line of Linerges all the way from one locality to the other, and it extended eastward as far as the eye could reach beyond the entrance to Key West harbor.

Again, in the track of the Gulf Stream we passed for a quarter of a mile through a stretch of Trichodesmiæ of a width of about a hundred yards judging from the discoloration of the water. And in this last cruise, when about half-way from Cape San Francisco to the Galapagos, we remained for a whole day within the belt of a swarm of Nautilograpsus, the current running at the rate of nearly four knots in twenty-four hours. Again, for more than seven hours we steamed against a current of about three miles through a field of gigantic Salpæ, which extended on each side of the ship as far as one could see. Finally, we passed through winrows of a new species of Siphonophore, a gigantic species allied to Praya, which filled the water in compact masses on all sides of us as we slowly forced our way through it between our dredging stations on the way to Cocos Island from Point Mala.

Hensen, in his quantitative analysis of the pelagic fauna, does not seem to have given sufficient weight to the changes due to seasons, to currents and winds, and to local influences, and in his earliest experiments, dating back to 1882, and carried on from Kiel to the Danish islands, he has disregarded many important variables noticed by other observers.

He himself mentions the sudden occurrence, on the Scottish coast,[1] of

[1] We should remember that all observations made on the Scottish coast, the North Sea, and Baltic are within the area of the 100 fathom line, and at no great distance from land.

swarms of Limacina, and of Sarsia and Aurelia[1] in the Bay of Kiel, and contrasts these swarms with the poverty of the surface of the sea far from land. We are scarcely justified in assigning the presence of food as the cause of the sudden appearance or disappearance of these swarms of pelagic animals, and we cannot entirely agree with Hensen when he asserts that the Pyrosomæ, Salpæ, and Ctenophoræ occur in limited schools, depending upon the influence of the richer or poorer Plankton. A single day in a given locality is certainly not sufficient time to allow for such a change in the food supply of the sea as to account for the sudden appearance at sea or along our coasts of such masses of Salpæ, of Ctenophoræ, and of Diphyes as often render all attempts at surface or other pelagic fishing hopeless.

It is true that in our experience we have frequently (in the open sea) passed over extensive tracts where the surface fishing was comparatively unproductive; but we have rarely been twenty-four hours without finding some district which more than made up for the poverty of its neighborhood.

Haeckel's Plankton Studies.

In Haeckel's historical sketch of the study of the pelagic fauna,[2] no well informed reader can fail to notice the absence of reference to most of the work done by Americans in this field. Surely, no investigator is justified in omitting from a general review of this kind the older literature on the subject. We naturally suppose that no one willingly ignores the work of his predecessors, and, indeed, any one may be excused for not having at hand the latest pamphlet on a given subject. But there is no such valid excuse for disregarding contributions which date back ten or more years, and have been regularly noted in the annual reports of progress in zoölogy, in order to give undue prominence to publications which deal only indirectly with the subject in hand.

If Haeckel had taken the pains to look up the literature of his subject, he would have found that there has been a vast amount of surface work accomplished by the American dredging expeditions, and that, while it is true that much of this material has not as yet been worked up, still it is not probable that any sea-coast has been so carefully explored as has the east coast of the United States along its immediate shores, and along the course of the Gulf Stream, by the "Fish-Hawk," the "Blake,"

[1] Swarms of Aureliæ, forming huge patches which discolor the surface of the sea over considerable areas are not uncommon in Massachusetts Bay.

[2] Plankton-Studien, von Ernst Haeckel, Jena, 1890.

and more especially by the "Albatross," which has invariably, during more than six seasons, used the surface tow-net and an open deep-sea tow-net in connection with its other work, and which has been duly recorded in the Annual Reports of the United States Fish Commission.

As early as 1865, in the "Seaside Studies," a sketch of the pelagic surface fishing off the coast of Massachusetts was given. In addition to the chapter on the Pelagic Fauna of the East Coast of the United States given in the "Three Cruises of the Blake," papers on the surface fauna of the Gulf Stream, on the pelagic stages of fishes, and numerous notices scattered through various embryological and faunistic memoirs,[1] there is an account of the fauna of the surface water of the Gulf Stream off New England, drawn up by Professor A. E. Verrill[2] from the material collected by the United States Fish Commission during many seasons' work, up to 1883.

The "Albatross" used a number of muslin nets (silk bolting cloth), known as "trawl rings," attached to the ends of the trawl frame, so as to be somewhat above the bottom, and many pelagic species have been

[1] Seaside Studies, by E. C. and A. Agassiz, Boston, 1865.

See also remarks on the occurrence of pelagic types, by A. Agassiz, scattered through the following papers: —

The Embryology of the Starfish, 1864, reprinted in Mem. Mus. Comp. Zoöl., Vol. V. No. 1, 1877.

Revision of the Echini, Ill. Cat. Mus. Comp. Zoöl., No. VII. Part IV., 1872–74.

North American Acalephæ, Ill. Cat. Mus. Comp. Zoöl., No. II., 1865.

Surface Fauna of the Gulf Stream, Mem. Mus. Comp. Zoöl., Vol. VIII. No. 2, 1883, and other papers on the Embryology of New England and Florida Invertebrates.

Embryology of the Ctenophoræ, Mem. Am. Acad., Vol. X. No. III., 1874.

Pelagic Stages of Young Fishes, by Agassiz and Whitman, Mem. Mus. Comp. Zoöl., Vol. XIV. No. 1, 1885.

On the Young Stages of Bony Fishes. I. Proc. Am. Acad., XIII., 1877–78; II. Ibid., XIV., 1878–79; III. Ibid., XVII., 1882.

Bull. Mus. Comp. Zoöl., Vol. VI. No. 8, Letter No. 4, 1880.

Bull. Mus. Comp. Zoöl., Vol. VI. No. 9, 1880, Sigsbee's Gravitating Trap.

Am. Jour. of Science, 1888, Vol. XXXV. p. 421, Review of Chun's Die Pelagische Thierwelt.

Three Cruises of the "Blake," by Alexander Agassiz, Bull. Mus. Comp. Zoöl., Vols. XIV., XV., 1888.

And, finally, Three Letters from Alexander Agassiz to Col. Marshall McDonald on the Cruise of the "Albatross" in 1891, Bull. Mus. Comp. Zoöl., Vol. XXI. No. 4, published before Haeckel's Plankton-Studien had reached this country.

[2] Results of the Explorations made by the U. S. Fish Commission Steamer "Albatross," Lieut. Z. L. Tanner commanding, off the Northern Coast of the United States in 1883, by A. E. Verrill, Washington, 1885. Annual Report of the Commissioner of Fish and Fisheries for 1883.

obtained which have not occurred in the surface nets. Of course, as Professor Verrill remarks, it is impossible to know whether such species actually live at or near the bottom, at the surface or in intermediate depths, for they are liable to enter these nets at any time during the descent or ascent of the trawl, as well as during the time that it drags on the bottom.

There is also a more detailed account of the Medusæ collected by the "Albatross," by J. Walter Fewkes, in the Annual Report of the Commissioner of Fish and Fisheries for 1884, Washington, 1886; but to give the lists of depths, varying from the surface to 2,369 fathoms, of specimens brought up with the trawl or in the "trawl rings," does not add to our knowledge of the bathymetrical range of the Medusæ collected. These localities and depths would have supplied Haeckel with many valuable bathymetrical stations. It is astonishing that he should not have availed himself of such appropriate data.[1] We can only suppose that Haeckel wilfully ignores whatever does not bring grist to his mill, or does not chime with his preconceived notions of the order of nature.

If Haeckel had taken the trouble to read the statements I made regarding the bathymetrical range of pelagic life,[2] he would have found that I stated in the "Three Cruises of the Blake" (Vol. I. p. 37): "These experiments serve to prove that the pelagic fauna does not extend to considerable depths, and that there is at sea an immense intermediate belt in which no living animals are found, — nothing but the dead bodies which are on their way to the bottom." I may also refer Haeckel to another and similar statement in the same volume (p. 202), in the chapter on the Pelagic Fauna and Flora: "The above experiments appear to prove conclusively that the surface fauna of the sea is really limited to a comparatively narrow belt in depth, and that there is no intermediate belt, so to speak, of animal life, between those living on the bottom, or close to it, and the surface pelagic fauna. It seems natural to suppose that this surface fauna only sinks out of reach of the disturbances of the top, and does not extend downward to any depth. The dependence of all the pelagic forms upon food which is most abundant at the surface, or near it, would naturally keep them where they found it in quantity." And again (p. 178): "How far down the pelagic fauna sinks during the day or night, to get out of reach of disturbances, is not

[1] Haeckel likewise omits all reference to the experiments of the Prince of Monaco, as well as those of Professor Fol off the Riviera.

[2] Bull. Mus. Comp. Zoöl., Vol. VI. Nos. 8, 9, 1880. Letter No. 4, on the results of the third cruise of the "Blake," and description of Sigsbee's gravitating trap.

yet accurately known; we can only form a rough guess from the few experiments made on the 'Blake.' . . . The lowest point is probably not far from 150 fathoms, which is perhaps the limit also of the greater superficial disturbances of heat, light, and motion, within which we may imagine the pelagic fauna to oscillate."

I also stated, in 1888 (Am. Jour. of Science, Vol. XXXV. p. 422): "Neither can the method adopted on the 'Blake,' of collecting at intermediate depths by means of the Sigsbee collecting cylinder, be considered decisive. It has not been tried long enough, or frequently enough, at great depths (it was not carried beyond 150 fathoms) to decide the depth to which the surface pelagic fauna might sink, or to prove the existence of an intermediate deep-sea fauna in the depth between the surface fauna and the deep-sea fauna."

I would also recommend to Haeckel's notice the following statement, by Murray, which is in full accord with the experience of the cruises of the "Blake" and of the "Albatross": "Mr. Murray's[1] researches led him to conclude that the great majority of pelagic organisms live at various depths, down to and even deeper than 100 fathoms, during the day-time and rough weather,[2] and only come to the surface during the night and in calm weather."

Both Thomson and I were careful to state that the question of the bathymetrical range of the pelagic fauna could only be definitely settled by the use of tow-nets so constructed as to tow horizontally at intermediate depths, and capable of being closed at will.

As for the proposition I enunciated that the deeper parts of the ocean contained no organic life, and not, as Haeckel says, "dass die Pelagische Thiere nicht tiefer als 100 Faden hinabgehen"; that must stand or fall, or be limited by explorations of a very different character from those of the "Challenger." It is childish for Haeckel to state that the so called exact experiments of the "Blake" are absolutely contradicted by the positive results of the "Challenger." If Haeckel is satisfied to base his

[1] Voyage of the "Challenger," Narrative of the Cruise, p. 218.

[2] Hensen considers the great percentage of water which enters into the composition of pelagic animals as a cushion against shocks, while the animals form, as it were, part and parcel of the surrounding medium. I may refer here to some measurements I made regarding the quantity of water entering into the composition of Echinoderms and Acalephs, which show how small a percentage of animal tissue they contain. For a large Cyanea there was no less than 99 per cent of water. The differences in the percentage of water contained in the tissues of pelagic types may account for their greater or less sensitiveness to the disturbing influences of waves and winds. See Proc. Bost. Soc. Nat. Hist., 1869, Vol. XIII. p. 107.

views on the population of the intermediate deeper parts of the ocean upon the positive results of the "Challenger" tow-nets, we must leave him to the full satisfaction of his belief. Haeckel's ideas of exact experiments must be very peculiar, if he imagines that an ordinary tow-net dropped to any depth, and then towed open all the way to the surface, will give us any exact data as to what is living at the deepest point reached. No amount of differential work will prevent that tow-net from gathering the pelagic fauna of the upper belt of 200 to 300 fathoms, which all the recent explorations at sea have shown to contain the greater mass of the pelagic fauna.

The dogmatic assertions of Haeckel regarding the value of the results obtained by the "Challenger" tow-nets are in marked contrast with the cautious statements of Sir Wyville Thomson, and they may be reproduced here for the benefit of Haeckel.

In the first place, the tow-net experiments of the "Challenger" were only conducted during the last part of the cruise: "In the investigations with the towing-net, made by Mr. Murray during the latter part of the cruise — at all depths, the nets being either sent down independently to the depths required, or attached to the dredge or trawl rope";[1] and while it is true that Thomson thought "that Radiolarians inhabit the water of the ocean throughout its entire depth, or, at all events, its upper and lower portions,"[2] yet we find in his summing up of the results obtained from the tow-nets the following statements: —

"We have every reason to believe, from a series of observations, as yet very incomplete, with the tow-net at different depths, that while foraminifera are apparently confined to a comparatively superficial belt, radiolarians exist at all depths in the water of the ocean. At the surface and a little beneath it the tow-net yields certain species; when sunk to greater depths additional species are constantly found; and in the deposit at the bottom, species occur which have been detected neither on the surface nor at 1,000 fathoms, the greatest depth at which the tow-net has yet been systematically used; and specimens taken near the bottom of species which occur on or near the surface give us the impression of being generally larger and better developed. The results from the tow-net are not so directly satisfactory as those from the trawl or dredge, which usually bring up animals which we know from their nature must have lived on the bottom, and it requires a little consideration to arrive at their precise value. . . . At present the tow-net, which

[1] Challenger, Atlantic, Vol. II. p. 341. [2] Ibid., p. 340.

consists simply of a conical bag of muslin or buntine attached to an iron ring, is constantly open, — descending, dragging along, and ascending. If worked on the surface there is of course neither difficulty nor question, but if brought up from 500 fathoms, at which depth it has been towing for some time, the net may be supposed to contain chiefly the species living at that depth; but mixed with these there must be a considerable number of more superficial forms, some taken when the net was going down with its open mouth downwards, and many more captured during its long ascent of half a mile through the upper layers. We cannot therefore as yet say with certainty whether the surface species live in the deeper belts or not, but we are justified in concluding that species which are absent on the surface, and present only when a certain depth has been gained, are special to that and probably to greater depths. If again species differing both from those procured on the surface and at intermediate depths are found in the bottom deposits, it is a legitimate inference that these live below the zone of our deepest tow-net observations." [1]

The expedition of the "National," much as it has been ridiculed by Haeckel [2] and his champion, Carus Sterne,[3] has done more to show that the pelagic fauna is a very scanty one to below 200 fathoms (400 meters) than all the work of all the other explorers together. The object was to work up the "Plankton." It is true it was not worked up according to Haeckelian methods,[4] but it has the immense advantage of being accurate, and not being based either upon guesses or upon misrep-

[1] Challenger, Atlantic, Vol. I. p. 236.

[2] In his attack on Hensen's work, Haeckel constantly refers to the "Ziele u. Wege der heutigen Entwickelungsgeschichte," Jena, 1875. In the present diatribe, he has almost surpassed his former achievements. Such contemptible attempts to overwhelm one's opponents with calumnies as are printed on pages 80 and 81 of the pamphlet referred to above are in accordance with his customary mode of argument.

[3] Rundschau, March, 1891.

[4] I quote from Hensen's Die Plankton-Expedition und Haeckel's Darwinismus, (p. 9): "Der Angriff auf die Expedition . . . kann vielleicht viel schaden, den er wird getragen von einer Autorität und wird begründet mit einer so grossen Anhäufung von einseitig gedeuteten Thatsachen, dass jeder mit den Verhältnissen nicht genau Vertraute davon überzeugt wird, dass die Plankton-Expedition völlig verfehlt sein müsse. Dennoch ist solche Ueberzeugung nur auf Sand gebaut und steht in völligem Wiederspruch mit den Thatsachen; und zwar nicht nur mit denjenigen, welche unsere Expedition nachweist, sondern, wie ich zeigen werde, selbst mit den Berichten, welche andere Expeditionen gegeben haben, sofern man dieselben nur richtig versteht."

resentations and scientific dishonesty, nor is it bolstered up or strengthened by abuse of one's opponents.

The majority of the organisms of the so called intermediate oceanic zones, as enumerated by Haeckel, have thus far proved to be inhabitants of the upper belt of less than 300 fathoms from the surface, and his attempts to subdivide this comparatively narrow belt of vertical distribution by expanding it to depths of which nothing is known, is thoroughly Haeckelian.

I can imagine no more disingenuous statement than the following, where Haeckel is speaking of Murray's account of the probable contents of the "Challenger" tow-nets coming up from great depths: "Er konnte aber dabei nicht dem Einwand entgehen, dass der Inhalt dieser beständig offenen bleibenden Taunetze aus sehr verschiedenen Tiefen, *oder auch nur von der Oberfläche stammen könne.* Den beim Heraufziehen des offenen Taunetzes konnten *möglicherweise* Thiere aus den verschiedensten Tiefen-Zonen *zufällig* in dasselbe hineingelangen." The italics are mine, and the kindness of the inhabitants of the deep in marshalling themselves, for Haeckel's[1] special edification, according to the depth from which they came, must be self-evident.

The subdivisions of bathymetrical distribution of the Radiolarians in the intermediate zones adopted by Haeckel are based upon the kind of evidence detailed above. Their true value, as well as that of the new nomenclature he has been good enough to flood us with in order to denote his imaginary bathymetrical ranges and their organic contents, can be accurately measured by those who do not allow themselves to be deceived by the dust and mud thrown up by Haeckel in the discussion of this subject.

I should be the last to question the indefatigable industry of Haeckel, which has produced the Monographie der Radiolarien, the System der

[1] It is one thing to clear up an old subject and introduce precision by a judicious manufacture of new terms, but it is quite another thing to burden a comparatively new and confused subject with such a superabundance of new names as are found in Haeckel's "Plankton-Studien." Moseley, in his Address on Pelagic Life, in 1882, was among the first to distinguish the different elements which go to form the pelagic fauna and flora, and his analysis has formed the basis of the endless subdivisions baptized by Haeckel. It is unfortunate that the value of Haeckel's analysis should be limited in so great a degree to his redundant terminology. Haeckel has enriched our nomenclature of deep-sea and pelagic faunistic combinations with a few dozen names which correspond usually not to anything known from observation or existing in nature, but to the pigeon holes skilfully put together by him.

Medusen, the deep-sea Medusæ, the Siphonophores, and the Radiolaria of the "Challenger" expedition. Yet I must remind the reader of Haeckel, that, in spite of the graphic account he gives of his own pelagic studies,[1] and in spite of his activity as a surface collector from localities near shore, he has had no experience whatever at sea of the sort of pelagic work which he so complacently condemns *ex cathedra.* The observations on the pelagic fauna on which Haeckel prides himself, made as a passenger in an East India steamer running from Suez to Bombay and to Ceylon, are of necessity, like its phosphorescent track, somewhat superficial.

The assumption made by Haeckel's satellite, Carus Sterne, that the cost of this expedition might have been saved had Haeckel been consulted as to its probable value, is as silly as it is unscientific. But it is fully in accordance with the dictum of the zoölogical pope at Jena that such an expedition was useless because he did not believe in its results. It is surprising that no one should as yet have objected to the cost of printing so many zoölogical fancy sketches as have come from Haeckel's facile pencil.

The account given by Haeckel of the distribution of the pelagic fauna and flora is premature, and as an accurate catalogue representing our knowledge is worthless. No attempt has been made to eliminate data which are in the least doubtful, but everything is enumerated as a correct observation of depth from the contents of the open townets of the "Challenger" to the material brought up on dredging and fishing lines and in the imperfectly self-closing nets of the "Vettor Pisani." The material obtained by Chun in the Mediterranean is not compared with that of the oceanic basins, and of the doubts which Chun himself and Hensen have thrown on the efficiency of the Petersen-Chun net he does not even speak. As a mere enumeration of the surface material, Haeckel's account will be useful if the future observer learns to separate fact from fiction.

The first observations of Chun,[2] as I have already stated, were made comparatively near shore and in the Mediterranean to a depth of 1,400 meters, and the conditions existing there or in the deep fiords of the coast of Scotland are of no value regarding the extension of the pelagic fauna in an open oceanic basin ; and it certainly is noteworthy that Hensen should have considered it sufficient to explore a belt of only 400 meters in depth, to get an adequate idea of the Plankton of the Atlantic Ocean, during the " National " expedition.

[1] Plankton-Studien, p. 16.

[2] Bibliotheca Zoologica, Heft I.

The regular appearance of certain forms at definite fixed periods has long been known to American investigators, as well as the periodic rising and sinking of fully grown forms of Salpæ and Ctenophoræ. But the facts seem to have had no value until rediscovered by Haeckel's friends.

It is not so astonishing as Haeckel seems to think that Hensen's results should be in direct opposition to those of the "Challenger"; the methods were entirely different, and the results of the "Vettor Pisani" were all vitiated by the serious defects of the net in use at great depths.

That I may not seem to be utterly prejudiced against Haeckel's methods, I will quote the views of one of the naturalists in the "National" expedition of the tactics in use by him: "Dass die Angriffe von Haeckel theils auf Mangel an Einsicht, theils auf Missverständnisse, theils endlich auf grobe Entstellungen und unverantwortliche Unrichtigkeiten in der Wiedergabe der Befunde anderer Forscher zurückzuführen sind."[1]

Observations on the Pelagic Fauna of the Panamic District by the "Albatross."

At every station we occupied, the surface tow-net was brought into requisition, and the contents of the net examined. The surface tow-nets, of about four feet in diameter, were made of muslin with a trap and a bag at the end of silk bolting cloth. A small net of finer bolting cloth was suspended in the centre of the opening of the net. This large tow-net was towed from the end of a boom off the ship's side when the speed of the vessel was sufficiently slow. A number of larger and more prominent surface animals were also constantly collected from the ship's deck with long hand nets. Excellent collections were invariably made with them when the electric light was lowered alongside. A very respectable collection of surface animals was thus brought together, which will form an interesting nucleus for comparison with the catches obtained by the Tanner tow-net at these same localities, either when dragged at definite depths, or when collecting on its way up from that point to the surface. As will be seen from the record of submarine tow-net stations (page 4), a number of collections were made which when carefully collated ought to give us important data respecting the bathymetrical range of the pelagic fauna.

In the Panamic region, currents from the west, from the north, and from the south meet, and then are diverted to a westerly direction, forming a sort of current doldrums, turning west, or east, or south,

[1] Brandt, Schriften des Naturw. Vereins f. Schleswig-Holstein, VIII., Heft 2.

or north, according to the direction of the prevailing current. The amount of food which these currents carry is small compared with that drifting along the course of the Gulf Stream. I was also greatly surprised at the poverty of the surface fauna. Except on one occasion, when during a calm we passed through a large field of floating surface material, we usually encountered very little. It is composed mainly of Salpæ, Doliolum, Sagittæ, and a few Siphonophores, — a striking contrast to the wealth of the surface fauna to be met with on a calm day in the Gulf of Mexico near the Tortugas, or in the main current of the Gulf Stream as it sweeps by the Florida Reef or the Cuban coast near Havana.

Although we often dredged in strictly characteristic Globigerina ooze or over bottoms containing numerous tests of Globigerinæ and Orbulinæ, I was much struck with the absence of living Globigerinæ on the surface. Only on two occasions during a calm did we come across any number of surface Globigerinæ and Orbulinæ. No pelagic Algæ were found, yet they occur in great fields off the west coast of South America as far north as Ecuador.

The number of new species which were constantly turning up in the contents of our tow-net, when hauled from 200 fathoms to the surface, plainly shows that no reliance can as yet be placed upon deductions drawn from the comparison of the contents of the nets at different localities and at varying depths. We evidently know as yet too little of the characteristic pelagic species living within the 250 or 300 fathom bathymetrical belt to enable us to state that the contents of open tow-nets lowered, say one to 500 fathoms and another to 1,000 fathoms, no matter how different they may be, are not due to the pelagic fauna living in the upper belt between the surface and 200 or 300 fathoms.

I am not questioning the existence of pelagic, or rather free-swimming species, at a moderate distance from the bottom, nor the presence near shore of such animals at considerably greater depths than those to which the oceanic pelagic fauna extends, or at short distances from shore, where an archipelago may form a barrier, as do the Canaries or the West India Islands, to the free action of oceanic currents, and where pelagic species may accumulate under radically different conditions from those of adjoining oceanic basins.

Too little is as yet known of the geographical distribution of the oceanic pelagic surface organisms of either the Atlantic or Pacific Ocean.[1] We know, it is true, something of their geographical distribu-

[1] See an interesting note by Chun in the Zool. Anzeiger, Nos. 214, 215, January, 1886.

tion along our coasts. We can distinguish, to a certain extent, an Arctic, an Acadian, a Virginian, or a West Indian district, as it were, among the Acalephs and other pelagic forms close to our shores. But when we come to attack the problem of the distribution of the pelagic forms of the oceanic basins, we are at a loss, with our present knowledge, to recognize anything beyond geographical realms practically corresponding to the arctic, temperate, and tropical regions of the oceans. The results of the only expedition which has as yet made a preliminary survey of the North Atlantic are not published, and they will probably show us how complicated the problem is when examined with reference to both a horizontal and a bathymetrical range. This part of the problem has been ignored by Haeckel.

To satisfy ourselves of the difficulty of determining the bathymetrical range of pelagic animals by differentiation of the contents of tow-nets sent down open to tow at different depths, we spent some time at Station 3282 in sending open tow-nets to 100 and 200 fathoms, and also at two other stations, with the following results.

On March 7th we lowered a large surface tow-net to a depth of 200 fathoms, and towed at that depth for fifteen minutes, bringing the open net rapidly to the surface at the usual rate. This trial was made at Station 3382, the bottom depth being 1,793 fathoms, the distance from the 100 fathom line about sixty miles, and the distance from land seventy miles.

The bulk of the material collected consisted of masses of a small species of Doliolum and of Sagitta, among these many of the large species of these genera previously mentioned. Among the other pelagic material were to be found the separate bells of the large Siphonophore first observed off Mariato Point, fragments of an Agalma as well as of the huge Pterophysa so often brought up on the dredging-wire rope, many bells of Crystallodes, and species of Diphyes. The other Acalephs were represented by species of Cytaeis, of Liriope, of Æquorea, of Saphenia, of a Melicertum-like genus, and a Stomobrachium, a very delicate pyriform Mertensia remarkable for the great length of its funnel, a Cunina, and a Discophore allied to Nauphanta. The Heteropods were represented by a species of Firoloides. Finally, the surface swarmed with Orbulinæ having an orange-red nucleus; also specimens of Polyipnus and of another Scopelid, of Gonostoma, and of a small fish allied to Astronesthes, several species of delicately tinted rose-colored shrimps in different stages of growth, as well as many larval stages, specimens of Phronima and Hyperia, many young Squillæ, a large semi-transparent Calanus, many Copepods, and many species of Sergestes.

A second haul was then made with the open tow-net from the 200 fathom level to the surface without towing at that depth. The net was drawn up more slowly, but the contents of the net differed in no way from the preceding hauls, except that the quantity of pelagic life obtained was naturally much less than when we spent in addition fifteen minutes in towing at the 200 fathom level. In hauling the net from 100 fathoms to the surface in a still shorter time, the amount of material was still more reduced. The surface tow-net contained scarcely anything, the sea being quite rough, a fresh trade wind blowing.

These hauls, made with open tow-nets, showed little variety in the constitution of the pelagic fauna at 100 and 200 fathoms, the surface animals having been driven to deeper waters by the disturbed state of the upper layers. We obtained nothing in the hauls from 100 and 200 fathoms which had not on some other occasion been obtained in the surface tow-net, though not in as great quantities as when towing at greater depths.

On the evening of the same day, it being calm, the surface tow-net was crowded with Nautilograpsus, and contained also nearly every species we had caught in the morning while towing at depths of 100 and 200 fathoms, and the number of specimens was quite as large as in the greater depths. The Stomobrachium, Liriope, and Saphenia, and likewise the Diphyes and Crystallodes, were more numerous perhaps, while Doliolum and Sagitta constituted the bulk of the material of the tow-net.

On the 9th of April, the Tanner net was sent down to tow at 175 fathoms, and thence hauled open to the surface. The net contained numerous specimens of Doliolum, Salpæ, Sagittæ young and old, transparent Annelids, Tomopteris, masses of Copepods, Leucifer, Sergestes, Schizopods, Sapphirina, Hyperidæ, Phronima, Ostracods, a few small Stomobrachium and Liriope, and numerous bells of three species of Diphyes and of Crystallodes, a few specimens of Pneumodermon, of Atlanta, of Hyalea, and of Creseis, and the same species of Rhizopods found in the surface tow-net at the same locality. No fishes were obtained in this haul.

The haul of the surface tow-net at this locality, though towed on a smooth and calm sea in a bright sun and with no wind, was comparatively poor. The Rhizopods were more numerous than from the deeper haul, but the number of species and of individuals of the Crustacea, Worms, and Siphonophores was much smaller, and there were no Pteropods.

Copepods with large blue eggs were obtained in both these hauls, which were made about 300 miles southeast of Acapulco, and the depth must have been about 2,200 fathoms, as we were near soundings of over that depth.

The same evening, about 250 miles from Acapulco, with a smooth sea which had continued all day, we towed the surface tow-net, carrying the electric light alongside. The net contained small Sagittas, Diphyes, Doliolum, and Hyalea. A great number of Halobates were attracted by the electric light, and caught with hand nets; flying-fish of all sizes were darting about the electric light. The motion of the flying-fish could readily be followed in the water. They used their huge pectorals with extraordinary skill; opening and shutting their wings rapidly, they regulated their speed with ease, and by suddenly opening or shutting either wing, and planting it at a right angle to their course, they managed to check and change their motion and direction instantaneously. Either wing might in any stage of expansion be fully spread out or closed like a fan, and the wings were in constant play, opening and shutting their powerful fans to control their movements. We can understand how readily they manage to escape the attacks of fishes following them from below in the water, or of aquatic birds darting at them from above the surface. The surface net also contained Pteropods, Atlanta, Creseis, a large number of Schizopods, Sergestes, Leucifer, bells of Crystallodes, and numerous small Stomobrachium and Liriope, pelagic Annelids, Copepods, Sapphirina, Glaucus, Firoloides, and pelagic flounder embryos. The number of specimens of Sagitta was extraordinary; they practically filled the net.

In the evening the Tanner tow-net was also sent to 175 fathoms, where it was towed for ten minutes, and the messenger sent down to close it. The lower net came up well filled with the surface pelagic species, which on this day were unusually varied, it having been smooth and calm the previous night, and the morning before the towing was made. But the quantity of animal life was much less, although the deep haul was continued longer than the surface towing. So that on this occasion the bulk of the pelagic fauna was evidently nearer the surface.

The Acalephs of the Panamic District.

As far as I could judge from a preliminary examination of the fragments of Siphonophores and of the specimens in more or less perfect state of preservation brought in by the surface tow-nets and the Tanner net, as well as in the trawl and attached to the dredging rope, the following are the genera which were noticed by us: Anthemodes, Bassia, Agalma, Athorybia, Crystallodes, Nectophysa, Pterophysa, Rhizophysa, Velella, Porpita, Physalia, Praya, Diphyopsis, Diphyes, Abyla, and Cymba.

Crystallodes and the genera of Diphyes were by far the most common of the Siphonophores; we scarcely made a haul of the tow-net without finding some bells or fragments of these two groups.

The other Acalephs were not numerous in species, although sometimes we passed through great numbers of a large species of Liriope, and some of the Ctenophores, of which a species of Mertensia and a Mnemiopsis were the most common. Ocyroë was observed once, Idya was comparatively rare, and Cunina was found occasionally, while the trawl and tow-nets frequently brought up Periphylla, Drymonema, Nauphanta, Atolla, Stomobrachium, an Æquorean allied to Tima, genera allied to Saphenia, to Melicertum, to Lizzia, and to Cytæis, and a genus allied to Rathkea.

Observations on the Pelagic Fauna of the Intermediate Depths in the Panamic District, made by the "Albatross" with the Tanner Tow-net.

As I stated at the time Chun published the results of his first experiments, I considered them inconclusive,[1] and was of course anxious to repeat them in a strictly oceanic district, in great depths, and at a considerable distance from shore.

On Plate I., I have given figures of a slightly modified Chun-Petersen tow-net, which was constructed by Ballauf, of Washington, for my use on this expedition.

Figure 1 shows the closed net ready to lower; Figure 2, the net opened, ready to tow at the required depth; and Figure 3, the closed net on its way up. *f* is the metal frame protecting the propeller *p*. The propeller shaft extends to the crossbar c'', fitting into a socket from which it is relieved after a few turns of the propeller, when the net is first moved horizontally, and liberates the rings of the chain *b* from the bar c'', and thus opens the jaws of the net, bringing the strain on the two parts of the chain *a*. As soon as the propeller shaft passes beyond the crossbar *c*, the upper parts of the chain *a* are relieved, and it then becomes the longest, and the strain comes upon the chain *b*, which pulls

[1] Am. Jour. of Science, 1888, Vol. XXXV. p. 421.

together and closes the jaws of the net at the termination of the time of towing, and it remains closed until it reaches the surface.

The 25th of February we made our first attempt with the modification of the Chun-Petersen closing net for towing at intermediate depths. On towing the same horizontally near the surface, so that we might watch the operation of the propeller in releasing the chains to open and then to close the net, it became very soon evident that but little reliance could be placed on the working of the propeller from the great pressure brought upon the shaft even during the slowest towing; and from this the uncertainty of the action was so great that we could not feel satisfied that the net had closed and opened at the limits within which it was supposed to act. A very small net might work satisfactorily on this principle, and prove useful for attachment to a line for simultaneous serial observations after the fashion in use for serial thermometric work. This was a great disappointment, as from the first account given by Chun I inferred that there were no drawbacks to this machine. He mentions them in the account of his voyage to the Canary Islands. After this failure, we made no other attempt to use the machine, and subsequently our fishing at intermediate depths was carried on with the Tanner self-closing net, a description of which is given further on.

Thanks to the ingenuity of Captain Tanner, we overcame these obstacles. He devised a net which could be closed at any depth by a messenger, and which worked to perfection at 200, 300, 400, and 1,000 fathoms, and had the great advantage of bringing up anything it might find on its way up above the level at which it was towed.

Figure 1 of Plate II. shows the general arrangement of the Tanner deep-sea closing net attached below the heavy shot, *a*, at the extremity of the wire dredging rope, *r*. The net itself is suspended between two ropes, r', r', to which a sixty-pound shot, *b*, is suspended; the extremity of the net is kept in place by a slack line, r''. Around the lower part of the net a set of rings is fastened, through which passes a loop line, going out through pulleys, *p*. At each end of the loop line is fastened a fourteen-pound lead weight, *w*, which is hung close to the pulley by strings, l' l', suspended by loops from a crank, *t*; this crank is securely fastened to the wire rope by a clamp, *n*, the details of which are seen in Figures 4 and 5.

The outer net is made of twine netting, with a mesh for the support of the thinner and weaker muslin which lines the lower half of the net; this in its turn is lined for its lower half with fine close-mesh silk bolting cloth. The net is lowered with the open frame (as represented in Fig. 1) uppermost, at the rate of about 100 fathoms in four minutes; when the net reaches the requisite depth at which it is to be towed, sufficient slack of wire is let out, so that the angle of the wire rope due to the speed of the vessel will keep the net towing at a nearly uniform depth. It is usually towed for twenty minutes, when the speed of the vessel is slackened, as the rope is wound in, until the net is vertical when the ship stops; the messenger, *m* (Figs. 1, 2), is then sent down on the wire rope, and, striking the crank *t*, trips it, and it drops to the position *t'*, as seen in Figure 4. This liberates the loops of the string *l l*, by which the weights *w w* are hung; these drop rapidly to the position *w w*, as seen in Figure 6, pulling both together, and closing tightly the loop which passed round the lower part of the net. The net is then hauled up at the same speed at which it was lowered, and invariably comes to the surface with the bottom part tightly closed. The upper part of the net above the loop remains open, and collects anything found on its way from the depth at which the towing was made to the surface. When the net reaches the surface, the loop closing the net is at once supplemented by winding below it a stout twine; the bottom fastening of the net is then opened, and the inside net carefully washed in filtered sea water, and that in its turn carefully examined.

Figure 2, the messenger *m* (made in halves), showing the grooves, *s*, by which it is fastened to the wire rope *r*.

Figure 3, the extremity of the dredging-wire rope, with its weight, from which the net is suspended.

Figure 4, showing the clamp attached to the wire rope *r*, with its crank, *t*, from which are hung the loops of the line *l*, holding the weights *w w* suspended; *t'* shows the position of the crank after it has been tripped by the messenger *m*.

Figure 5, the same as Figure 4, seen from above.

It will be noticed that we used no contrivance by which the Tanner net was sent down closed, and subsequently opened when at the required depth. To obviate this difficulty, we loaded the wire rope with a heavy shot, *a* (Figs. 1, 3), to counterbalance its weight, and in addition attached to the bottom of the guides of the Tanner net a heavy weight, *b* (Figs. 1, 6), so that, when lowering the apparatus slowly, the net was sent down with the closed extremity leading. In this way the pressure of the water on the bag of the net kept the lower part of the sides closely compressed together. Water passed through only the upper open parts of the net, close to the mouth frame, where the meshes are those of an ordinary bait hand-net. As there is a double net of muslin and of fine silk bolting cloth extending half-way up the net, everything is kept out of the net on its way down. It is an interesting experiment to drag a tow-net through the water with the closed point leading, and to observe how completely the sides are collapsed, and prevent the admission of water into its lower extremity. The water in the pans in which the contents of the net were to be washed was always carefully strained through fine silk bolting cloth, as was done on the "Blake" with the Sigsbee trap. Two pans were thus prepared, one for the contents of the lower part of the net, — the closed part, — the other for the examination of the contents of the upper part of the net, which remained open all the way from the level at which the net was towed to the surface.

On the 9th of March, at Station 3388, at a depth of 1,168 fathoms, fifteen miles from the 100 fathom line and twenty-five miles from the nearest land, we made our first trial of the Tanner net. Before sending it down to the deeper belts, it was tried near the surface within sight, and, the performance of the messenger and the action of the closing weights having proved satisfactory, it was sent to tow at a depth of 400 fathoms, and towed for seventeen minutes, the ship being carefully slowed so as to keep the depth nearly uniform, and then the length of the wire rope gradually reduced from 570 fathoms, the length of line let out on the hypotenuse, to 400 fathoms vertically. The angle of the line was carefully checked the whole time by means of Captain Tanner's goniometer, so that the variation in the depth at which the net was towed could not amount to more than a few fathoms. The messenger was then sent down to liberate the weights hanging from the slings suspended upon the crank of the stopper, which were to close the bottom part of the net. The net was then hauled up at a speed of about four minutes to the 100 fathoms, so that for some sixteen minutes the upper open part of the net was scooping in the pelagic life in its track. When the Tanner net approached the surface, it was found that the bottom part of the net had been securely closed, as represented in Plate II. Fig. 6. The bottom part of the net was opened after having tied securely the upper end of the bottom of the bag, below the loop, to prevent any part of the contents of the open part of the net from falling into it. The lower part of the net was then carefully washed out in water which had been filtered, and that water was then examined. There was absolutely nothing found in the water. On the other hand, the upper part of the bag, which had remained open the whole way up from 400 fathoms to the surface, was found to contain very much the same species we had obtained when towing with the open surface net from a depth of 200 fathoms, two days before, at Station 3382, a distance of about sixty miles. We brought up, in addition to the species obtained at that station, Pyrosoma, Benthoteuthis, a number of Sternoptyx, some of them quite small, not measuring more than half an inch in length, Scopelus, Stomias, Gonostoma, Astronesthes, Melamphaës, Plagusiæ, a fine black Beryx-like fish of a new genus which we had brought up alive in the trawl at Station 3383, and which evidently is not a bottom fish, while I had assumed at that time that it might come from 1,832 fathoms. We also brought up in the open part of the net a number of young Eryoneicus, from half an inch to an inch in length. Our first specimens of the genus came up in the trawl at Station 3375, depth 1,201 fathoms, afterwards at Station 3377, depth 764 fathoms, and, before we lowered the Tanner net, the trawl at Station 3388 had also brought up a fine large specimen of this genus, which we then considered to have come from a depth of 1,168 fathoms. But it is more probable that even the old of this genus, with their huge swollen cephalothorax, are peculiarly adapted to float passively, and live in the intermediate belt between the surface and the deepest point to which the pelagic fauna may extend. At the time the haul with the Tanner net was made, it was blowing quite a fresh trade wind, and it was a favorable day for deeper hauls, as the disturbance of the surface had been great during the earlier part of the day and the preceding night.

On the 11th of March (at Hy. Station No. 2619, depth 1,100 fathoms) the Tanner net was sent to tow at a depth of 300 fathoms. We paid out 430 fathoms of wire rope and towed nineteen minutes. The extra length was slowly taken up, until the line became vertical. The messenger was then sent down to detach the closing weights, the time of the messenger to reach the tripping crank being two minutes and twenty seconds. The time can readily be ascertained by retaining a hold of the wire rope, as the shock of the striking messenger can be most distinctly perceived on deck. The net was then hauled up at the usual rate of about 100 fathoms in four minutes. The Tanner net reached the surface with the bottom of the bag well closed. The same precautions were taken to isolate the lower part of the bag, and with the water in which the net was washed, as on the first trial. As then, we found that the lower part of the bag, closed at 300 fathoms, again contained absolutely nothing.

The upper part of the net, which remained open all the way from 300 fathoms to the surface, contained the same amount and quality of material we had obtained on the first trial. There were, perhaps, not so many specimens of Doliolum, but the same types of Crustacea, Copepods, Macrurans, and Siphonophores, the same species of fishes, with a different larval Plagusia from that of the former haul, characterized by a dark violet black longitudinal band along the flanks, and a young Octopus.

Immediately after the above trial, at the same station (Hy. Station 2619, depth 1,100 fathoms), we sent down the Tanner net to tow at a depth of 1,000 fathoms, to endeavor to ascertain what might be obtained by towing as nearly as possible about 100 fathoms above the bottom. We let out 1,160 fathoms of wire rope, and towed for nearly sixteen minutes; the extra length of rope was then slowly wound in to bring it vertical, and the messenger was sent down to trip the crank; the time of the messenger in reaching the detacher was seven minutes and thirty-five seconds; the Tanner net was then hauled up at the usual rate of four minutes per 100 fathoms, and the customary precautions used in examining the contents of the upper (open) and lower (closed) parts of the net. A sounding was taken immediately after the net came to the surface, and we found that during the time we trawled and towed we had drifted into a depth of 1,482 fathoms, so that we failed in the immediate object of our trial. We found in the closed net a large violet Amphipod, and a brilliant carmine shrimp, of the usual color of the deep-sea Macrurans. These two specimens must have come from a belt of not more than 350 fathoms above the bottom, and were different from anything we had collected before. The open part of the bag contained an Atolla, a fine specimen of the pink Stomobrachium, both probably from a comparatively moderate depth, judging from their perfect state of preservation. The same Crustacea and fishes came up as on other trials in that part of the Tanner net, and also a fine orange Amphipod like one brought up in the trawl at Station 3383, and assumed then to come from a depth of 1,832 fathoms. The open net also contained a huge Noctiluca, measuring about half an inch in diameter, with a peduncle fully ten times the diameter of the disk.

On the 25th of March, at a point not quite half-way between Cape San Francisco and the Galapagos, Hy. Station 2627, the depth being 1,832 fathoms, the Tanner net was sent to tow at a depth intended to be about 100 fathoms above the bottom, and which varied from 1,773 fathoms to 1,739. Within these limits the net was towed for twenty minutes, the same precautions being taken to bring the wire rope gradually vertical before the messenger was sent down to close the net; the messenger was seven minutes in reaching the detacher. The net was then hauled up, and the contents of the lower part, which had closed, were carefully examined, using the same precautions to strain the water of the pans as on former hauls. With the exception of the fragments of a few decayed leaves, evidently caught while on their way to the bottom, the net contained nothing; it was barren of animal life.

The upper part of the Tanner net, which had remained open all the way to the surface, brought up the same species which on former occasions the net contained when towing at a depth of 200 fathoms from the surface. There were found a great number of small Doliolum and of a large Sagitta. The number of individuals as well as of species of Crustaceans in this haul was very marked. Several species of Leucifer, of Sergestes, of Schizopods, Copepods, and of highly colored Hyperiæ probably parasitic on a Salpa, which was abundant, as well as a number of Macrura fully as bright red as any of the deep-sea Schizopod types, in addition to the transparent pelagic types. We also obtained a Stomobrachium, a large Beroë measuring nearly six inches in diameter, a number of bells of Diphyes, and a huge Ostracod allied to Crossophorus, with a thin membranous test, — a giant of its kind, measuring somewhat more than an inch in length. The largest Ostracod previously known is not more than one third of an inch long. The pelagic Benthodytes, which first came up in the trawl at Station 3,364, also occurred in the open part of the net.

Among the so called deep-sea Medusæ several specimens of Atolla and of Periphylla were found in the open part of the net. The net also contained a Leptocephalus and two other species of fishes, the one allied to the Scopelids, the other to the Stomiadæ, many of which have been regarded as typical deep-sea forms.

The surface at this point was also examined with the tow-net, and the pelagic animals found to be the same as those brought up in the open part of the Tanner tow-net on its way from the bottom. The number both of species and specimens was, however, much less than in the Tanner net.

On the following day, March 26, the Tanner tow-net was sent to be towed at a depth of 204 fathoms. After twenty minutes the messenger was sent down and the net hauled up. The bottom part of the net came up tightly closed. Its contents were examined in the same manner as before, in well strained water, and the water was found to be absolutely barren, while the upper part of the net, which came up open and was not more than eight or nine minutes on the way, was only fairly filled with surface life. The upper net contained a few specimens of

Doliolum, Sagitta, Hyalea, Creseis, and a couple of species of Macrurans. The poverty of this deep haul may be accounted for by the corresponding poverty of the surface. The surface tow-nets hauled for nearly twenty minutes contained scarcely anything beyond a few Sagittæ, Appendiculariæ, Copepods, and pelagic fish eggs, and perhaps a larger number of bells of Diphyes and Crystallodes than in the Tanner net; yet the sea had been smooth during the night, and up to 9 A. M., the time of the haul, not a breath of wind had ruffled the surface. Our position, Hy. Station 2628, was a few minutes of latitude south of the equator, about 250 miles from the Galapagos, and about the same distance from Cape San Francisco; the depth probably between 1,500 and 1,800 fathoms. Soon after, the open tow-net was also hauled from a depth of 200 fathoms up to the surface. In addition to the species enumerated above, we obtained Sergestes, larvæ of Penæids, a bright yellow Æolis, a large Stomobrachium, and numerous bells of Crystallodes and Diphyes. The wire rope passed through myriads of Nautilograpsus swarming on the surface; they literally choked the surface tow-net.

On the 8th of April, about 7 A. M., Station 3414, depth 2,232 fathoms, 350 miles from land, the sea was quite rough, a heavy swell rolling, and the trade wind was blowing briskly; the Tanner net was sent to tow at 100 fathoms and closed by messenger; time of messenger in reaching the detacher, forty-five seconds; after towing the net about twenty minutes, it was hauled up to the surface. The lower closed part of the net, and the upper part, which had remained open the whole time, contained the same species. The lower part of the net contained a good deal more animal life, having been towed for twenty minutes at about 100 fathoms from the surface, while the contents of the open upper part passed through 100 fathoms in about four minutes. The haul of the upper net consisted of a large red Cypris, a small transparent cuttle-fish, a few Doliolum, a large pinkish Hyperia, a large Cystisoma parasitic on Doliolum, Sapphirinæ, transparent Penæids, bells of Crystallodes and of two species of Diphyes, fragments of Beroë, a number of Collozoum colonies, and Calanus and other Copepods. The lower net contained the same things, the Sapphirinæ and Hyperiæ being rather more numerous, and a few specimens of Atlanta which had not been obtained in the haul of the upper part of the net from 100 fathoms to the surface.

An hour later, the Tanner net was sent to tow at a depth of 200 fathoms. After towing for ten minutes the messenger was sent to close the net, the dredge rope having, as in all cases of towing at intermediate depths, been gradually brought to be vertical before the net was closed. We found in the lower closed part of the net, in addition to the same shrimps and Copepods obtained from 100 fathoms, Firoloides, Mertensia, and a small Sagitta. In the upper part of the net, which was towed open from 200 fathoms to the surface at the rate of four minutes to 100 fathoms, the animal life consisted of the same species as in the lower part of the net, and in addition the *tasters* of a large Pterophysa fully two and a half inches long, — the same species fragments of which so frequently came up on the dredge rope, — specimens of a large and of a small Sagitta, two species of Phronima, a Typhis, and two species of Salpæ; the Doliolum were more abundant than in the lower depths. Fragments of the bell of a large Diphyes of an unknown genus, from two to three inches in length, with a delicate yellow stem, and a few bells and fragments of another species of Diphyes and of Crystallodes, and a few specimens of Scopelus. Time of messenger in reaching the detacher at 200 fathoms, fifty seconds.

At this same station the Tanner net was next sent to tow at 300 fathoms, but, the detacher lines having got entangled with the dredge-rope swivel, it failed to close, and came up open all the way to the surface from 300 fathoms. The contents of the open net were identical with those of the previous haul from 200 fathoms to the surface; we added, however, a number of young specimens of Sternoptyx. The net was sent again to tow at 300 fathoms, and the messenger sent to close the net after towing fifteen minutes; time of messenger in reaching the detacher, two minutes and forty seconds. The lower part of the net came up well closed, and its contents were carefully examined, taking the usual precautions. The lower closed part of the bag contained nothing. The upper open part of the net contained Sternoptyx, Stomias, Scopelus, a small violet cuttle-fish, and a number of Schizopods, Euphausiæ, Thysanopodæ, Siriella, Nyctiphanes, Eucopia, and the like, apparently identical with those found in the hauls from a depth of 100 and 200 fathoms to the surface. Many of the same Crustacea (Schizopods, etc.) were also obtained in the surface tow-net at this locality, although the wind and swell continued during our experiments, and the surface was greatly disturbed.

On the morning of the 11th of April, the Tanner net was sent to tow for twenty minutes at a depth of 300 fathoms, at a locality about thirty miles southeast of Acapulco, at a depth probably of over 1,800 fathoms, the surface being moderately rough, a light wind having blown all night. The messenger was sent to close the net after the usual precautions, time occupied three minutes and fifteen seconds, and the net hauled rapidly to the surface. The lower part of the net had closed satisfactorily, and on examination was found to be barren of animal life, even at so small a distance from the land. The upper part of the net contained an unusually rich assortment of surface species, a large number of Scopelus, Euphausiæ, Leucifer, Sagitta, fragments and bells of Diphyes and of Crystallodes, species of Schizopods, Doliolum, Salpæ, and some undetermined Penæids, with many Rhizopods, mainly specimens of Collozoum and of Acanthometra.

On the 16th of April, at 10 A. M., about 120 miles in a northwesterly direction from Acapulco, probable depth over 2,000 fathoms, the surface tow-net was hauled, the surface being quite smooth, the wind having gradually lessened from the time we left Acapulco. It contained very little beyond the usual Sagittæ, a small species of Salpa, a few Doliolum and Appendiculariæ, Calanus and other Copepods, Sergestes, Leucifer, and Euphausiæ, the same Mertensia we had found farther south, as well as the bells of a couple of species of Diphyes and of Crystallodes, apparently the same as those we obtained earlier in our cruise.

We then sent the Tanner tow-net to tow for fifteen minutes at a depth of 175 fathoms; it was closed by the messenger as usual. The lower part of the bag contained the same species we had caught in the surface tow-net; the number of individuals, however, was somewhat more abundant, and we obtained in addition Hyalea and Creseis, as well as Squilla larvæ.

On the 22d of April, about 75 miles southwest of Guaymas, in the middle of the Gulf of California, Station 3436, at a depth of 905 fathoms, the Tanner net was sent to tow at a depth of 800 fathoms. We towed fifteen minutes, when the messenger was sent to close the net. We must have shoaled our water, as the bottom net came up containing some mud. We brought up in the net Periphylla, and a new genus of Bougainvillia, allied to Rathkea, having eight chymiferous tubes, but only four clusters of tentacles.

The same day, Hy. Station 2637, at a depth of 773 fathoms, the Tanner net was again sent down to tow for twenty minutes, at a depth of 700 fathoms. The wire rope having fouled the detaching lines, the net came up open all the way to the surface. It must have towed very close to the bottom, as we brought up a fine specimen of Nettastoma, and two of the red deep-sea Caridids; but otherwise it contained nothing which we had not on some previous occasion obtained inside the 200 fathom limit from the surface. The proximity of land was apparent from the presence of numbers of brachyuran larvæ, such as we had already found on the previous day in our surface haul. We obtained Periphylla, Stomobrachium, the new genus of Bougainvillia, bells of Diphyes and other Siphonophores, Doliolum, several species of Pteropods, Sagittæ, Ostracods, Copepods, Hyperiadæ, Schizopods, Penæids, and a few species of pelagic fishes.

On the 23d of April, a few hours before reaching Guaymas, we made one more attempt with the Tanner tow-net, Hy. Station 2638, at a depth of 622 fathoms, sending the net to be towed for about fifteen minutes, at a depth of from 500 to 570 fathoms. We found in this case in the bottom part of the net, which came up tightly closed, a Scopelus, a red Penæid, and a Hyalea, while the upper open part of the net contained the same surface species we had obtained in the surface tow-net on other occasions, such as Squilla larvæ, Ostracods, Doliolum, Euphausiæ, and Pteropods.

Our experience in the Gulf of California with the Tanner self-closing net would seem to indicate that in a comparatively closed sea, at a small distance from the land, there may be a mixture of the surface species with the free-swimming deep-sea bottom species, a condition of things which certainly does not exist at sea in deep water, in an oceanic basin at a great distance from shore, where the surface pelagic fauna only descends to a comparatively small depth, i. e. about 200 fathoms, the limits of the depth at which light and heat produce any considerable variation in the physical conditions of the water. The marked diminution in the number of species below 200 fathoms agrees fairly with the results of the "National" expedition.

The other experiments with the Tanner net, made in an oceanic basin on the way to Acapulco from the Galapagos, and to the Galapagos from Cape San Francisco, seem to prove conclusively that in the open sea, even when close to the land, the surface pelagic fauna does not descend far beyond a depth of 200 fathoms, and that there is no intermediate pelagic fauna living between that depth and the bottom, and that even the free-swimming bottom species do not rise to any great distance, as we found no trace of anything within 60 fathoms from the bottom where it had been fairly populated.

The first experiments of Chun regarding the distribution of the pelagic fauna were made in the Mediterranean, within a comparatively short distance from the shore, and in a closed basin having, as is well known, special physical conditions, its temperature to its greatest depths being considerably higher than the temperature of oceanic basins at the limit of 200 fathoms, or thereabout, which we assume now to be near the limit of the bathymetrical range of the true oceanic pelagic fauna. At 200 fathoms in the Panamic district, the temperature was from 49° to 53°, while, as is well known, the temperature of the Mediterranean soon falls, already at 100 fathoms, to about 56°, a temperature which is continued to the bottom in this closed basin. Of course, if temperature is one of the factors affecting bathymetrical distribution, there is no reason except the absence of light which would prevent the surface pelagic fauna from finding conditions of temperature at the greatest depth similar to those which the surface fauna finds within the limit of 200 fathoms in an open oceanic basin.

My reasons for modifying the results obtained by Chun on his trip to the Canaries, I have given elsewhere, on page 23.

The results even of those who claim to have proved the existence of an intermediate fauna agree in showing that the number of species and the number of individuals greatly diminish near the 200 fathom limit, and that though my first experiment on the "Blake" proved the rapid diminution of the pelagic fauna at or below 150 fathoms, yet the azoic limit is a most variable one, judging from the later results of Chun and of Hensen, and from my own on the "Albatross." As long and as often as the experiments for determining the lower limits are confined to the Mediterranean or any closed or comparatively closed sea basin, or are carried on within close proximity to land, disturbing influences are at work which carry this limit far lower than we find it to be in an open ocean basin, far from land, where below 200 or 250 fathoms; and at 300 fathoms little or nothing has been found by us.

The Galapagos Islands.

As is well known, the Galapagos, when discovered by the Spaniards in the sixteenth century, were uninhabited, and remain so to-day; with the exception of the colony still maintained on Chatham Island by Mr. Cobos, all other attempts at settlement have failed.

Distant only a little over 500 miles from the Ecuadorian coast, they have often been visited by whalers, who landed on the islands for water, and for a supply of the large land turtles which made a pleasant variety in the sea fare of the whaling fleet frequenting these waters during the first half of this century.

The temporary occupation of some of the islands as a penal settlement by the Ecuadorian government followed the attempt at settling

Charles Island in 1831. After the disappearance of the convicts, they were occasionally visited by the orchilla traders, who cut down the scanty forests for the sake of obtaining more easily the valuable moss growing on the trees.

Dr. Theodor Wolf,[1] Ecuadorian State Geologist, has given a most interesting account of his visit to the islands, supplementing in many ways the account we owe to Darwin in his "Voyages of the Adventure and Beagle," and his "Volcanic Islands."

The Flora of the Galapagos.

Dr. Wolf has given a most characteristic description of the three belts of vegetation, which can be recognized on all the islands. (Plates XV.–XX.) The lower or more barren belt, characterized by its stunted vegetation, consisting near the beaches of salt-loving plants, probably all immigrants from the mainland, followed by grayish white apparently dry bushes, with small leaves and inconspicuous blossoms, the most common of which are a Verbena bush and a species of Acacia, with a large tree, the Palo Santo, which grows to a height of thirty feet. Where the lava fields seem to prevent the growth of any other plants, we find a tree-like Opuntia and a huge Cereus (Plate XX.). The last disappear as we rise, and on reaching the so called high plateau, the Acacia and Palo Santo increase in size, and the Verbena vanishes. When we reach the second belt, the lava blocks have become decomposed into a soft reddish earth by the action of the moisture from the prevailing trade winds, which blow refreshingly across from the south, and, carrying with them masses of moisture, have completely changed the aspect of the vegetation on the plateau (Plate XVII.), and of the weather side of the islands. The woods are green, composed of small trees, principally recalling the Polylepis of the Andes; they are open, their paths separated by grassy plots, till we gradually pass into the last and highest region, bare of trees, and covered by a rather coarse grass, which extends to the highest summits of the islands (Chatham, Charles, Indefatigable, and James).

Chatham Island is noteworthy for the special development of the lower volcanic barren region, and of the higher and grassy woody district, and, in addition, is distinguished by the barren volcanic tract which forms the eastern extremity of the island, on which, as we sailed by, we could scarcely distinguish any trace of vegetation, — the whole a mass of blocks of volcanic rock scattered between the numerous small volcanoes

[1] Ein Besuch der Galapagos Inseln, mit drei Kärtchen. Heidelberg, 1870.

so characteristic of that extremity of the island. Here and there grow, like huge candelabra, Cereus and Opuntias, forming clusters often over twenty feet in height, with thick branches; and close to the beach were clusters of small bushes and weeds, which probably represent, with the Opuntias growing between the lava blocks, the earliest flora which found a foothold in the Galapagos.

We may readily imagine, as pictured by Andersson, how, from the decomposition of a few Opuntias, a little humus formed the nucleus from which the seeds of other plants may have diverged, and gradually given rise, by a repetition of the process, to the soil supporting the present vegetation. Perhaps, if we contrast the so called characteristic species of the Galapagos, which find their analogues in the Central American district, we may be justified in looking upon the flora as a part of that district, an outlyer which has extended from the eastern centre to the westward, and yet regard the differences noticed in the flora as an expression of the special conditions due to the position, the climate, the age, and the soil of the islands, as contrasted with the corresponding conditions of the mainland.

As we ascend, we come upon thicker vegetation, not exactly of trees, but of large bushes, gradually passing into the region of small trees and of open fields, over which the mist hanging on the highest parts of the island spreads a slight moisture, and supplies the higher district with abundant vegetation and water over the fields which once were the home of the galapagos. And it may be that Chatham Island, as has been suggested by Andersson, being the one of the islands most exposed to the Humboldt Current and to the southeast trades, is the one which was first covered by South American plants.

On Charles Island, or Floreana, the vegetation is less luxuriant, the distance between the trees and bushes greater than on Chatham, and there seems to be a more definite limitation of the districts occupied by each group of plants (Plates XX., XXI.); and on the shore of Black Beach[1] we come at once upon a number of plants which are quite com-

[1] "We anchored in Black Beach Road in eleven fathoms, sand. This anchorage is an open bay, but being on the west or lee side of Charles Island affords a good shelter from the trades, which blow most of the year. It is the seaport of what was at one time a flourishing settlement, now abandoned, and derives its name from a short stretch of black lava sand beach lying at the head of the bay, between low cliffs of dark lava rock. [See Plates XVIII., XIX.] At the time of our visit [1888] great numbers of cattle, horses, mules, donkeys, sheep, and hogs were running wild. The buildings were fallen to ruin, but there was a plentiful supply of fruit on the trees, from which we procured many bushels of oranges and limes, a

mon on the coast of Panama and Guayaquil. In the upper regions of Charles the vegetation is more luxuriant, the open fields forming quite extensive undulating plains.

The general appearance of the vegetation of Indefatigable is much the same in its general subdivisions as that of Chatham and Charles.

As Andersson says,[1] with the exception of Australia and some of the islands of that faunal district, no land perhaps possesses so many characteristic plants as the Galapagos, as more than half of the plants thus far known are peculiar to the Galapagos, and of these only a very small portion are common to all or a majority of the islands.

Part of the vegetation has come from the West Indies and Panama, or is allied to that of Southern California, of Mexico, of Southern Colombia, and of the high plains of the Western Andes, perhaps as far south even as Chili. No one has better than Hooker[2] given the probable course which was followed by the plants which have reached the Galapagos from these different regions, and which in the course of centuries have become more or less modified, so as to bear but a distant resemblance to the plants now growing in the very regions from which they came.

The course of the currents along the Mexican and the Central and South American coasts clearly indicate to us the sources from which the fauna and flora of the volcanic group of the Galapagos has derived its origin. The distance from the coast of Ecuador (Galera Point and Cape San Francisco) is in a direct line not much over 500 miles, and that from the Costa Rica coast but a little over 600 miles, and the bottom must be for its whole distance strewn thickly with vegetable matter, which, as I have already stated, came up in great masses in almost every haul of the trawl. This was especially noteworthy in the line from the mainland to Cocos Island, and certainly offers a very practical object lesson regarding the manner in which that island must have received its vegetable products. It is only about 275 miles from the mainland, and its flora, so similar to that of the adjacent coast, tells its own story. Malpelo, on the contrary, which is an inaccessible rock with vertical sides (Plate XIV., and destitute of any soil formed from the disintegration of the rocks, has remained comparatively barren, in spite of its closer proximity to the mainland.

pleasant addition to our monotonous fare. The distance from the landing to the first improvements was about three miles, over what had been a good wagon road."— Tanner's Report.

[1] Linnæa, XXXI., 1861-62, p. 595.

[2] Hooker, J. D., Linn. Soc. Trans., 1851, Vol. XX. p. 163.

The velocity of the currents in the Panamic district is very great, sometimes as much as seventy-five miles a day, so that seeds, fruits, masses of vegetation harboring small reptiles, or even large ones, as well as other terrestrial animals, need not be afloat long before they might safely be landed on the shores of the Galapagos. Its flora, as is well known, is eminently American, while its fauna at every point discloses its affinity to the Mexican, Central or South American, and even West Indian types, from which it has probably originated; the last indicating, as well as so many of the marine types collected during this expedition, the close connection that once existed between the Panamic region and the Caribbean and Gulf of Mexico, — a connection once extending, probably, through deep and wide passages all the way from the northern extremity of Colombia, the Isthmus of Panama, Costa Rica, and as far north as the Isthmus of Tehuantepec.

Having followed in the footsteps of Dr. Wolf on Charles Island, I cannot do better than to refer to his accurate description of that island, to which I shall add my own observations, as well as those on Chatham and on Duncan, which the "Albatross" also visited. To attempt the ascent of any one of the islands directly from the beaches near the anchorages is a most difficult task. (See Plates XVIII., XIX., XX.) The lower slopes, although rising very gradually, yet are so covered with stunted vegetation, growing between the crowded angular blocks of lava (Plate XVI.), that progress is very slow. One has to pick one's way over the lower lava fields which extend unbroken to a height of nearly 800 or 900 feet from the level of the sea before they begin to show the effect of the disintegrating action of the moisture of the higher regions of the islands.[1] The general aspect of this higher plateau, both on Charles and Chatham (Plate XVII.), is much varied, a large number of small, isolated rounded peaks rising from the general level to a height of 200 to 400 feet, and culminating towards the central mass in the highest points of the islands. On the weather side the moist region reaches to a lower level than on the lee side, and on both Chatham and Charles this year quite heavy rains extended to the very level of the sea, a somewhat unusual state of things. I was informed by Mr. Cobos

[1] Although Darwin, in his account of the visit of the Beagle to Charles Island, in the last part of September, 1835, after commenting on the similarity, in all the islands, of the first part of the road leading from the sea inland, says: "Higher up, the road gradually became greener, and immediately we had crossed the ridge of the island our bodies were cooled by the fine southerly trade wind, and our senses refreshed by the sight of a green and thriving vegetation."

that rains do not usually extend uniformly to so low a level even during the rainy season,[1] being limited to the higher levels above 500 or 600 feet, and to the higher plateaus, where even during the dry season, the fall and early winter, there are frequent falls of mist.

Arriving as we did at the Galapagos at the beginning of a remarkably early rainy season, I could not help contrasting the green appearance of the slopes of the islands, covered as they were by a comparatively thick growth of bushes, shrubs, and trees, with the description given of them by Darwin, who represents them in the height of the dry season as the supreme expression of desolation and barrenness.[2] Of course, here and there were extensive tracts on the sea-shore where there was nothing to be seen but blocks of volcanic ashes, with an occasional cactus standing in bold relief, or a series of mud volcanoes, or a huge black field of volcanic rocks, an ancient flow from some crater to the sea; but as a rule the larger islands presented wide areas of rich, fertile soil, suitable for cultivation. The experiments at Charles Island, where there is a deserted plantation, and at Chatham Island, where Mr. Cobos has under successful cultivation a large plantation, producing sugar, coffee, and all the tropical fruits, as well as extensive tracts on which his herds of cattle, sheep, and donkeys roam towards the higher central parts of the island, show the fertility of these islands. They are indeed as favorably situated for cultivation as the Sandwich Islands or Mauritius, and there is no reason why plantations, if properly managed, should not in the near future yield to their owners as large returns as they do on those islands.

From the very shore, after passing the coral sand beach (Plate XV.), the road leading from Wreck Bay,[3] Chatham Island, to the hacienda of

[1] Yet the experience of Captain Tanner, in 1888, would seem to indicate that even at the level of the sea heavy rains may occur. He says: "The weather was partly overcast when we left our anchorage at Albemarle, but we thought little of it, supposing it to be one of the short passing squalls so frequent during the rainy season. When we reached the vicinity of Cape Berkeley, however, the rain poured down in torrents for several hours, and it became so thick that we were obliged to stop the engines until the weight of it passed, when we continued our course, anchoring in James Bay at 1.30 P. M. in six fathoms, white sand."

[2] Darwin says of his first landing on Chatham Island: "Nothing could be less inviting than the first appearance. A broken field of black basaltic lava is everywhere covered by a stunted brushwood, which shows little signs of life." And speaking of the plants, he says: "I succeeded in getting only ten kinds; and such wretched-looking little weeds would have better become an arctic than an equatorial flora."

[3] With the consent of the Commissioner of Fisheries, I have added to my own account of the Galapagos extracts from the excellent reports of Captain Tanner

Mr. Cobos was almost impassable from the mud, and on our way up in the last of March, we could not fail to see the traces of the damage done to the road by the washing of the heavy rains which had fallen during February and March, and which were falling during a part of the days we spent on the island. The higher part of the island (Plate XVII.), where the plantations of Mr. Cobos are placed, are well watered by irrigation, and the supply, brought from about five miles, is ample for a large extent of territory. But although there is an abundance of water in the central parts of the islands, we saw nowhere, as on Cocos Island, such an abundance of water running into the sea. The contrast between Cocos and the Galapagos is most striking. Although not very distant, yet the former is in the rainy belt, and its luxuriant vegetation, extending from the summit close to the water's edge (Plate XIII.), is in marked contrast to the distribution of vegetation on the Galapagos. Cocos Island is reeking with moisture, and its rocky faces, matted with ferns and covered with groves of palms towering above the other trees, seem to have nothing in common with the scanty vegetation characteristic of the lowest slopes of the Galapagos.

made to the U. S. Fish Commissioner relating to his visit to the islands in the "Albatross" during the early part of 1888, while on the way from New York to San Francisco: "This [Wreck Bay] is the seaport of the Hacienda del Progreso, a plantation located on the highlands in the interior of the island, about five miles distant, and connected with the coast by a good wagon road. The bay is surrounded by low land covered with bushes and small trees, and a smooth steep sand beach affords convenient landing. The land begins to rise a few hundred yards from the beach, and the ascent is constant until the hacienda is reached, at an elevation of about 900 feet above the level of the sea. The low lands of Chatham, in common with those of all the islands of the archipelago, are entirely without living water, and in the dry season present a most barren and desolate appearance. All this is changed, however, during the rainy season, which usually begins about the 1st of April, and continues until the last of June. It began in February this year, and in consequence everything was fresh and green, the general aspect being decidedly tropical. In company with Señor Cobos and son we rode over a portion of the estate, where we saw great fields of sugar-cane, sweet potatoes, and other tropical and semi-tropical products, growing side by side. A young coffee plantation gave promise of future profit, and oranges, lemons, and limes were growing in profusion. Large herds of cattle were seen feeding in excellent pastures, enclosed with iron fences, hedges, or the favorite broad deep ditch, the proprietor estimating the number of cattle on the island at 20,000. Horses, mules, asses, sheep, and hogs were seen in large numbers, more than sufficient for all purposes of the plantation. Water was procured from a large spring and carried to the settlement by ditches, which could be seen winding around the hills. Chatham Island, and in fact all the islands of the archipelago, are of recent volcanic origin, the only arable land being in the elevated basins of the craters. Here, on the principal cone near the centre of the island, we found the Hacienda del Progreso."

Topography of the Galapagos.

As seen from the sea from the southeast, distant about ten miles, the western half of Chatham Island forms its principal and highest part. It rises more rapidly from its western extremity at Wreck Point to a height of 2,490 feet, as marked on the Admiralty charts. This summit is separated by a high land from the next highest point, which reaches an elevation of nearly 2,000 feet. From here the western mass gradually falls with gentle slopes toward the east, and is separated by a low valley from the central mass, slightly undulating and with two nearly equal summits, which reach less than one third the height of the western half. This in its turn is separated from the eastern extremity of the island, which is somewhat higher than the central mass. The southern slopes of the western mass of the island are covered by numerous small craters, and here and there its even outline as seen against the sky is interrupted by the sharp line of a smaller crater. Along the southern shore on the eastern half of the island there are a large number of the so called tuff craters, readily distinguished from the other craters, even at the distance at which we saw them, by their reddish color. They form a prominent line of well defined low, sharp cones, with more or less perfect craters.

Hood Island we did not visit. Captain Tanner, who passed a day on the island in 1888, says: "It is low compared with others of the group, its surface being covered with masses of broken lava rock. A little soil has formed between the blocks, in which bushes of various kinds find root, and during the season of rains lend a rich green hue to the otherwise barren surface. It is wholly devoid of fresh water during the dry season, and has no commercial value. Gardner's Bay is a good anchorage in the fine weather that usually prevails."

Indefatigable Island is perhaps the one of the Galapagos which best shows the mode of their formation. It forms a single mass, rising gently on all sides toward the great central plateau; its sides are comparatively little broken by lateral craters; the central plateau is surrounded by a series of rounded elevations, the remnants of the rim of the old crater. According to Mr. Cobos, after passing the lower line of the lava boulders one reaches, at about the same elevation as on Chatham and Charles, the plateau region, where the lava has become decomposed into a most fertile soil, and for the size of the island its area fit for cultivation is quite extensive. The general character of the lower slopes, which reach to the water's edge, do not differ from those of the other islands we visited. Innumerable spits, composed of huge lava blocks running into the sea and separated by small coral rock beaches, similar to those I have described at Wreck Bay on Chatham Island, at Black Beach on Charles Island, and on Duncan Island. Conway Bay itself, where we anchored for the night, on Indefatigable Island, is a fine example of one of the coral rock beaches so characteristic of the Galapagos. Off to the north of Conway Bay are the Guy Fawkes Islands, one of the old craters of which is still barely visible. The craters of the other island appear to have been sloughed off on their southern face.

Captain Tanner, in the report of his visit to the Galapagos in 1888, says: "Indefatigable Island is circular in form and about twenty miles in diameter, with a central cone, in the basin of which lies a vast tract of arable, well watered land, capable of growing all the tropical and semi-tropical products in great perfection. Its natural resources are greater than those of any other island in the group, yet it is uninhabited and wholly undeveloped. The low lands are devoid of water, and, like the other islands, barren and desolate during the dry season, the rain only bringing life to the bushes and stunted trees, which find a precarious existence among the lava boulders and scoria."

Narborough Island, as stated by Captain Tanner, "presented in the distance (as seen from the weather side) an unbroken covering of rich green foliage to the very summit of its central peak, 3,720 feet above the sea, and, on nearer approach, a fringe of luxuriant mangroves, bordering the eastern shore and the margin of a small bay or lagoon, added fresh charm to the view. As we steamed through the narrows between Narborough and Albemarle Islands the contrast of a rich and abundant vegetation on the one hand, and utter barrenness and desolation on the other, was very striking."

Narborough, which on this trip we only saw from a distance, towering behind Albemarle, may show the character of the building up of the separate islands better even than Indefatigable, for its single cone, rising to a height of over 3,700 feet, still possesses a well preserved crater.

The composite nature of some of the islands is best seen on Albemarle. It rises to a greater height than any of the other islands (4,700 feet), and, as we saw it from the sea, the lower slopes of its five highest cones passed one into the other at various elevations. The three northern ones were separated by a comparatively low isthmus from the two southern peaks, which form the southern half of the island, the general trend of which is nearly at right angles to that of the northern craters.

We only saw Albemarle in the distance, and the following account of the island is taken from Captain Tanner's report: —

"Albemarle Island is by far the largest of the archipelago, but is uninhabited, and has no present commercial value except for its orchilla, which grows on bushes and trees, and has slight resemblance to Florida moss. It is used for making purple dye, and commands a high price in the European markets. The highest point on the island is within three or four miles of the southern extremity, and reaches an elevation of 4,700 feet. A rich green foliage covered the rugged surface of huge lava boulders to the very summit. Further to the northward, and all along the west coast as far as Tagus Cove, the land was comparatively low, and presented a striking resemblance to a burnt district dotted with numerous small volcanic cones. The general aspect was a reddish brown, but it was varied by occasional pyramids, symmetrical in form, and of lighter color, resembling artificial mounds of sand and mud which had had barely time to dry. The line of demarcation between the rich carpet of foliage and utter desolation of the barren district was so regular and well defined that it was difficult to realize that it was Nature's handiwork. The watering place marked on the chart was perfectly dry, and we learned from Mr. Cobos that it was only during the latter part of the rainy season that water could be found. There were patches of green near the northern end of Albemarle Island, but the general aspect was barren and desolate."

James Island as seen from Duncan rises rapidly on its western edge, culminates in a high crest, broken by numerous projecting rounded summits forming the central ridge of the island, and slopes rather gradually towards its eastern extremity, where there are a number of small cones and craters similar to those of the southeastern face of Chatham Island.

Darwin passed a week on James Island. He paid a visit to its upper regions, and reached an altitude of nearly 2,000 feet. He speaks of "the upper region being kept damp from the moisture of the condensed clouds, and supporting a green and flourishing vegetation," although he found the lower region covered by nearly leafless bushes.

James Bay, where the "Albatross" anchored in 1888, is, as Captain Tanner says in his Report to the Fish Commissioner, "on the west end of James Island, which protects it from the prevailing winds, the swell being partially broken by projecting points and small islands. It is a good anchorage with easterly winds, and may be recognized by the following landmarks. Albany Island is conspicuous, being lighter in color than its surroundings, and abreast of it are bold lava cliffs, which extend to a short stretch of white sand beach at the bottom of the bay. The southern extremity is marked by a point having a double peak, from which extends a barren lava-colored belt, resembling that described on Albemarle Island. Small salt lagoons lie just back of the sand beach. The watering place mentioned is on a point nearly abreast of Albany Island, and during the latter part of the rainy season furnishes a good supply, but at other times the flow is either very small, or fails altogether. The supply is so limited and uncertain that the orchilla pickers who visit the island periodically do not depend upon it. The general aspect north and east of the bay was fresh and green, and a fringe of mangroves surrounding the lagoons gave that portion of the bay a particularly attractive appearance, while to the southward was a barren waste."

The landing at Duncan is in a boat cove, protected by a small island. The bottom is covered by coral sand, formed of fragments of Pocillopora. A number of seals evidently had chosen this spot as their favorite haunt, and on their way to a small plateau a little higher up, which they evidently frequented, had in some places worn the shore rocks perfectly smooth. There were perhaps twenty or thirty seals here, who must have found an abundant supply of fish, judging from the number we saw around the ship while she lay at anchor off the island. They must have been quite common on the Galapagos, and have been noted as occurring on Hood, Charles, Chatham, James, and Jarvis. Both albatross and penguin appear to have been known on the islands, the latter a species characteristic of the group.[1]

The photograph of a part of the eastern slope of Duncan Island (Plate XXII.), opposite our anchorage, will give a better idea of the character of its shores and its vegetation than any more lengthy description I could give. Duncan Island rises quite abruptly on all sides from the sea, and with the exception of a small plateau on its southern extremity well towards the summit, and of a slight depression between the highest point and the northern end, presents a nearly regular conical outline as seen from the sea.

Opposite our anchorage on Duncan Island we found a number of

[1] I am informed by Captain C. A. M. Taber of New Bedford, who twice visited the Galapagos, the first time as early as 1843, that he discovered an albatross rookery on the weather side of Hood's Island, and on his second visit he made a number of observations on the seal rookeries of various islands, which he mentioned in a late number of "Science," May 27, 1891.

the aquatic Amblyrhynchus crawling about upon the lava rocks, close to the water's edge. Neither at Chatham, Charles, nor Duncan did I see any specimens of the terrestrial species.

Captain Tanner in speaking of the anchorage off Duncan Island says: "We anchored in fifteen fathoms in an open bay on the northeast side of Duncan Island. We were off a conspicuous gorge in the mountain side, and about two hundred yards to the southward of a small islet which lay directly in front of it, and about fifty yards from the shore. Its surface was covered with bushes and other vegetation, which distinguishes it from rocks farther to the southward. There was an excellent landing place for boats inside of the islet. The general appearance of Duncan Island was green, bushes and cactus being distributed over its surface. There is no living water on the island, yet it is a favorite resort for the celebrated galapagos."

The northern and northeastern islands of the group are far more barren than the central and southern. This is natural, as neither Bindloe nor Abingdon is high enough to reach the altitude where in the larger islands we find a comparatively moist and cool climate, and where the high plateau is fairly fertile and capable of cultivation. On the Admiralty charts, according to the survey of Fitzroy, Bindloe is not more than 800 feet, and Abingdon has only a small area above 1,000 feet. So that, as far as we could judge while sailing by these islands, they hold an intermediate position as regards their appearance between such islands as Duncan and Wenman, and the larger, higher, and more fertile islands Chatham and Charles. Tower Island we did not sight. Seen from the ship, the geological structure of Abingdon and of Bindloe did not differ from that of the other islands of the group. Bindloe as seen from the west resembles Chatham somewhat, but is more broken by craters, and a large part of the southern face of the island is covered by a huge flow of black lava rocks, standing out in bold relief against the green slopes surrounding it on every side.

Bindloe, although so much broken up by its many craters, forms only a single mass, the craters being arranged in a somewhat irregular ring around the plateau which constitutes its centre.

The eastern face of Wenman is a perpendicular cliff. The top of the island is covered with a thin coating of green, consisting of tall grass, and of a scant vegetation, and is evidently more barren than Duncan Island. Its eastern face seems to have been sloughed off.

Culpepper Island we passed in the dark.

The Fauna of the Galapagos.

In addition to a large number of oceanic birds shot by Mr. Townsend during the cruise, he also made an important collection of birds from Chatham and Charles Islands, considering the short time we were there. On our way up to the hacienda of Mr. Cobos, we had our first experience of the great tameness of the birds. They did not seem to be in the least affected by our presence, and while we halted some of them rested on the mules' hind quarters, and even on the shoulders and hats of some members of the party. Our experience on Charles Island was similar. On all sides the finches and thrushes paid no attention to us, and a number could readily have been caught with a butterfly net, or even a hat. Yet there has been some population on Chatham Island for a number of years, and Charles Island has of late been rarely visited. I need only refer to Darwin's account of the tameness of birds, in his "Voyages of the Adventure and Beagle," Vol. III. p. 475.

As regards the fauna of the Galapagos, I may mention having seen a bat, which I was told by Mr. Cobos he had noticed on Chatham Island only for the last six or seven years. Dr. Wolf mentions them in 1875, and I hear from Dr. Baur that he has collected some specimens. It is interesting to remember that since Darwin's visit, in 1835, a number of domesticated animals have become wild, and have greatly multiplied since the abandonment of the settlements on Charles Island. We have wild cattle on Chatham, on Charles, on James, and on Indefatigable; also, wild donkeys, hogs, sheep, goats, cats, dogs, and the common fowl.

I collected insects on Chatham, Charles, and Duncan, and was amazed at the poverty of the catch. Of course a prolonged stay would undoubtedly bring to light many interesting things; but of the few species of Lepidoptera, an Argynnis, a Colias, a Eudamus, and a Lycæna seemed to be the most characteristic, and were found on all these islands. A few Noctuidæ, and only few species of Diptera, of Hymenoptera, or of Neuroptera, though one of the species of the Libellulidæ was very abundant on Chatham, two species of Acridium, a large one inland and a smaller species in the lower levels, and two or three species of Coleoptera, among which was a Carabus, were all I found. My short experience seemed not to differ materially from that of Dr. Wolf, whose entomological collections were most meagre, although he collected in the dry season. I was greatly struck with the vast number of caterpillars, but of a few species only, of Noctuidæ, Geometridæ, and Sphingidæ, which covered the grasses and bushes on Charles and Chatham Islands, and must have supplied the insectivorous birds with abundant food.

A few reptiles were collected at the Galapagos, Cocos Island, and Malpelo.

The only tortoise we obtained was found on Duncan Island by Mr. Townsend; we kept it on board the "Albatross" as far as Guaymas, and from there it was shipped to Washington, where it arrived safely.

The well worn tortoise tracks which Darwin saw on landing at Chatham Island, leading to the springs, which are situated on the larger islands towards the central parts and at a considerable elevation, are still quite marked on Charles Island. I saw no trace of them either on Chatham or on Duncan, on the parts of the islands which I examined. On Chatham, the tortoises, I was told by Mr. Cobos, have long since disappeared. According to Darwin, "it is said that formerly single vessels have taken away as many as seven hundred of these animals," so that the disappearance of the turtles is not astonishing; and they and the terrestrial Amblyrhynchus, which also serves as food, have become comparatively rare. We also collected at Duncan Island a few specimens of the aquatic Amblyrhynchus.

Sharks are very abundant throughout the waters of the Galapagos, and they, as well as the strong currents sweeping through the passages which separate the islands, may play an important part in checking the migration of animals from one island to another. We saw small sharks in great numbers at all our anchorages. Captain Tanner says that, in 1888, "the anchorage at Wreck Bay was infested with small sharks, which were taken by dozens until the fishermen tired of the sport."

A few specimens of rocks were also brought together from the different islands we visited, and such plants collected as it was possible to get during our short stay on shore.

The Coral Sand Beaches of the Galapagos.

I obtained from Mr. Cobos a piece of the so called sandstone said to occur on Indefatigable Island, and which of course I was most anxious to see, as the occurrence of true sandstone would have put quite a different face on the geological history of the Galapagos from the one usually received. This I found to be nothing but coral rock limestone, either a breccia or slightly oölitic, identical with the formation found back of the beach at Wreck Bay on Chatham Island. I found there an old coral rock beach, extending on the flat behind the present beach, composed entirely of fragments of corals, of mollusks, and other invertebrates, cemented together into a moderately compact oölitic limestone, which when discolored, as it often is, and turned gray, might readily be mistaken for sandstone. This coral rock is covered by just such a thin, ringing coating of limestone as characterizes the modern reef rock of other localities. On nearly all the islands there are a number of sandy beaches made up of decomposed fragments of corals and other invertebrates, and cemented together at or beyond high-water mark into the modern reef rock I have described. The coral is mainly made up of fragments of Pocillopora, which is found covering more or less extensive patches off these coral sand beaches, but which, as is well known, never forms true coral reefs in the Panamic district. The only true coral reef belonging to this district is that of Clipperton Island (if we can trust the Admiralty charts), situated about 700 miles to the southwest of Acapulco. But neither at Cocos Island, nor at the Galapagos, nor anywhere in the Panamic district, do we find true coral reefs, — nothing but isolated patches of reef-building coral. The absence of coral reefs in this district has of course already been noted by other naturalists, who have been struck by this feature in an equatorial region. Dana has ascribed it to the lower temperature of the water due to the action of the Humboldt Current coming from the south, pouring into the Bay of Panama, and then flowing westward with the colder northerly current running along the west coast of Mexico and Central America. From the investigations made this year by the "Albatross," I am more inclined to assume that the true cause of the absence of coral reefs on the west coast of Central America is due to the immense amount of silt which is brought down the hill and mountain sides every rainy season, and which simply covers the floor of the ocean to a very considerable distance from the land, the terrigenous deposits being found by us even on the line from the Galapagos to Acapulco, at the most distant point from the shore to the side or extremities of our line. The mud in Panama Bay to the hundred fathom line is something extraordinary, and its influence on the growth of coral reefs is undoubtedly greatly increased from the large amount of decomposed vegetable matter which is mixed with the terrigenous deposits.

The Origin of the Fauna and Flora of the Galapagos Islands.

In an article on "The Origin of the Galapagos Islands," in the American Naturalist, (March and April, 1891,) Dr. Baur has expressed views on the origin of the fauna and flora of the Galapagos entirely at variance with what is known of their geological structure. He speaks of the Galapagos as being connected with the mainland by the 4,000 meter line. The ease with which such connections are made on a chart requires no serious discussion. Then he adds, "This [the connection of the Galapagos with South America] is an important fact; all the older maps showed the Galapagos separated from Central America." (!)

The islands of Duncan and Gallego, which are said to have existed between Clipperton and the Galapagos, he assumes to have disappeared. Their existence does not rest on any better basis than that of so many islands and shoals constantly reported by inexperienced or hasty navigators. Take the Rivadeneyra Shoal, — on which the "Albatross" has paid out over 1,000 fathoms, — which has been twice reported of late years, and is either a rip or an effect of light.

The connection of Vancouver and the Alaska Islands with the mainland, or that of the Santa Barbara Islands, Guadalupe, and other Californian islands, has nothing to do with the question of the former connection of the Galapagos with the South American continent. Each case must be judged by itself. Baur also brings up the case of the Tres Marias, which consist of stratified rocks and are close to the Mexican coast, separated from it by a flat of not more than thirty fathoms, and speaks of them as on the same bank as Socorro and the Revilla Gigedo Islands. This seems to be taking a good deal of poetical license with our present knowledge, and especially to bring them up as an argument from analogy that the Galapagos have been a part of South America because they may have been and are within the 4,000 meter line. One would imagine from Dr. Baur's argument that the islands of Felice and Juan Fernandez are closely connected with and due south of the Galapagos. Surely so much is known of the habits of the seals and of the albatross that we need not look upon their existence on the islands as proving any land connection between the southern points where they are known to breed, and the Galapagos, where they also have colonized. Dr. Baur also mentions the case of the Sandwich Islands as having originated by subsidence. No more unfortunate suggestion could have been made regarding their origin. All we know of their geology seems to show that the different islands have been gradually built up around a central nucleus by successive eruptions, much in the same way that the Galapagos were. It seems hardly worth while, on the basis of the assumption of Dr. Baur, to renew speculations on the theory of the permanence of the Pacific Ocean basin. After Dr. Baur has completed his examination of the Galapagos, and has given us the additional soundings leading to different views from those based upon our present knowledge, it will be time to discuss the matter. When Dr. Baur says, "It would appear that the whole west coast of America has undergone subsidence," he is making a statement which is absolutely without foundation. On the contrary, all that we know of the geology of the west coast of Mexico, of Central America, and of South America, shows that their shores have been rising to a very great elevation as far south as the southern part of Chili. Dr. Baur need only refer to Darwin's "Geological Researches," and to the statements of the geologists who have examined the geology of Central America, to satisfy himself on that point.

What has taken place north of the Gulf of California need not detain us. Why should not Cocos Island and Malpelo come within the same influences of subsidence? Some of the causes which Dr. Baur applies to the Galapagos to explain their present state have given the one its luxuriant vegetation, and have kept the other barren, and they are still plainly visible on the most cursory examination. The vegetation of the rainless belt along the coast of South America presents the same peculiarities and the same contrasts as that of the Galapagos and Cocos; given an absence of rain, and what can be more desolate than the region around Payta, the greater part of the coast of Peru, and northern Chili? Yet where do we find more brilliant verdure than along the river beds of the same region, or in districts which can be irrigated? Absence of rain and moisture in the equatorial regions apparently produces as great a diminution in the size of the constituents of a flora as the excessive cold of an arctic climate or a high altitude.

It seems far more natural to us to appeal, as we have done, to the agency of the trade winds and currents to account for the origin of the fauna and flora of these interesting islands. We are thus not called upon to accept a theory of extensive subsidence in an area where all the geological indications are those of elevation, especially when the proof of this subsidence is based on no better evidence than the so called alpine character of parts of its flora, and upon the presumed former connection of the Galapagos Islands with the Central American continent. The alpine features of the flora we have attempted to explain by its similarity to that of the adjoining rainless belt of South America, and we deny the existence of a former connection of these volcanic islands with the mainland, separated as they are now by a plain of nearly 2,000 fathoms in depth.

While slowly steaming through the archipelago from island to island, we had an excellent opportunity of studying the natural features of these islands, and also as we passed their shores or were dredging within a moderate distance. As far as a cursory examination like ours could prove anything regarding the nature of the geological structure of the islands, our observations fully agree with those of Darwin and of Wolf, that this group presents one of the best examples of true volcanic islands.

The majority of the islands are evidently formed around a central crater or centre of elevation. They have increased in size and in height from successive lava flows. There is nothing to show that the separate islands are entirely the result of the disintegration of a larger volcanic chain, though of course a certain amount of denudation and submarine erosion has undoubtedly taken place, as is readily seen on the slopes of the islands and on examination of the soundings between them. Neither do we find any indications either of elevation or of subsidence of any part of the area of the Galapagos district which would affect their topography, and, as Wolf maintains, we can still less explain their formation by a separation in former periods from the South American continent. On the contrary, every part of their structure seems to prove that the islands have been slowly formed by submarine eruptions at first, and subsequently by similar accretions at the level of the sea, until finally some of the islands have reached an elevation of over 3,000 feet. During this process of growth some of the islands have become joined together, as for instance Albemarle, which is probably composed of three islands originally independent, and also the eastern and western parts of Chatham, which were surely once two separate islands, and are now connected only by a low isthmus.

The volcanic activity of some of the islands has continued to comparatively very recent times. I am informed by Mr. Cobos that smoke has been seen to issue from Narborough as late as 1836, and it is well known that Captain Collet was driven from Tagus Cove by the heat due to an eruption on the neighboring Narborough. It is quite probable that the age of the Galapagos does not reach beyond the earliest tertiary period, and many parts have undoubtedly not been formed before the present epoch, so that the time is geologically short during which so many animals and plants peculiar to the islands have developed from their South American, their Central American, their Mexican, or their West Indian ancestors.

Wolf has already called attention to the fact that the petrographic character of the Galapagos volcanoes is different from that of the volcanoes of the mainland, the latter consisting of trachytic and andesite material, while the former are made up of basaltic rocks. The specimens of volcanic rocks which I collected at Chatham Island, on Charles, and on Duncan Island, were all basaltic.

Wolf, whose acquaintance with the flora of the high Andes appears to be very extensive, was struck with the Andean character of the Compositæ, and with the analogy of a species of Polylepis and other trees with those forms that in the high Andes[1] make small forests, reaching to an altitude of 13,000 feet. He found also a remarkable similarity in the mosses and ferns with those of the Quito district, and some of the species he even considers as identical.[2] As he well says: "Es ist kein Zweifel, dass die Vegetation, trotz ihrer Eigenthümlichkeiten, im Ganzen einen südamerikanischen Typus besitzt, sowohl nach den Gattungen als nach dem äussern Habitus; wodurch sie sich aber auf den ersten Blick von der Flora des Festlandes auch dem Nicht-Botaniker unterscheidet, ist die Kleinheit der Blattorgane[3] die Abwesenheit schöner Blüthen, die Seltenheit der epiphytischen Gewächse, und das Fehlen der Lianen oder Schlingpflanzen." We miss all the wealth of the tropical forests, which is so striking in the equatorial zone of Central and South America.

The Deep-Sea Fauna of the Panamic District.

As a striking result of the character of the deep-sea fauna of the Panamic district, we found, in the first place, a great many of my old West Indian friends. In nearly all the groups of marine forms among

[1] Is it not perhaps more natural to compare the vegetation of the lower belt of the Galapagos to that of the rainless belt extending along the coast of South America from Ecuador southward? The stunted character of the vegetation of the rainless belt is as marked a feature of that district as it is of the Alpine regions.

[2] Hooker, while discussing (Trans. Lin. Soc., 1851, Vol. XX. p. 163) the affinities of the flora of the Galapagos and its origin, lays great stress upon the action of currents coming north from the Guyaquil River, and those flowing westward from the Bay of Panama, as agents for the distribution of South and Central American plants. Speaking of the affinities of the plants of the Galapagos, he says: "The new species being for the most part allied to plants of the cooler parts of America, or the uplands of the tropical latitudes. The more peculiar are the same as abound chiefly in the hot and damper regions, as the West Indian Islands and the shores of the Gulf of Mexico."

[3] As Darwin says, the bush which from its minute brown leaves chiefly gives the leafless appearance to the brushwood is one of the Euphorbiaceæ, and an acacia and a cactus are quite common in some parts, while in the upper regions of the islands the ferns and coarse grasses are abundant.

the Fishes, Crustacea, Worms, Mollusks, Echinoderms, and Polyps, we brought up familiar West Indian types or east coast forms, together with quite a number of forms whose wide geographical distribution was already known, and is now extended to the Eastern Pacific. This was naturally to be expected from the fact that the district we explored is practically a new field, nothing having been done except what the "Albatross" herself has accomplished along the west coast of North and South America. The "Challenger," as will be remembered, came from Japan to the Sandwich Islands, and from there south across to Juan Fernandez, leaving, as it were, a huge field of which we attacked the middle wedge. As far as we can judge at present, it seems very evident that, even in deep water, there is on the west coast of Central America a considerable fauna which finds its parallel in the West Indies, and recalls later Cretaceous times, when the Caribbean Sea was practically a bay of the Pacific, — a deep-sea fauna showing relationship on the one side to Atlantic and West Indian types, and on the other pointing to the eastward extension of western Pacific types of wide geographical range, which mix with the strictly deep-sea Panamic ones. The western and eastern Pacific fauna, while as a whole presenting very marked features in common, yet also present striking differences. The vast extent of territory over which some of the marine types extend, through all the tropical part of the Pacific, may readily be explained from the course of the great western Equatorial Current and the eastern counter currrent, which cannot fail to act as general distributers in space for the extension of a vast number of marine Vertebrates and Invertebrates. A similar extensive geographical range from north to south has also been observed in the distribution of some of the Mollusks, Echini, and Starfishes, which extend all the way from the southern extremity of South America to the Panamic region. The course of the northerly current setting along the west coast of South America must of course act as a distributer of the marine fauna of that region. There are, indeed, a number of genera in the deep water, and to some extent also in the shallower depths, which show far greater affinity with the Pacific than with the Atlantic fauna. Of course, further explorations may show that some of these genera are simply genera of a wider geographical distribution; but I think a sufficiently large proportion of the deep-sea fauna will still attest the former connection of the Pacific and the Atlantic.

In the first part of our cruise I was somewhat disappointed in the richness of the deep-sea fauna in the Panamic district. It certainly does not compare with that of the West Indian side, or that off the eastern coast of the United States. I have little doubt that this comparative poverty is due to the absence of a great oceanic current like the Gulf Stream, bringing with it on its surface a large amount of food which serves to supply the deep-sea fauna along its course.

The same comparative poverty of animal life also characterized our second line of explorations. After we reached Galera Point, we began our line across the Humboldt Current, which was to give us a fair idea of the fauna of that part of the coast as far as the southern face of the Galapagos. With the exception of three good casts, the trawling on that part of the sea bottom proved comparatively poor, nor did the sea face of the southern slope of the Galapagos give us anything like the rich fauna I had expected. Theoretically, it seemed certain that a sea face like that of the Galapagos, bathed as it is by a great current coming from the south and impinging upon its slope, and carrying upon its surface a mass of animal food, could not fail to constitute a most favorable set of conditions for the subsistence and development of a rich deep-sea fauna.

On leaving the Galapagos we took up a former line of the "Albatross" run off Indefatigable Island, hoping to obtain from that quarter our best results, but our hauls were very disappointing. The ground proved not only most difficult to dredge upon, but also comparatively barren, and it was not till we got into the oceanic basin again, between the Galapagos and Acapulco, that our catches improved. But even then they were not to be compared with the hauls at similar depths in the Atlantic off the West Indies, or along the course of the Gulf Stream.

In the first cruise we also found great difficulty in trawling, owing to the considerable irregularities of the bottom. When trawling from north to south, we seemed to cut across submarine ridges, and it was only while trawling from east to west that we generally maintained a fairly uniform depth.

In the Panamic region proper, — the region occupied by our track to Cocos, to Malpelo, and back to Panama, and from there to Galera Point, the Galapagos, and on toward Acapulco, — the most interesting things we found were representatives of the Ceratias group of Fishes, which the naturalists of the "Albatross" tell me they have not met before on the west coast of North America. I may also mention many types of Macruridæ and of Ophidiidæ, fine specimens of Bathyonus, of Bathybrissa, and of Bathypterois, and a few specimens of Ipnops in excellent condition. The Crustacea have supplied us with a most remarkable type of the Willemœsia group (Eryoneicus), together with the many types characteristic of muddy bottoms, as Glyphocrangon, Notostomus, Heterocarpus, Pentacheles, and Nematocarcinus, many of which we afterwards dredged in the Gulf of California. I may mention one haul which contained a goodly number of a species of Nephrops. The paucity of Echini is most striking, although we brought up in one of the hauls numerous fragments of a gigantic species of Cystechinus, subsequently dredged in the channel between Galera Point and the Galapagos, as well as in the Gulf of California. The occurrence of Cystechinus so far north is interesting; the specimens collected by the "Challenger" came from the Southern Ocean, and a fossil species of the genus has been described by Gregory from Barbados. Other Echini characteristic of muddy bottoms, such as Aspidodiadema, Urechinus, Pourtalesia, and Schizaster, were brought up from deep water, while on rocky bottom we found Salenia and some species of Cidaridæ, all closely allied to their West Indian representatives. The number of Ophiurans was remarkably small as compared with the fauna of deep waters on the Atlantic side, where it often seems as if Ophiurans had been the first and only objects created. The absence of deep-sea corals is also quite striking. They play so important a part in the fauna of the deeper waters of the West Indies, that the contrast is most marked. Gorgoniæ and other Halcyonoids are likewise uncommon. We found but few Siliceous Sponges, and all of well known types. Starfishes are abundant, and are as well represented in the variety of genera and species as on the Atlantic side of the Isthmus. I may also mention the large number of deep-sea Holothurians (Elasipoda) which we obtained, as well as a most remarkable deep-sea Actinian, closely allied to Cerianthus, but evidently belonging to a new family of that group. We found occasionally, when trawling over the region of green mud, large tracts of mud tubes; they belong to the usual types of deep-sea West Indian Annelids.

In the deeper parts of the channel between Galera Point and the southern face of Chatham Island we found a great number of Elasipoda, among them several genera like Peniagone, Benthodytes, and Euphronides, represented by numerous species. The Starfishes of the second part of our cruise did not differ materially from those collected during our first trip, but we added some fine species of Freyella, Hymenaster, Astrogonium, Asterina, and Archasteridæ to our collections. Among the Sea-urchins on two occasions we brought up fine hauls of a species of Cystechinus with a hard test, many specimens of which were in admirable state of preservation. Among the Ophiurans nothing of importance was added, unless I may except a lot of Ophiocreas attached to a Primnoa, and a pretty species of Sigsbeia attached to a species of Allopora, from the south side of Chatham Island.

The Gorgonians were remarkably few in number. This is undoubtedly due to the unfavorable nature of the bottom we worked upon.

From the nature of the bottom we naturally expected rich hauls of Siliceous Sponges, but we did not find many, and I do not think there are many novelties among those we have collected. On two occasions, a number of specimens of Ascidians were brought up; among them was a fine white translucent Corinascidia.

Among the Bryozoans, the most noteworthy haul was a number of beautiful specimens of the delicate Naresia (Kinetoskias), in excellent condition. On the line from the Galapagos to Acapulco we brought up a good many Foraminifera from the mud bottoms. On several occasions the bottom must have been covered with huge masses of a new type of an arenaceous Foraminifer, forming immense curling sheets attached by one edge to stones or sunk into the mud. This Foraminifer seems to increase in size by forming irregular more or less concentric crescent-shaped rings. When it comes to the surface, it is of a dark olive-green color. This and a species of Rhabdamina allied to R. lineata were the most striking Foraminifera collected.

Among the Worms, the Maldaniæ, Halinæcia, Terebella, and limicolous types were unusually abundant at some localities, the empty mud tubes often filling the bottom of the trawl. Some very large specimens of Trophonia were collected, and remarkably brilliantly colored (orange and carmine) Nemerteans and Planarians.

The Mollusks were comparatively few in number, and the types eminently Caribbean. The absence of Comatulæ or other Crinoids was equally disappointing, even when trawling on the extension of the line started three years ago by the "Albatross," on the eastern face of the Galapagos slope, when on her way from Chatham Island to San Francisco, although we were fortunate enough to bring up off Mariato Point in 782 fathoms a single fine specimen of Calamocrinus, with a part of the stem and its base, showing the mode of attachment of this genus to be similar to that of the fossil Apiocrinidæ.

Two of the hauls made in the Gulf of California are specially worthy of mention, as being characteristic of the deep-water fauna of the Gulf of California, one made in 995 fathoms and the other in 1,588 fathoms. We obtained in these hauls a number of Ophiomusium and Ophiocreas, some fine specimens of Schizaster, a new genus allied to Paleopneustes, and also the same species of Cystechinus, with a hard test, and of Phormosoma, which we had obtained before on the line from the Galapagos to Acapulco. Besides these, there came up a number of specimens of an interesting species of Pourtalesia, most closely allied to Pourtalesia miranda, the first type of the group dredged in the Florida Channel by Count Pourtalès.

The deeper haul was especially rich in Holothurians, among them a fine large white Cucumaria, some specimens of Trochostoma, several species of Benthodytes, some of them remarkable for their white color, their huge size, and the comparatively small number of ventral tentacles. With these were numerous specimens of an interesting species of Euphronides. In this haul I was specially struck with the Elasipoda, and the great variety in the consistency of the skin in individuals of one and the same species; it varied in different individuals from extreme tenuity to a comparatively tough gelatine-like consistency. On carefully sifting the mud, we found a number of interesting Foraminifera, and of delicate and minute Gasteropods and Lamellibranchs, fragments of the shell of an Argonauta, and two species of a huge ribbed Dentalium. Among the Starfishes were specially noticeable a large Brisinga, a long-armed Cribrella, and several species of Astropecten. The usual types of Worms were found in the mud at these greater depths. In addition to a number of Macruroids, we obtained a pink Aphyonus, a large black Beryx-like fish, a fine Nettastoma, and a couple of species of Lycodes. The usual surface species of Stomias and of Scopelus also came up in the trawl. Among the Crustaceans were a fine lot of Arcturus, of Colossendeis, of Glyphocrangon, and of a Caridid with a deep blue patch on the base of the carapace, making the strongest possible contrast to the dark crimson coloring of the rest of the body. Blue is a very unusual color in the deep-sea types, although the large eggs of some of the deep-sea Macrurans are often of a light blue tint.

We brought up in the trawl at various times, and subsequently also in the Tanner net, from depths of less than 200 fathoms, the same gigantic Ostracod which I mentioned before, several specimens of Atolla, and fragments of a huge Periphylla, which must have been at least fifteen inches in diameter; also a most interesting new type of Bougainvillia, remarkable for having eight clusters of marginal tentacles, but only four chymiferous tubes. Of course neither these Acalephs, nor some of the Beryx-like fishes, of the Scopelids, Stomias, Melamphaës, and the like, which were brought up from less than 300 fathoms by the Tanner net, can any longer be considered as part of the deep-sea fauna.

After passing the Tres Marias, we made several hauls, and obtained some Umbellulæ, Pennatulæ, Trochoptilum, Anthoptilum, and a fine Antipathes, a few Comatulæ, a large Astropecten, some fine specimens of Urechinus and of Schizaster, a few Holothurians, Lophothuria, and Trochostoma, and two species of Elasipoda, besides a few fragments of Gasteropods, with an empty shell of Argonauta.

Among the Crustacea there came up the usual types found living upon muddy bottom, such as Glyphocrangon, Heterocarpus, Notostomus, Pentacheles, Nematocarcinus, and Nephrops, together with species of Lithodes and of Munida. The usual types of limicolous Annelids were also found here, Halinæcia, Terebella, Maldania, and the like; a few Ophiurans, Ophiopholis and Ophiocantha; a few fragments of Farrea, and a huge Hyalonema of the type of H. toxeres. Among the Fishes there were a few Macruridæ, Bathypterois, Lycodes, and Malthe.

Comparison of the Deep-Water Echini obtained in the Panamic and Caribbean Districts.

There will naturally be considerable delay in obtaining the results even of the preliminary examination of the collections sent to the different specialists. To illustrate, therefore, somewhat more in detail the contrasts between the deep-water fauna of the Panamic and of the Caribbean districts, I will make here a very general comparison of the Echini collected on the two sides of the Isthmus of Panama. The identifications here given are of course subject to the revision of the closer and final determination of the collections. This subject will later be fully illustrated by comparative tables of the distribution of the species on the two sides of the Isthmus.

I may state, in general, that we have discovered in the deep-sea fauna of the Panamic district only one genus of Sea-urchins, allied to Salenia, not previously represented on the Atlantic side. The poverty in Clypeastroids was as striking as on the Atlantic side, and in the very heart of the shallow water district so markedly characterized by Clypeastroids on both the Atlantic and Pacific sides we dredged only one specimen of Clypeaster, in 75 fathoms. As in the Caribbean, we find Phormosoma and Asthenosoma; also one species of Aspidodiadema and one of Salenia; Cidaris, Dorocidaris, and Goniocidaris, as well as Porocidaris; which offer an exact parallel in the Pacific to the same genera on the Atlantic side. Of course, how far they are allied a more accurate comparison alone can determine. We may, however, call attention to the absence of Arbaciadæ, which as littoral genera are eminently characteristic of the temperate and tropical American shores. Some of the genera of the family extend into deep water on the Atlantic side, but they have not been found by the "Albatross" in the Pacific Panamic district. Neither Podocidaris nor Cœlopleurus was dredged by us. The absence of the latter genus is specially noteworthy, as it is found at Mauritius and has been dredged by the "Challenger" in the East Indian Archipelago. The only Pacific genus found in deep water was Maretia. It should be remembered that the genera of Cidaridæ and of Echinothuriæ all have an extensive Pacific, as well as Atlantic distribution. There were no deep-water Nucleolidæ, although they are found in shallow water in the Central American district and in deep water in the West Indian fauna. The occurrence of Echinocrepis, Cystechinus and Urechinus, types characteristic of the Southern Ocean and Southern Pacific, is interesting, associated as they are with Pourtalesia proper, a genus of wide geographical distribution, which, as well as Urechinus, is found in the Caribbean district. The ubiquitous Schizaster and Brissopsis were associated on the Pacific side with Paleopneustes, Homolampas, and Hemiaster, as in the West Indian district; and the remarkable Aërope, which has an extensive geograpical distribution, — it is found in the Arafura Sea and off the eastern coast of North America, — was not uncommon in the Panamic area. Moira, on the contrary, which again is a characteristic American genus on both sides of the continent in the temperate zone, was not obtained by the "Albatross" on her present cruise.

I need at present only to refer to the chapter on the origin of the West Indian Fauna in the report of the "Blake" Echini,[1] where lists will be found of the Cretaceous and Tertiary Echini, and where they are compared with those living in the West Indian and neighboring areas at the present day. It is interesting to note here the occurrence of a species of Cystechinus from the Radiolarian Marls of Barbados, mentioned by Gregory.[2] I understand from him that a species allied to Paleopneustes has also been detected in the same beds. The existence of Cystechinus at Barbados is another link in the evidence of a former connection between the Caribbean and the Pacific, — of a time when, as I have suggested, the Caribbean was probably a bay of the Pacific, — until later cretaceous times; but they gradually during the tertiary period[3] became

[1] Mem. Mus. Comp. Zoöl., Vol. X. No. 1, and Three Cruises of the "Blake," Vol. I. pp. 92, 109–124.

[2] See Quart. Journ. Geol. Soc. London, November, 1889.

[3] See the Memoir of Gabb on the Geology of Santo Domingo, in the Trans. of the Am. Phil. Soc., Vol. XV., 1873, pp. 49-259.

separated by elevations which finally left the Caribbean, up to a comparatively recent time, only connected with the Pacific, as it is to-day with the Atlantic, merely by narrow passages.

The Color of Deep-Sea Types.

During our cruise a good deal of attention was given to making colored sketches of as large a number of deep-sea types as possible. There is among them considerable variety as well as range of coloration. Although it is true, as has been noticed by Thomson and others, that the violets, reds, and purples are the prevailing colors, yet we find also a number of forms in which yellows prevail, as, for instance, in the Comatulæ and in Calamocrinus; the yellow in the latter genus passing to a greenish tinge, in the Comatulæ to a reddish tinge, or even to brilliant red as the principal tint. In the Crustacea the deep-sea types like Gnathophausia, Notostomus, and Glyphocrangon are of a brilliant scarlet; in some types, as in the Munidæ and the Willemœsiæ, the coloration tends to pinkish, or yellowish pink, while in Nephrops and Heterocarpus the scarlet passes more into greenish tints and patches. The color of the deep-sea Pycnogonidæ did not differ from that of the littoral species. The large eggs of some of the deep-sea genera are of a brilliant light blue, and in one genus of Macrura we found a deep dark metallic blue patch on the dorsal part of the carapace, in striking contrast to the brilliant crimson of the rest of the body. Blue is an uncommon color among pelagic animals, and is certainly not specially protective, as is stated by Hensen and others; for the Porpitidæ, Yanthina, Physalia, Glaucus, and a few other types, which form the exceptions, are among the most conspicuous of all surface animals. Many of these, especially among the Acalephs, are colorless, it is true, yet in spite of their transparency often become conspicuous objects from the development of more or less opaque genital organs or actinal appendages.

The Starfishes, as a rule, were of duller hues than the Crustacea, but all more or less tending to pinkish tints, with a greater or less mixture of yellow or orange among the Astrogonidæ on the one side, while on the other the Archasteridæ developed more into pinkish grays or ashy hues. The same was the case with the Brisingidæ. The Hymenasteridæ, on the contrary, varied from light bluish violet to deep reddish chestnut colors. Among the Ophiurans, with the exception of Ophiocreas, which are of a yellowish brick-red, the species we dredged (mainly from muddy bottoms) were of a dull grayish color, or with a more or less yellowish pink tint. A pretty Sigsbeia attached to an Allopora varied from nearly porcelain-white individuals to specimens more or less belted with bands of ashy violet.

The Pourtalesiæ with thin tests, like the other species of the family already known, were of a delicate pink color; those with stouter shells, of a dark violet or deep claret color. The same is true of Urechinus and of Cystechinus, in which the color varies from a light brownish pink to a pale claret tint.

The species of Asthenosoma were of a deep claret-color, varying from that to light brown, almost straw-color. Some of the Phormosomæ, on the contrary, are usually of a brownish brick-color, others of a deep violet. In Paleopneustes we find the same variation in tints as in the Echinothuriæ.

The coloration of the deep-sea fishes is comparatively monotonous. The tints are all of a light violet base, tending more or less to brownish or brownish yellow, or even to a greenish tint, especially among the Macruridæ. Some of the Liparidæ were of a dark violet, and one species was characterized by a brilliant blue band. The Ophidiidæ, Nemichthys, and the like, are usually of an ashy violet tint, while in Ipnops and Bathypterois the tints were of a decidedly yellowish brown. When we come to questionable deep-sea types, such as the Beryx-like fishes, we find some of them nearly black with a slight violet hue, resembling more in their coloring the prevailing body tints of Stomias and the like, and other fishes which occur within the 300 fathom line from the surface. Among the most strikingly colored fishes we obtained was a species of the Ceratias group, of a brilliant vermilion with yellowish blue patches on the sides, in striking contrast with its Atlantic congeners, which are usually of a blackish tint.

The semi-transparent deep-sea types, like Aphyonus, are usually pinkish, while the Scopelids and the like, which are pelagic fishes, the majority of which do not descend below 300 fathoms, have a dark, almost black coloration, in striking contrast with their silvery flanks, which often carry phosphorescent organs. In a species of Stomias there is on the sides a wide band, gradually tapering towards the tail, of a brilliant yellow.

Among the Holothurians we noticed the greatest variety in the coloring. In one species the color was of a delicate green tinge. Trochostoma does not differ greatly in coloration from its littoral allies. We obtained a white Cucumaria and some species of Benthodytes of the same color.

Peniagone and its nearest allies varied from a transparent milky white to yellow and light yellowish brown. Others again were of a pinkish color.

Deima, Orphnurgus, and their allies, were of a light brown or of a dirty yellow color. Benthodytes and Euphronides, with the exception of a few translucent specimens of a whitish tint, varied from a reddish violet to a deep claret, or to reddish with pronounced bluish tints, and one fine specimen of the group was of a bluish color with delicate violet shades passing into whitish milky blue.

Psychropotes and allied genera were of a reddish violet color on the dorsal side, with bluish violet of a lighter shade on the ventral surface.

The Maldaniæ, Serpulæ, and Terebellæ did not differ in their type of coloring from their littoral congeners.

The coloring of the so called deep-sea Acalephs, Periphylla, Atolla, and the like, has already been noted; it is usually of a deep violet or yellowish red. Although they have the characteristic coloring of many of the deep-sea types, yet they are known to live within comparatively shallow limits, inside the 200 fathom line, and even to come to the surface.

A species of Stomobrachium was remarkable for its light carmine color, a tint hitherto not observed among Acalephs.

The color of the Cephalopods, like that of the Acalephs, is limited mainly to violet, both in types which are undoubted deep-sea species and in those which are certainly pelagic.

Among the deep-sea Actiniæ, a species of a new Cerianthus was of a dark brick-red, while other Actinians allied to Bunodes were of a deep violet. Actinauge-like forms with tentacles of a pinkish violet tinge frequently have the column of a yellow shade. The Zoanthidæ were grayish green.

We cannot fail to be struck in this enumeration of colors with the preponderance of violet shades, as also with the great variety in tints, and their apparent absence of adaptation to the surrounding greenish gray waste of mud in which a fauna so diversified in coloring flourishes.

This variation in coloring extends to species of the same group, and is specially marked among the Holothurians. Among the Fishes and Crustaceans it is less so, the former having to a great extent apparently assumed the grayish or brownish shades of their surroundings; while in the Crustacea nothing could be more marked than the contrast between the brilliant coloring of the group and the dull surface upon which they dwell. In the Holothurians as well as in the Actinians we find both the contrast and the apparent adaptation to the surroundings.

This great diversity in coloration brings up interesting questions regarding the influence of the environment upon the fauna at great depths. But until we know more of the effects produced by the penetration of light through such masses of water, speculations as to their cause cannot rest upon a very substantial basis.

It is difficult to understand how so great and numberless variations may have been brought about, or to account for such a case of mimicry as was observed in a crab allied to the Maiadæ, in which the dorsal face of the carapace appears like a bit of muddy area covered by corals, with a huge white arm resembling a fragment of an Isis-like Gorgonian.

At present the simplest explanation is that suggested by Moseley, that the deep-sea types have little by little found their way into greater depths from the littoral limits, and have retained or lost many of the features characteristic of their littoral predecessors under conditions radically different from those existing in the abysses of the sea. As denizens of the littoral belt, they were subject to all the disturbing influences of the action of light, of heat, of a varying supply of food, and to a certain extent of the motion of the water. All these conditions are in striking contrast to those we may imagine to exist at great depths, where little change can be produced by whatever light may find its way to the bottom of an oceanic basin, where the temperature is uniform, where there is no motion, and where in fact all the factors we are accustomed to associate with marine life as we see it on our shores are practically wanting.

EXPLANATION OF THE PLATES.

PLATE I.

Modified Chun-Petersen Tow-Net.

Fig. 1. The net ready to lower.
Fig. 2. The net opened, ready to tow horizontally at the required depth.
Fig. 3. The net closed on its way up to the surface.

For lettering, see the description of the net, page 45.

PLATE II.

Tanner Deep-Sea Tow-Net.

Fig. 1. Sketch of the Tanner tow-net open.
Fig. 2. Messenger for closing the net, sliding on wire rope.
Fig. 3. Sinker attached above the Tanner net.
Fig. 4. Bell crank tripped by messenger to liberate the slings.
Fig. 5. Attachment of bell crank to wire rope.
Fig. 6. Showing the lower part of the Tanner net when closed.

For lettering, see the description of the Tanner tow-net, pages 46, 47.

PLATE III.

Hydrographic Sketch of the Pacific, from the Gulf of California to Northern Ecuador, with the Track of the "Albatros."

PLATE IV.

Sketch of the Galapagos Islands, with the Track of the "Albatross."

The sounding of 329 fathoms to the east of Indefatigable Island should read 392 fathoms.

PLATE V.

Temperature Section and Profile, from Mariato Point to Cocos Island.

February 23d to February 28th.

PLATE VI.

Temperature Sections and Profiles.

Fig. 1. From Cocos Island to Station 3375, a point 100 miles southwest of Malpelo Island. March 1st to March 4th.

Fig. 2. From Station 3375 to Malpelo Island, to Rey Island, one of the Pearl Islands in the Bay of Panama. March 4th to March 11th.

PLATE VII.

Temperature Sections and Profiles.

Fig. 1. From Station 3392, thirty miles southeast from Point Mala, to Caracoles Point.

Fig. 2. From Station 3392, thirty miles southeast from Point Mala, to Point Mala.

Fig. 3. From Station 3383, fifty miles southeast from Caracoles Point, to Panama.

PLATE VIII.

Temperature Section and Profile.

From north of Galera Point to off Galera Point, to Chatham Island, one of the Galapagos. March 23d to March 28th.

PLATE IX.

Temperature Section and Profile.

From off Chatham Island to off James, to between Abingdon and Wenman Islands, to Acapulco. April 3d to April 12th.

PLATE X.

Temperature Sections and Profiles.

Fig. 1. From north of Wreck Bay, Chatham Island, to Station 3408, six miles southwest of Bindloe Island.

Fig. 2. From Indefatigable Island to Bindloe Island.

Fig. 3. From Gordon Rocks, Indefatigable Island, to 392 fathoms, in an easterly direction.

Flg. 4. From north of Sulivan Bay, James Island, to Station 3407.

PLATE XI.

Temperature Sections and Profiles.

Fig. 1. From Charles Island to Indefatigable Island.
Fig. 2. From Charles Island to Hood Island.
Fig. 3. From Hood Island to Chatham Island.
Fig. 4. From three miles south of Wreck Point, Chatham Island, to Station 3401.
Fig. 5. From ten miles northwest of Wreck Bay, Chatham Island, to twenty miles northeast of Hobbs Reef, Chatham Island.

PLATE XII.

Temperature Sections and Profiles.

Fig. 1. From Hydrographic Station 2630, eleven miles east of Wenman Island, to Abingdon Island.
Fig. 2. From Hydrographic Station 2630 to Wenman Island.

PLATE XIII.

Vegetation of Cocos Island, Chatham Bay.

PLATE XIV.

Malpelo Island, seen from the Westward.

PLATE XV.

Coral Sand Flat, back of the Landing Beach at Wreck Bay, Chatham Island.

PLATE XVI.

Vegetation characteristic of the Barren Belt on the Way to the Cobos Hacienda, Chatham Island.

About a mile from the landing at Wreck Bay.

PLATE XVII.

Fertile High Plateau of Chatham Island.

Seen looking east from the Cobos Hacienda.

PLATE XVIII.

Lava Blocks west of Black Beach, Charles Island (Floreana).

PLATE XIX.

Lava Rocks and Black Beach, Charles Island.

PLATE XX.

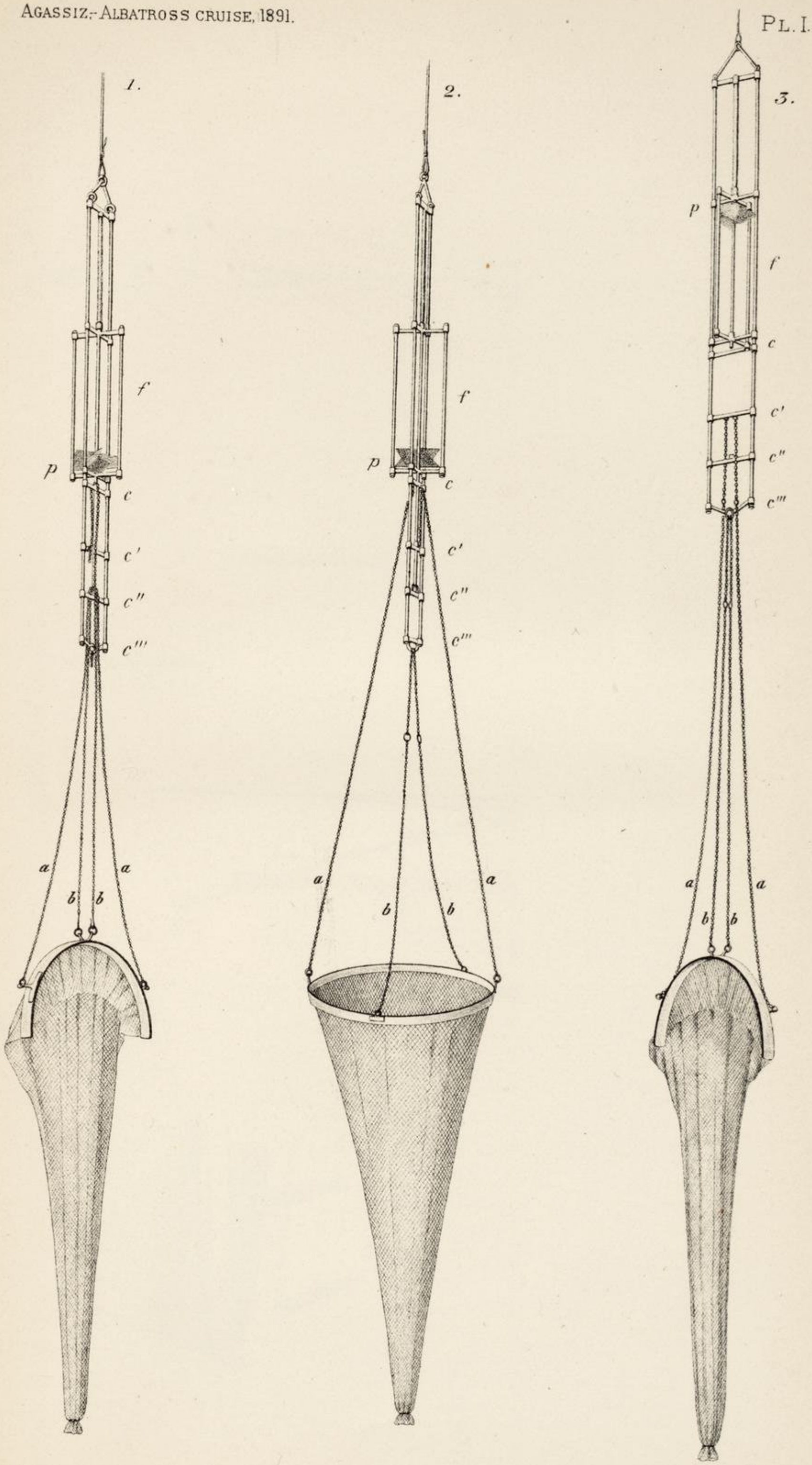
Vegetation near Black Beach, Charles Island.

PLATE XXI.

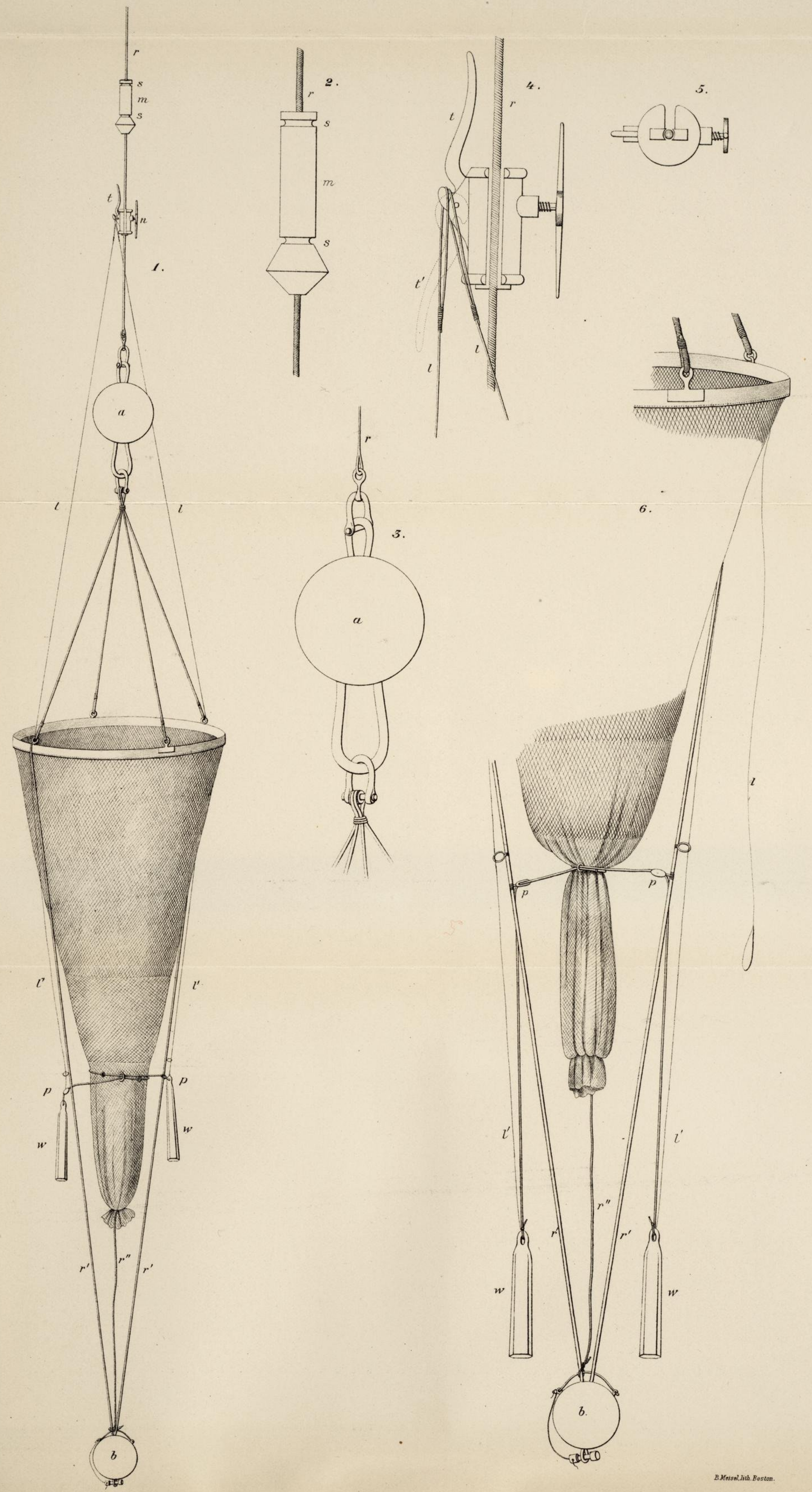
Vegetation on the Way to the abandoned Villamil Hacienda, Charles Island.

PLATE XXII.

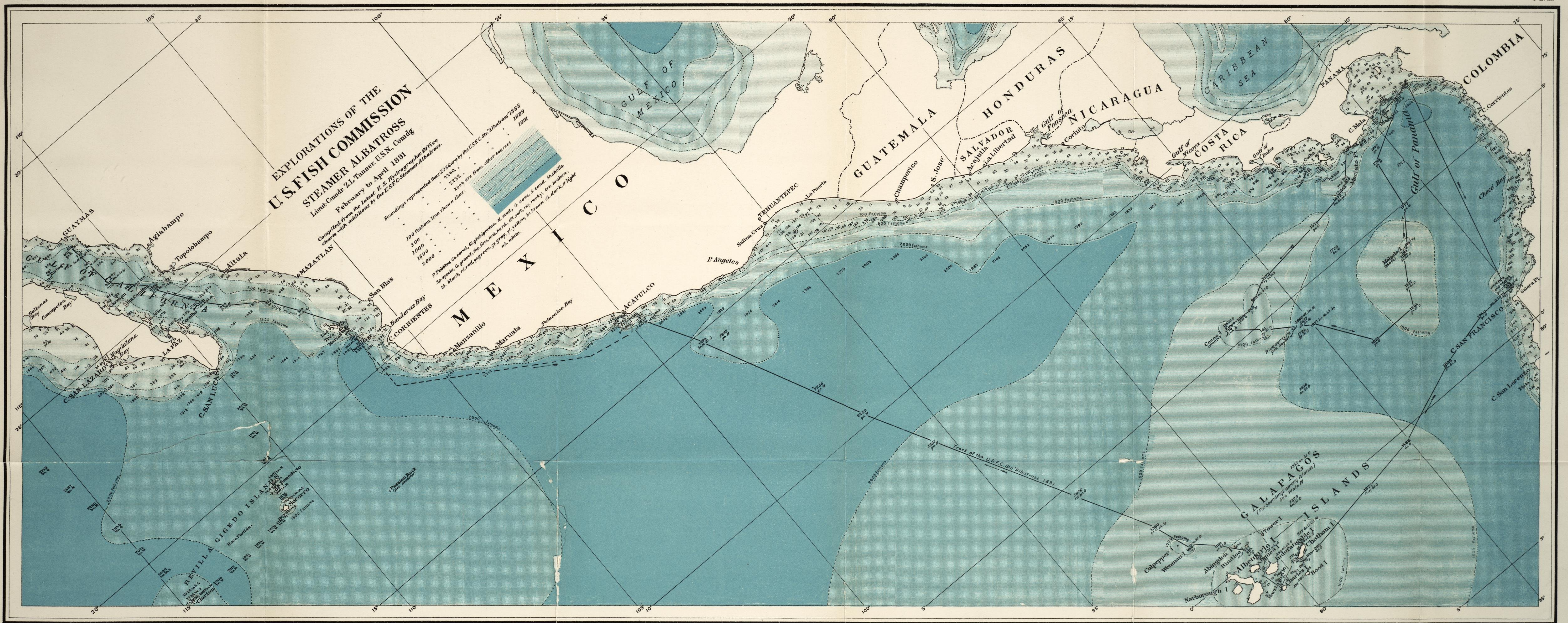
Part of Eastern Face of Duncan Island, near the Landing Cove.



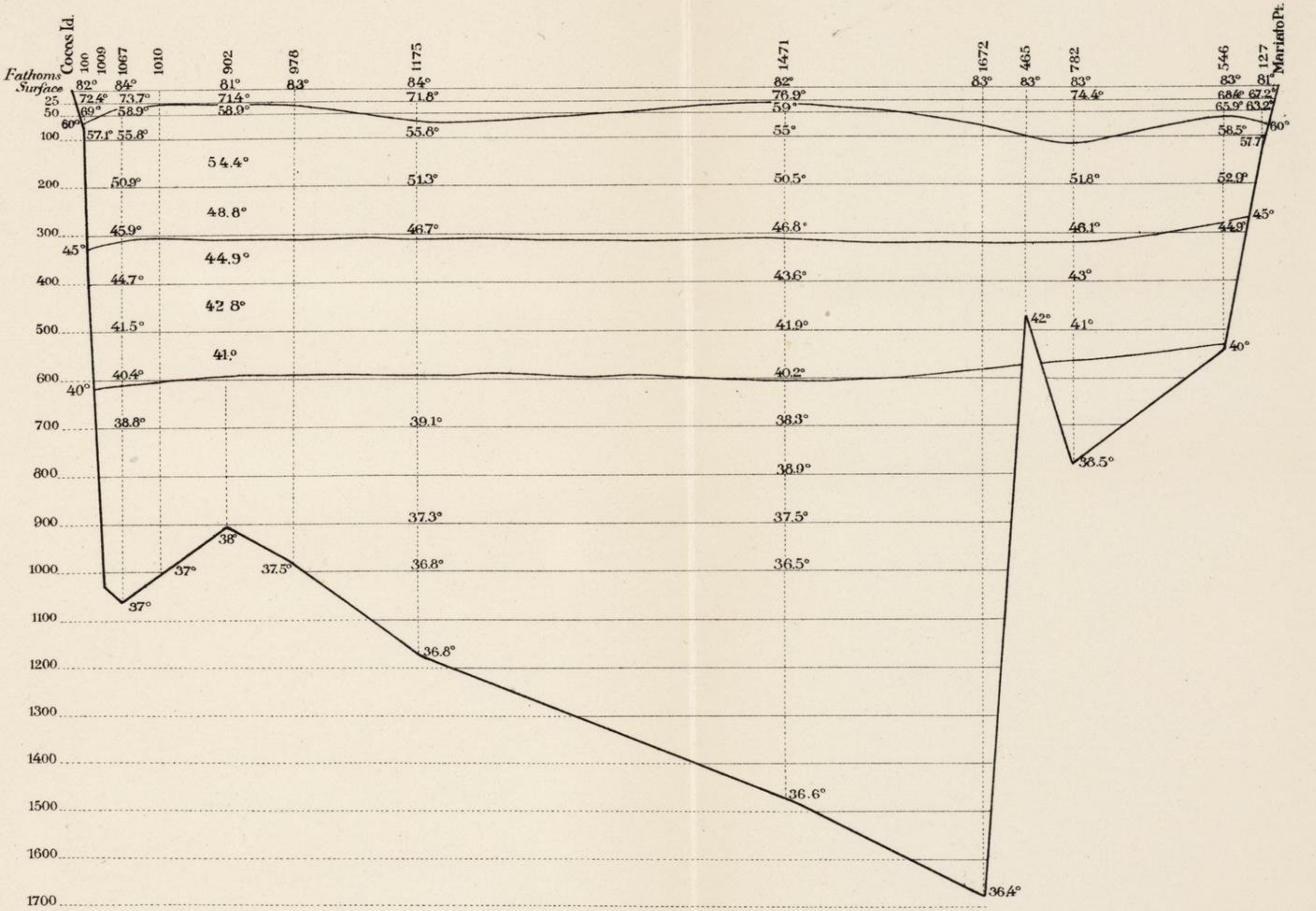
P. Meisel, lith. Boston.



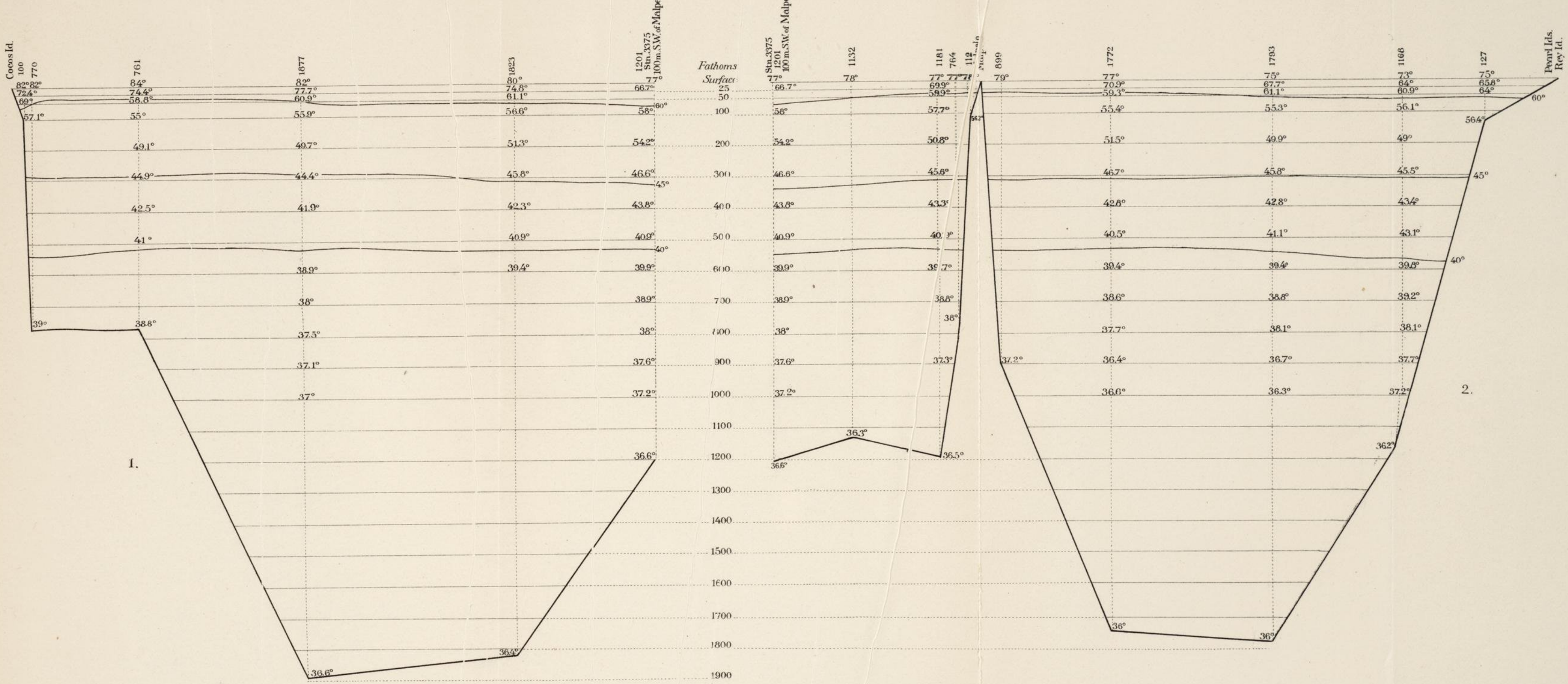
B. Meisel, lith. Boston.


EXPLORATIONS OF THE
U.S. FISH COMMISSION
STEAMER ALBATROSS
Lieut. Comdr. Z. L. Tanner. U.S.N., Comdg.
February to April 1891
Compiled from the latest U. S. Hydrographic Office charts with additions by the U.S.F.C. Steamer Albatross.
Soundings represented thus: 2256, are by the U.S.F.C. Str. "Albatross" 1888
" " " 2280, " " " " " 1889
" " " 2232, " " " " " 1891
" " " 2004 are from other sources
100 fathom line shown thus:
500 " " " "
1000 " " " "
1500 " " " "
2000 " " " "
P. Pebbles, Co. coral, Gl. globigerina, M. mud, O. ooze, S. sand, Sh. shells, Sp. specks, G. gravel, fne. fine, hrd. hard, sft. soft, rky. rocky; brk. broken, bk. black, rd. red, gn. green, gy. gray, yl. yellow, bn. brown, dk. dark, lt. light wh. white.
MEXICO
GULF OF MEXICO
GUATEMALA
HONDURAS
SALVADOR
NICARAGUA
COSTA RICA
CARIBBEAN SEA
COLOMBIA
PANAMA
Gulf of Panama
GULF OF CALIFORNIA
GALAPAGOS ISLANDS
REVILLA GIGEDO ISLANDS
GUAYMAS
Agiabampo
Topolobampo
Altata
MAZATLAN
San Blas
Banderas Bay
C. CORRIENTES
Manzanillo
Maruata
Petacalco Bay
ACAPULCO
P. Angeles
Salina Cruz
TEHUANTEPEC
La Puerta
Champerico
S. José
Acajutla
La Libertad
Gulf of Fonseca
Corinto
Gulf of Nicoya
Gulf of Dulce
C. Mala
C. Corrientes
Chocó Bay
C. SAN FRANCISCO
C. San Lorenzo
LA PAZ
C. SAN LUCAS
C. SAN LAZARO
Magdalena Bay
Socorro
Clarion
Passion Rock
Track of the U.S.F.C. Str. "Albatross" 1891
Culpepper I.
Wenman I.
Abingdon I.
Tower I.
Albemarle I.
Indefatigable I.
Chatham I.
Hood I.
Charles I.
Narborough I.
Malpelo I.
Cocos I.

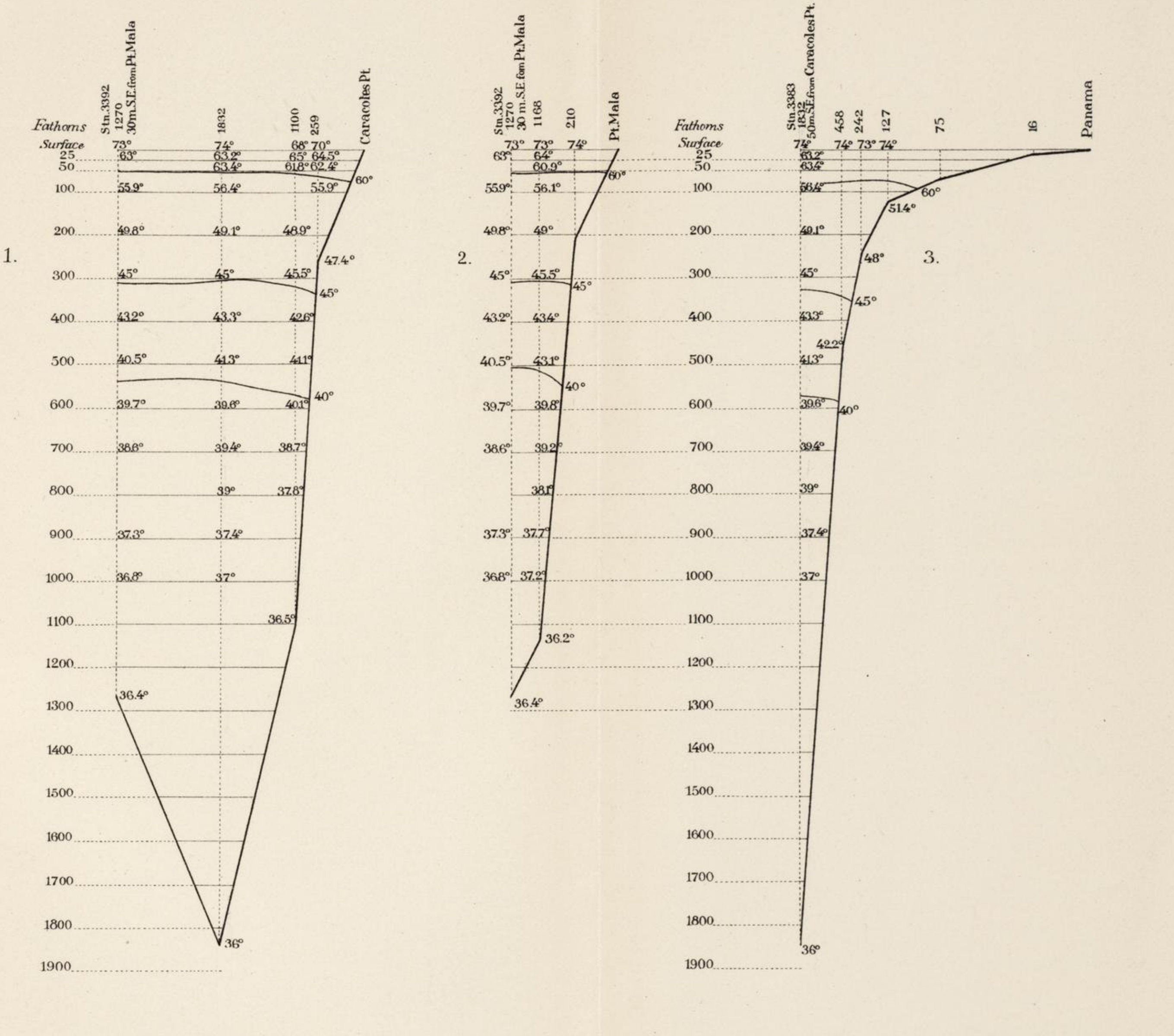
B. Meisel photo. lith.



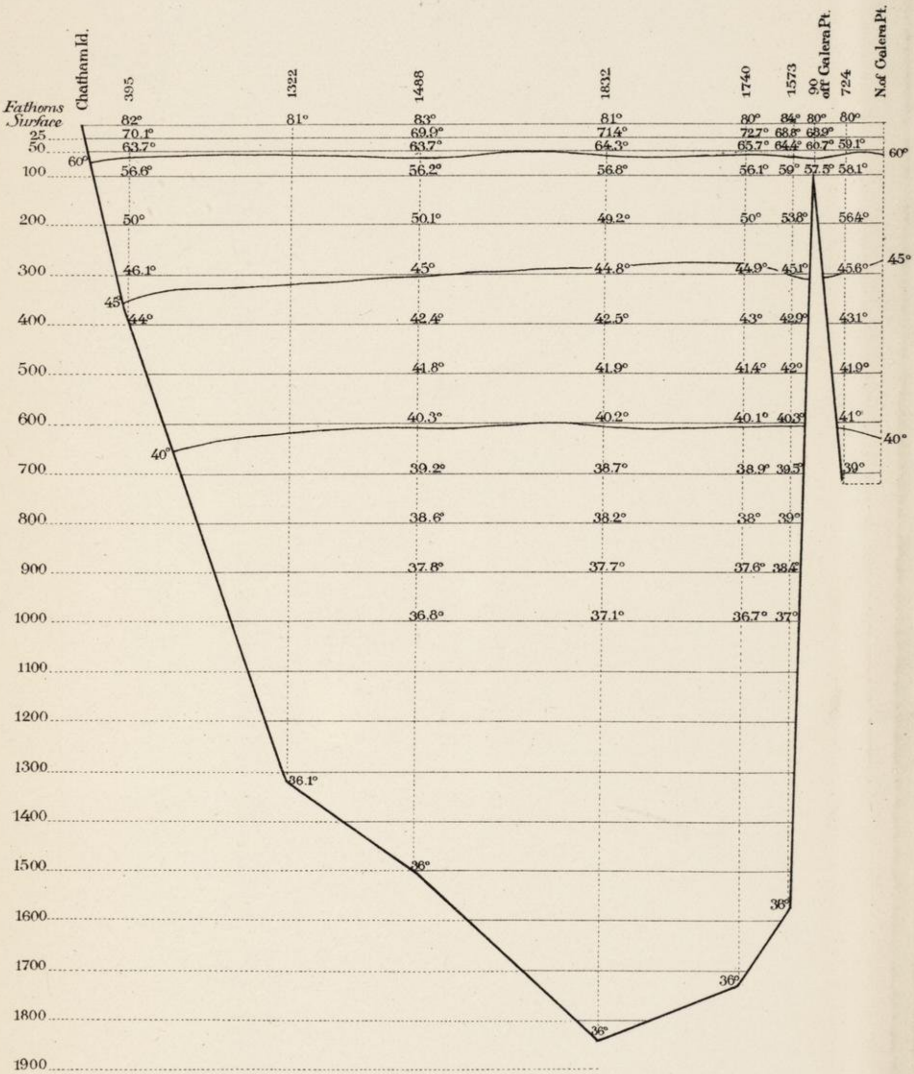
B. Meisel, lith. Boston.



B. Meisel, lith. Boston.



B. Meisel, lith. Boston.



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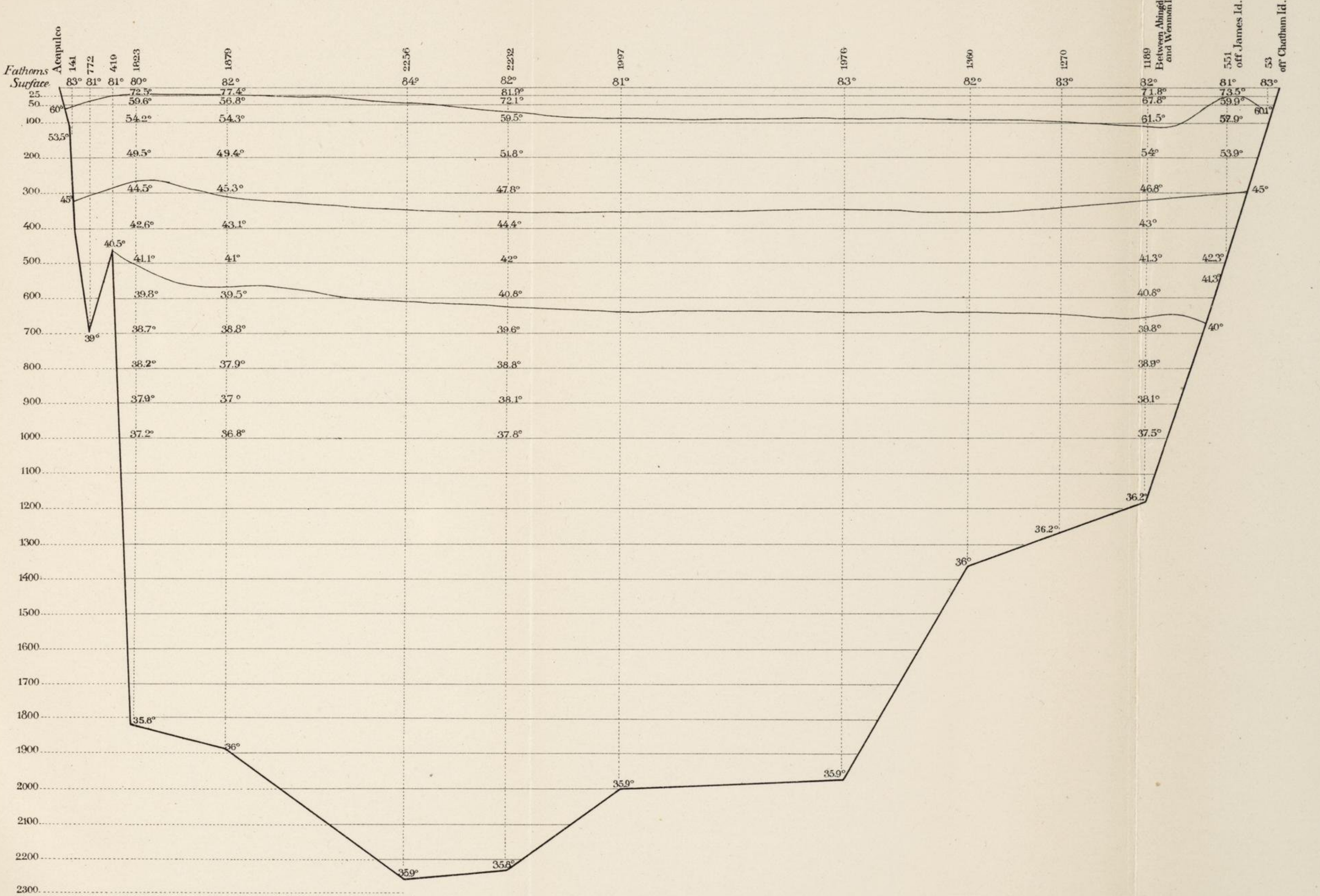
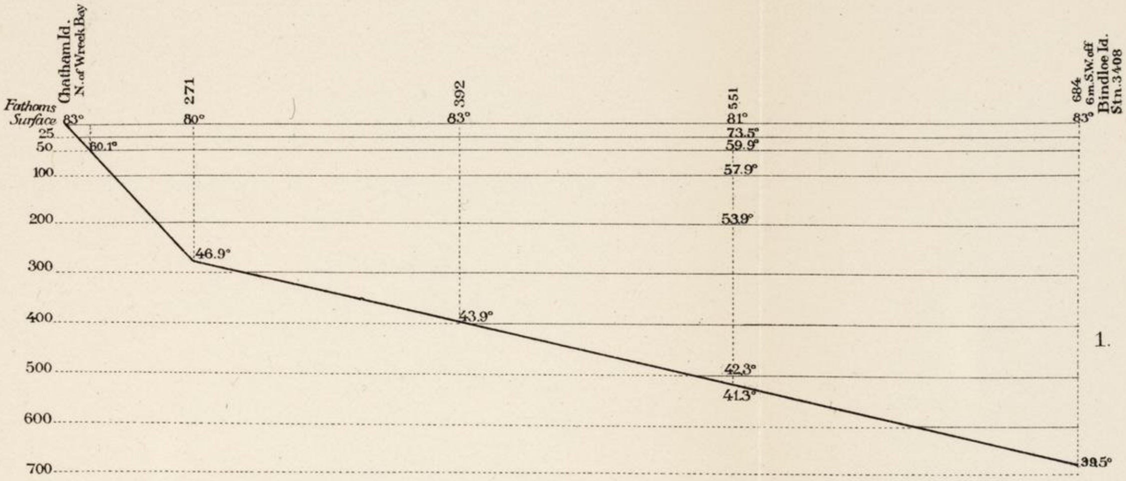
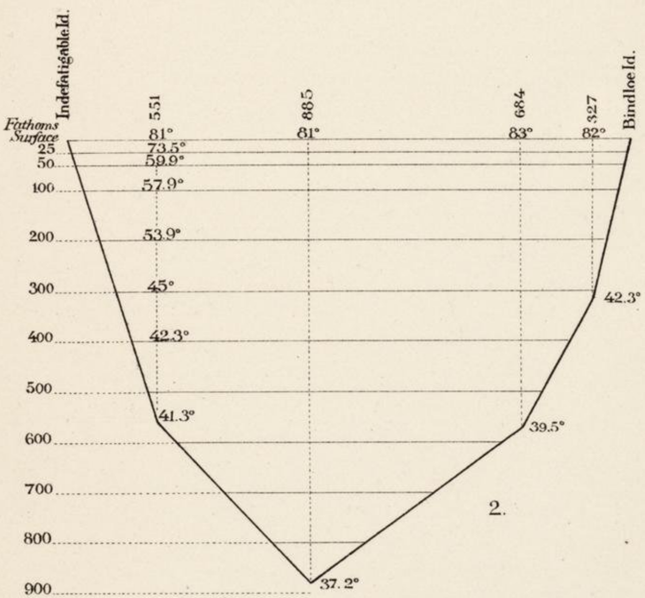

Fathoms
Surface
Acapulco
Between Abingdon and Wenman Ids.
off James Id.
off Chatham Id.
B. Meisel, lith. Boston.



1.



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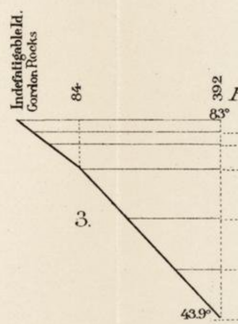

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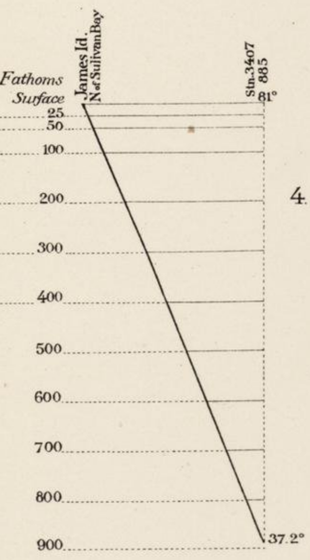

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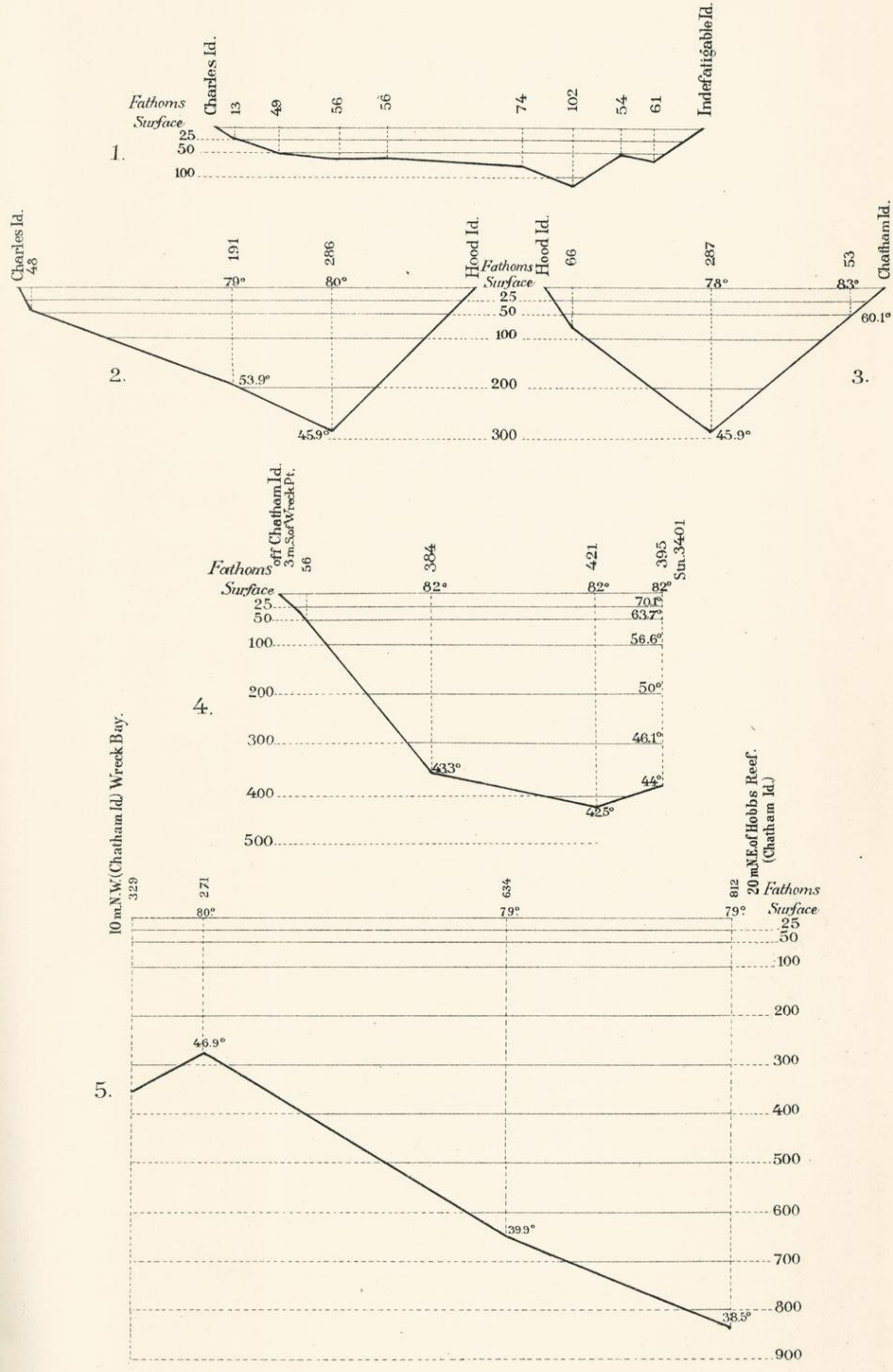
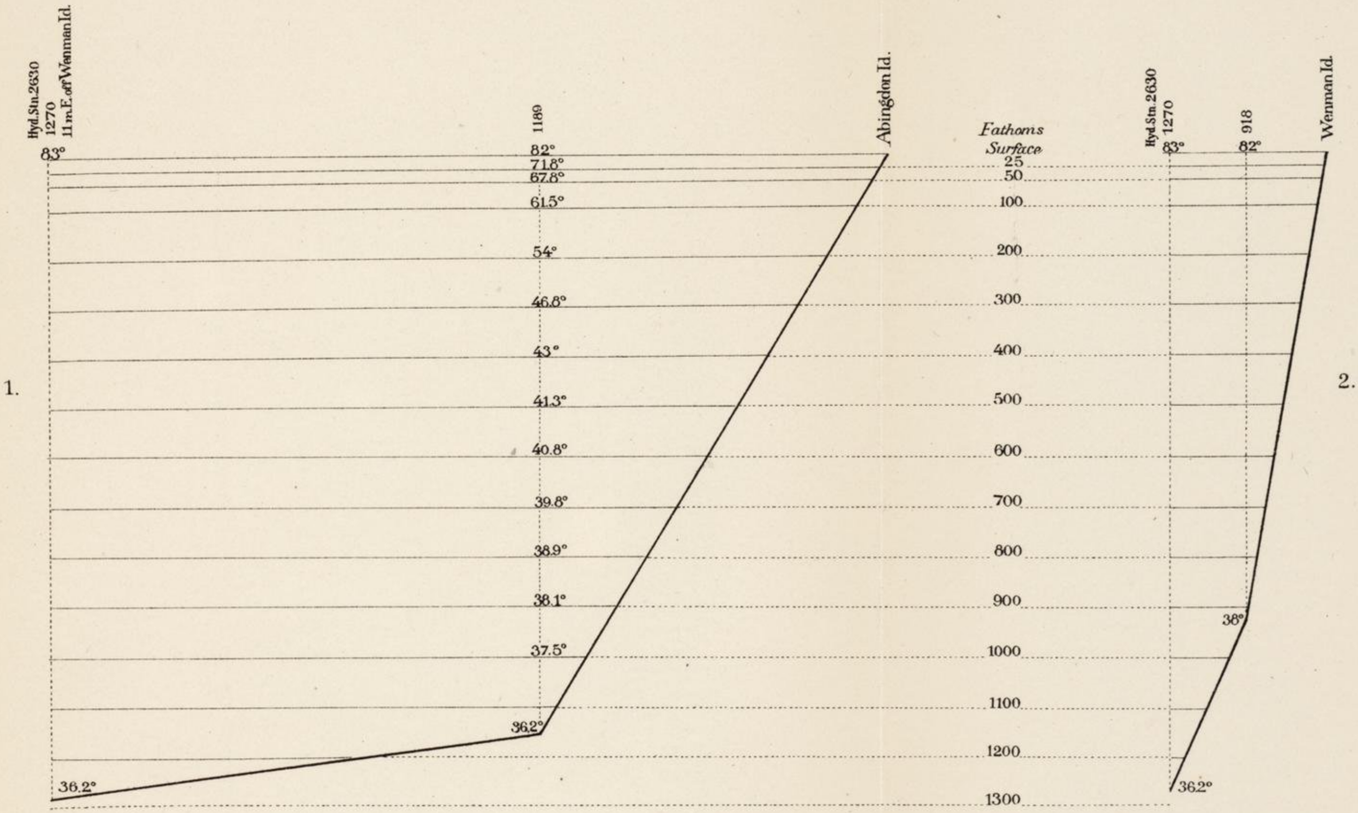
B. Meisel, lith. Boston.


1.
Fathoms
Surface
25
50
100
Charles Id.
13
49
56
56
74
102
54
61
Indefatigable Id.
2.
Charles Id.
48
191
286
79°
80°
53.9°
45.9°
Hood Id.
Fathoms
Surface
25
50
100
200
300
Hood Id.
66
287
53
Chatham Id.
78°
83°
60.1°
45.9°
3.
4.
Fathoms
Surface
off Chatham Id.
3 m. S. of Wreck Pt.
56
384
421
395
Stn. 3401
82°
82°
82°
70.1°
63.7°
56.6°
50°
46.1°
43.3°
44°
42.5°
25
50
100
200
300
400
500
5.
10 m. N.W. (Chatham Id.) Wreck Bay.
329
271
634
812
20 m. N.E. of Hobbs Reef.
(Chatham Id.)
Fathoms
Surface
80°
79°
79°
46.9°
39.9°
38.5°
25
50
100
200
300
400
500
600
700
800
900



B. Meisel, lith. Boston.

N. B MILLER, PHOTO.

ARTOTYPE, E. BIERSTADT N. Y.

CHATHAM BAY COCOS ISLAND.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT, N. Y.

MALPELO ISLAND.

SEEN FROM THE WESTWARD.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT, N. Y.

CORAL SAND FLAT, BACK OF LANDING BEACH, WRECK BAY.

CHATHAM ISLAND.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT, N. Y.

ON WAY TO HACIENDA.

CHATHAM ISLAND.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT N. Y.

PLATEAU SEEN LOOKING EAST FROM HACIENDA.

CHATHAM ISLAND.

N. B. MILLER, PHOTO.

ARTOTYPE, E. BIERSTADT N. Y.

LAVA BLOCKS WEST OF BLACKBEACH.

CHARLES ISLAND.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT, N. Y.

ROCKS AND BLACKBEACH.

CHARLES ISLAND.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT, N. Y.

VEGETATION NEAR BLACKBEACH.

CHARLES ISLAND.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT, N. Y.

CHARLES ISLAND.

VEGETATION ON WAY TO HACIENDA.

N. B. MILLER, PHOTO. ARTOTYPE, E. BIERSTADT. N. Y.

DUNCAN ISLAND.

EAST FACE NEAR LANDING COVE.

The following Reports are in preparation on the Dredging Operations off the West Coast of Central America to the Galapagos, to the West Coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U. S. Fish Commission Steamer "Albatross," Lieut. Commander Z. L. Tanner, U. S. N., Commanding.

A. AGASSIZ. General Sketch of the Expedition of the "Albatross," from February to May, 1891.

A. AGASSIZ. The Acalephs and Pelagic Fauna.

A. AGASSIZ. On Calamocrinus, a new Stalked Crinoid from the Galapagos.

A. AGASSIZ. The Echini.

JAS. E. BENEDICT. The Annelids.

R. BERGH. The Nudibranchs.

GEO. BROOK. The Antipathids.

W. H. DALL. The Mollusks.

C. B. DAVENPORT. The Bryozoa.

S. F. CLARKE and F. E. PEABODY. The Hydroids.

W. FAXON. The Crustacea.

S. GARMAN. The Fishes.

A. GOËS. The Foraminifera.

C. HARTLAUB. The Comatulæ.

W. A. HERDMAN. The Ascidians.

W. E. HOYLE. The Cephalopods.

G. von KOCH. The Deep Sea Corals.

R. von LENDENFELD. The Phosphorescent Organs of Fishes.

H. LUDWIG. The Holothurians.

C. F. LÜTKEN. The Ophiuridæ.

E. L. MARK. The Actinarians.

JOHN MURRAY. The Bottom Specimens.

ROBERT RIDGWAY. The Alcoholic Birds.

W. PERCY SLADEN. The Starfishes.

L. STEJNEGER. The Reptiles.

TH. STUDER. The Alcyonarians.

H. V. WILSON. The Sponges.

W. M. WOODWORTH. The Planarians.

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Vols. XVI. and XXIII. of the BULLETIN and Vols. XI., XIV., and XVII. of the MEMOIRS are now in course of publication.

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ALEXANDER AGASSIZ, *Director.*