WOODS HOLE OCEANOGRAPHIC INSTITUTION

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Preliminary Cruise Report

ATLANTIS II - Cruise 8

International Indian Ocean Expedition

July 5, 1963 - December 20, 1963

by

Arthur R. Miller and R. W. Risebrough

Sponsored by Grant NSF-GP 821 from the

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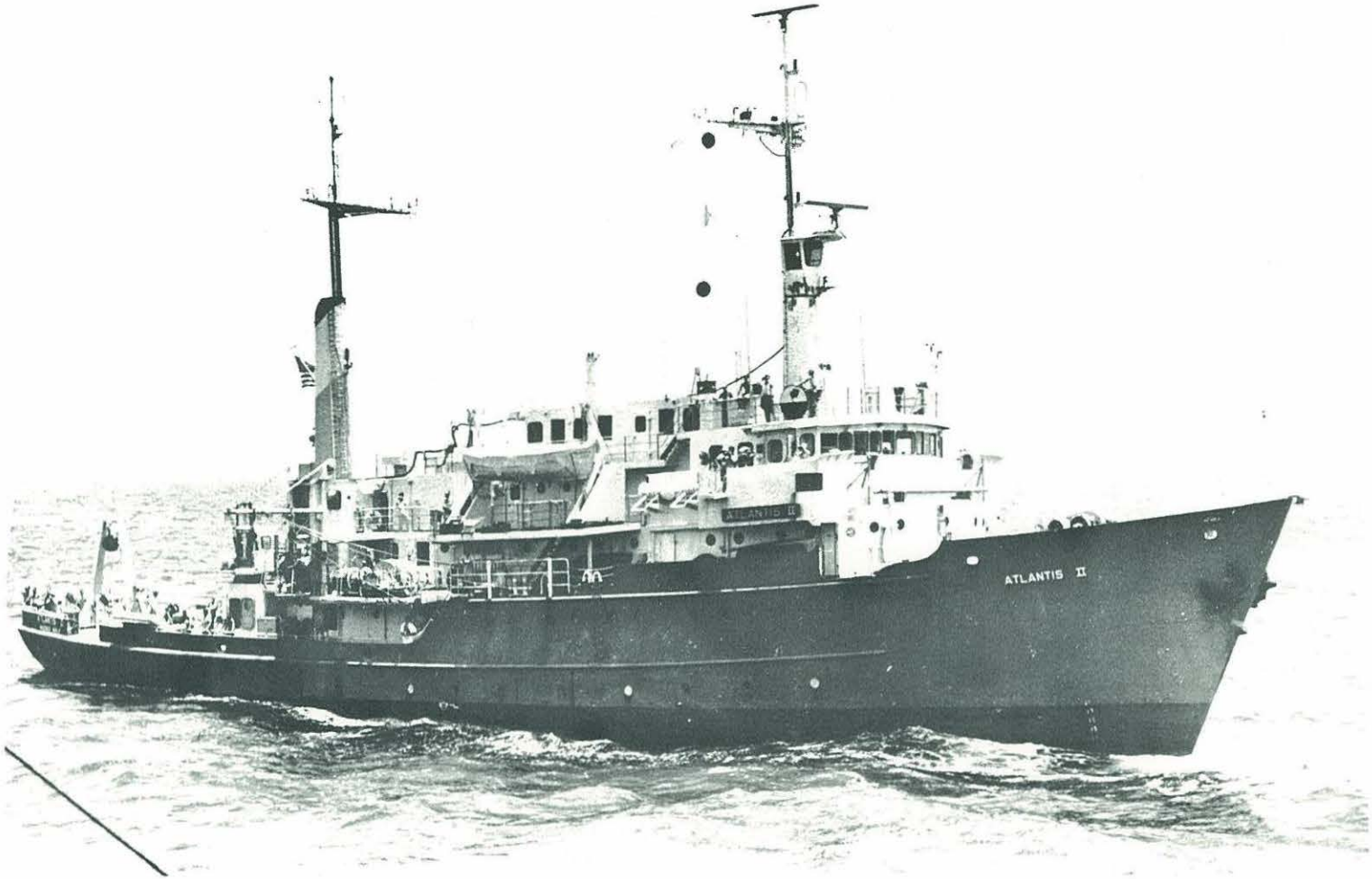
APPROVED FOR DISTRIBUTION Paul M. Fye

Paul M. Fye, Director



ATLANTIS II ON STATION NEAR THE SEYCHELLES ISLANDS
(PHOTOGRAPH FROM THE ROYAL RESEARCH SHIP DISCOVERY
TAKEN BY MR. T. HUMPHREY, CHIEF ENGINEER)

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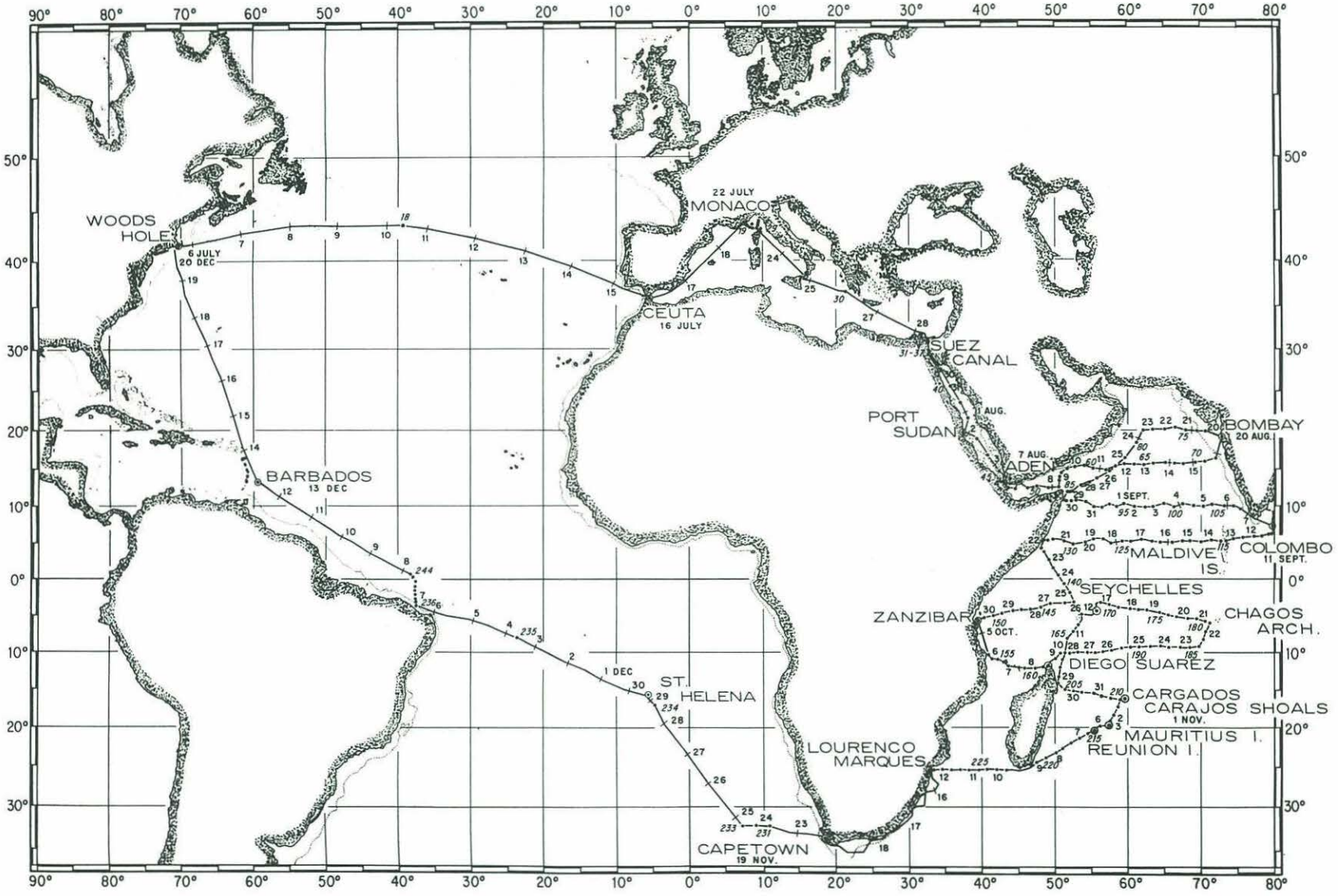
INTRODUCTION

ATLANTIS II was delivered to the Woods Hole Oceanographic Institution on January 31, 1963. She was built at Baltimore, Maryland by Maryland Shipbuilding and Drydock Company with funds granted by the National Science Foundation. After some short cruises she left Woods Hole on July 5 to participate in the International Indian Ocean Expedition, her first major effort of long duration since her delivery. Cruise Eight was a strict test of the capabilities, endurance, facilities and comfort for which she was designed. ATLANTIS II returned to Woods Hole on December 20, 1963 after a cruise of 5 1/2 months and 30,000 miles of travel. She stood the test well for after mooring dockside for three weeks she departed on another long voyage for four months in the North Atlantic.

The investigations in the Indian Ocean were perhaps unique among other cruises of the Expedition in that full coverage of the Arabian Sea was obtained during the Southwest Monsoon in August and September. Further coverage to the south was obtained in October and November where southeast winds were predominant. Inclusion of the Red Sea as part of the Expedition, the total number of hydrographic stations completed during this portion of the cruise was 193, consisting of observations more or less at standard depths to the bottom. These observations, together with various meteorological measurements

and chemical analyses are being processed and evaluated. Geophysical observations such as bathymetry and magnetometer results are also being processed along with the navigational positions from the VLF Navigation System.



TRACK OF ATLANTIS II, CRUISE 8 GIVING NOON
POSITIONS FOR EACH DAY AND STATION POSITIONS (18 THROUGH 244)

ITINERARY

The first port-of-call of major importance of ATLANTIS II was Monaco where an exchange of scientists took place and considerable chemical equipment was taken aboard. Liaison and visits from scientists of the International Hydrographic Bureau, the International Laboratory of Marine Radioactivity, the Musee Oceanographique and the Centre Scientifique de Monaco were in order. It became evident that there was considerable curiosity and interest in the ATLANTIS II and, consequently, an in-port scientific watch was established to show off and demonstrate the apparatus aboard the ship. This procedure was followed throughout the voyage.

Immediately upon leaving Monaco a series of stations was taken in the Ligurian Sea. These stations permitted the guest scientists from the International Laboratory of Marine Radioactivity to obtain data which would serve as a reference both with data collected previously in this area and with those obtained later in the Indian Ocean.

During one of these stations, the ATLANTIS II was host to a party of Italian scientists and NATO officials from La Spezia.

At Port Said, officials of the Suez Canal Authority boarded the ATLANTIS II and remained aboard as guests during the passage through the Canal. Dr. Morcos of the University

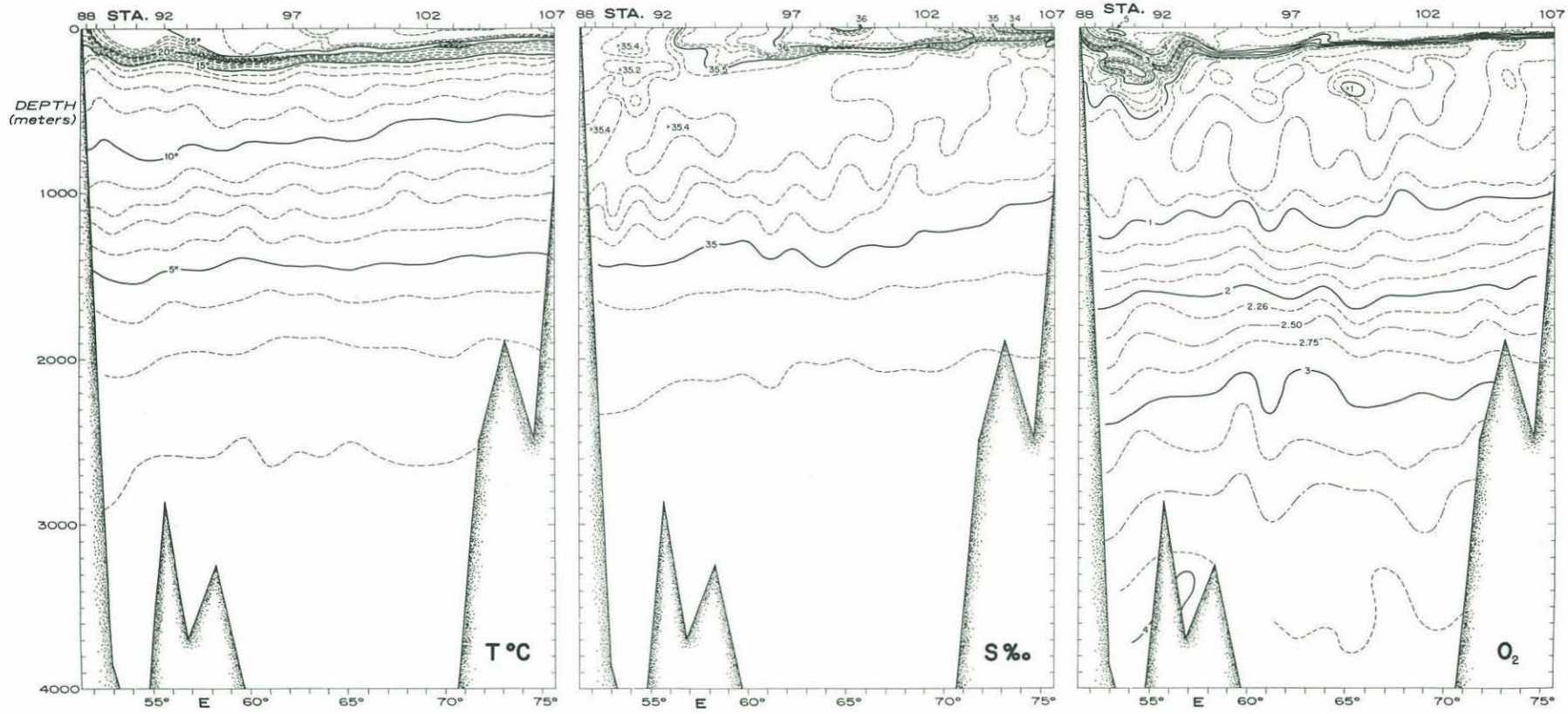
of Alexandria also joined the ship in Port Said and participated in the work performed in the Great Bitter Lake, where a series of stations was taken.

Stations were also taken during the passage through the Red Sea. The very high salinity at the bottom of a deep hole, reported by the R/V ATLANTIS in 1958, was confirmed. Rendezvous with the French Research Vessel CALYPSO was made off Port Sudan. Here, Captain Cousteau and his staff had built an undersea chamber ten meters below the sea surface. Visits were exchanged.

The ship was refueled in Aden.

In the Gulf of Aden, radio contact was made with the Royal Research Ship DISCOVERY, and a very useful discussion of the respective work of the two ships ensued. North of Cape Guardafui the first reference station was taken. Other ships participating in the International Indian Ocean Expedition also took stations on this location so that the respective data might be compared. The track then lay north to the Arabian coast and east on 15 N towards India. Stations were at intervals of 50 or 60 miles.

In Bombay the scientific staff were guests of the University of Bombay. In return the ATLANTIS II was visited by numerous Indian scientists and members of the general public. Chemical supplies and other scientific equipment were obtained



SALINITY, TEMPERATURE AND OXYGEN PROFILE
ACROSS THE SOMALIA CURRENT 10°N.

locally through the assistance of Dr. Satyanarayana Rao, chairman of the Coordinating Committee of the International Indian Ocean Expedition.

From Bombay the track lay north, then west along 20 N towards the Arabian coast, south-west past the island of Socotra, east on 10 N and south to Colombo. Two more reference stations were taken. Except for those areas where additional data were desirable, stations as before were at intervals of 50 or 60 miles.

From Colombo the route was west on 5 N to the Somali coast where direct measurements of the Somali current were taken. During a rendezvous with the Royal Research Ship DISCOVERY, hydrographic cable was transferred to the ATLANTIS II. After a track to the south-east to 5 S, and a track to the south-west, the ATLANTIS II reached Zanzibar on September 30. 105 stations had been taken in the north-western sector of the Indian Ocean during the period of the South West Monsoon.

From Zanzibar the track was planned so as to obtain maximum coverage of the southern Indian Ocean west of the Indian Ocean Ridge within the time available. The route was east towards northern Madagascar; northeast to the Seychelles Islands; east through the Chagos Islands; west on 10 S; south-east to the Cargados Carajos where a landing party went ashore to collect biological material; south to Mauritius; west to Lourenco Marques

In Capetown the scientific staff were guests of the University of Capetown and of the Cape Divisional Council.

During the return trip, stations were taken at 32 S and in the Equatorial Current east of Brazil. Brief stops were made on Saint Helena and Barbados.

HYDROGRAPHIC STATIONS LIST

Station	Date	Time	Depth	Latitude	Longitude
18	7/10	13.0	4297	43°30.0'N	39°47.5'W
19	7/21	09.5	951	43°39.5'N	07°37.0'E
20	7/21	13.3	2423	43°31.5'N	08°03.5'E
21	7/21	20.1	2573	43°35.0'N	08°39.0'E
22	7/22	00.2	2476	43°22.5'N	08°27.5'E
23	7/22	08.0	2150	43°13.5'N	08°52.5'E
24	7/22	17.0	0292	43°57.5'N	09°41.5'E
25	7/22	19.3	0426	43°47.0'N	09°35.0'E
26	7/22	21.0	0686	43°38.5'N	09°31.0'E
27	7/23	01.0	0377	43°04.5'N	09°17.5'E
28	7/23	04.2	0503	43°09.0'N	09°40.5'E
29	7/23	06.3	0549	42°49.0'N	09°46.0'E
30	7/25	18.9	5084	36°34.5'N	21°04.5'E
31	7/29	03.0	0012	30°18.5'N	32°24.7'E
32	7/29	04.8	0012	30°18.7'N	32°25.9'E
33	7/29	05.4	0011	30°20.6'N	32°24.7'E
34	7/29	06.7	0007	30°22.6'N	32°23.4'E
35	7/29	07.5	0012	30°21.5'N	32°21.6'E
36	7/29	08.5	0012	30°20.8'N	32°20.0'E
37	7/29	09.0	0016	30°18.9'N	32°22.3'E
WB1	7/29	06.1	0008	30°20.8'N	32°25.6'E
2	7/29	06.7	0006	30°22.8'N	32°23.9'E
3	7/29	07.1	0005	30°23.8'N	32°21.5'E
4	7/29	07.6	0003	30°23.4'N	32°18.9'E
5	7/29	08.0	0006	30°21.4'N	32°19.3'E
6	7/29	08.3	0007	30°19.7'N	32°19.5'E
7	7/29	09.0	0006	30°17.5'N	32°23.6'E
38	7/29	19.0	0073	28°50.0'N	32°59.0'E
39	7/30	05.4	1150	27°28.0'N	34°14.0'E
40	7/30	20.9	0817	25°20.5'N	35°40.0'E
41	7/31	10.3	1039	23°10.5'N	37°00.0'E
42	8/1	00.4	1980	21°21.5'N	38°04.5'E
43	8/2	04.0	0841	18°55.5'N	39°08.0'E
44	8/2	19.3	1298	16°42.0'N	40°53.5'E
45	8/3	09.1	0419	14°28.0'N	42°22.0'E

Station	Date	Time	Depth	Latitude	Longitude
46	8/3	18.3	0232	13°07.5'N	43°03.0'E
47	8/3	23.9	0304	12°22.0'N	43°38.5'E
48	8/4	05.6	1178	12°09.5'N	44°36.0'E
49	8/6	22.0	1503	12°21.0'N	46°16.0'E
50	8/7	07.7	2273	12°28.5'N	47°44.0'E
51	8/7	16.9	2270	12°12.5'N	49°13.0'E
52	8/8	02.4	2337	12°22.0'N	50°40.0'E
53	8/8	10.6	2506	13°15.0'N	50°36.5'E
54	8/8	21.5	2543	13°44.0'N	50°42.5'E
55	8/9	03.0	2187	14°16.0'N	50°59.5'E
56	8/9	12.1	1022	14°59.0'N	51°57.0'E
57	8/9	14.6	1852	15°00.0'N	52°17.0'E
58	8/9	20.7	2180	15°03.0'N	52°51.5'E
59	8/10	05.0	2704	15°08.0'N	54°10.5'E
60	8/10	14.2	2356	15°00.5'N	55°21.5'E
61	8/11	00.3	3195	14°56.5'N	56°59.0'E
62	8/11	12.0	3833	15°05.5'N	58°13.5'E
63	8/11	21.5	4245	15°14.5'N	59°39.5'E
64	8/12	06.6	4080	15°18.5'N	60°58.5'E
65	8/12	16.5	3973	15°23.5'N	62°22.0'E
66	8/13	02.2	3861	15°29.0'N	63°43.5'E
67	8/13	13.0	3786	15°34.0'N	65°05.5'E
68	8/13	23.5	3839	15°42.0'N	66°25.0'E
69	8/14	10.7	3811	15°48.0'N	67°46.0'E
70	8/14	20.4	3740	15°53.0'N	69°13.5'E
71	8/15	05.6	3521	15°58.0'N	70°34.5'E
72	8/15	16.5	0949	16°12.0'N	72°03.5'E
73	8/20	05.6	0082	19°59.5'N	70°37.0'E
74	8/20	13.9	0940	19°59.5'N	69°18.0'E
75	8/20	23.2	3091	19°59.0'N	67°57.0'E
76	8/21	09.8	2692	20°02.0'N	66°57.0'E
77	8/21	21.1	3166	19°58.5'N	64°58.0'E
78	8/22	19.6	3360	20°00.0'N	63°38.0'E
79	8/23	07.2	3541	19°59.0'N	62°06.0'E
80	8/23	23.5	3778	18°16.0'N	61°14.0'E
81	8/24	20.6	2536	16°06.5'N	59°50.0'E
82	8/26	01.0	3080	14°15.5'N	57°23.0'E
83	8/27	00.2	3947	13°18.0'N	55°47.0'E
84	8/27	15.1	3411	12°53.0'N	54°38.5'E
85	8/28	15.2	1048	11°48.5'N	52°16.5'E

Station	Date	Time	Depth	Latitude	Longitude
86	8/28	18.3	1017	11°47.0'N	52°04.5'E
87	8/28	21.1	0936	11°46.0'N	51°52.0'E
88	8/29	11.9	0380	10°27.5'N	51°41.0'E
89	8/29	16.1	1500	10°21.0'N	52°06.0'E
90	8/29	21.7	3862	10°25.5'N	52°57.0'E
91	8/30	06.7	4492	10°20.5'N	54°11.0'E
92	8/30	16.8	2847	09°47.5'N	55°34.0'E
93	8/31	01.5	3702	09°45.0'N	56°44.5'E
94	8/31	17.3	3235	09°58.0'N	58°17.0'E
95	9/1	03.1	4023	10°05.0'N	59°39.0'E
96	9/1	17.4	3985	09°56.0'N	60°58.5'E
97	9/2	03.4	4512	09°48.5'N	62°18.0'E
98	9/2	13.7	4439	09°58.0'N	63°40.0'E
99	9/3	02.7	4413	10°04.5'N	65°00.5'E
100	9/3	13.4	4422	09°56.0'N	66°22.5'E
101	9/3	23.5	4451	10°02.5'N	67°39.5'E
102	9/4	10.5	4532	09°58.0'N	69°03.0'E
103	9/4	20.5	4371	09°58.0'N	70°24.0'E
104	9/5	07.4	2540	10°00.0'N	71°46.0'E
105	9/5	16.8	1921	09°58.5'N	73°08.0'E
106	9/6	01.2	2452	09°59.5'N	74°31.0'E
107	9/6	13.6	0962	09°32.0'N	75°30.5'E
108	9/10	21.3	0607	06°10.0'N	79°50.0'E
109	9/11	01.2	3374	06°04.0'N	79°22.0'E
110	9/11	09.8	3268	05°49.5'N	78°20.0'E
111	9/11	20.2	2504	05°42.0'N	77°03.0'E
112	9/12	06.3	2300	05°28.0'N	75°44.0'E
113	9/12	17.1	2595	05°15.0'N	74°24.0'E
114	9/13	03.8	0713	05°05.0'N	73°23.0'E
115	9/13	09.2	2244	05°00.0'N	72°39.0'E
116	9/13	19.2	3996	05°01.5'N	71°15.0'E
117	9/14	05.8	4345	05°00.0'N	69°59.5'E
118	9/14	16.3	4098	05°00.0'N	68°39.0'E
119	9/15	02.0	??	05°00.0'N	67°26.0'E
120	9/15	15.4	3886	04°56.0'N	65°59.0'E
121	9/16	01.3	3828	04°59.0'N	64°38.0'E
122	9/16	11.1	3574	05°00.0'N	63°17.5'E
123	9/16	21.1	2855	05°03.0'N	61°57.5'E
124	9/17	06.3	3074	04°59.5'N	60°34.5'E
125	9/17	15.5	4292	04°56.0'N	59°15.5'E

Station	Date	Time	Depth	Latitude	Longitude
126	9/18	01.4	3987	04°56.0'N	57°53.0'E
127	9/18	13.0	4563	05°07.0'N	56°41.0'E
128	9/19	00.7	5040	05°04.0'N	55°20.0'E
129	9/19	11.3	5141	05°00.0'N	54°08.5'E
130	9/20	08.2	5112	04°44.0'N	52°36.0'E
131	9/20	18.6	5066	05°00.0'N	51°17.0'E
132	9/21	06.9	3815	05°05.0'N	49°57.5'E
133	9/21	19.7	1758	05°00.5'N	49°03.0'E
134	9/21	22.8	0318	05°00.0'N	48°43.0'E
135	9/22	06.9	0633	04°00.0'N	48°04.5'E
136	9/22	11.6	3301	03°33.5'N	48°28.0'E
137	9/22	22.0	4481	02°23.0'N	49°01.5'E
138	9/23	07.8	5020	01°19.0'N	49°58.0'E
139	9/23	21.3	5093	00°13.0'N	50°39.0'E
140	9/24	09.4	5106	00°57.0'S	51°23.0'E
141	9/24	20.1	5154	02°01.0'S	52°06.0'E
142	9/25	09.1	4572	03°10.5'S	52°43.0'E
143	9/26	01.1	5097	03°30.0'S	51°33.0'E
144	9/27	00.7	5024	03°43.0'S	49°22.0'E
145	9/27	11.8	4912	04°06.5'S	48°08.0'E
146	9/27	20.5	4780	04°22.0'S	46°49.5'E
147	9/28	07.5	4649	04°33.5'S	45°31.0'E
148	9/28	16.6	4395	04°40.0'S	44°11.5'E
149	9/29	07.5	3882	05°00.5'S	42°57.0'E
150	9/29	16.5	3006	05°15.0'S	41°35.5'E
151	9/30	02.3	1895	05°41.0'S	40°16.0'E
152	9/30	07.8	0826	05°38.5'S	39°35.0'E
153	10/5	17.0	0609	10°41.0'S	40°44.0'E
154	10/5	22.6	2818	11°06.5'S	41°26.0'E
155	10/6	07.6	2619	11°22.0'S	42°14.0'E
156	10/6	14.7	2548	11°40.5'S	43°02.0'E
157	10/6	23.1	1971	12°10.0'S	43°55.0'E
158	10/7	08.6	2024	12°28.0'S	45°07.0'E
159	10/7	14.6	3531	12°35.0'S	45°54.0'E
160	10/8	01.0	3495	12°30.5'S	47°12.5'E
161	10/8	09.6	1074	12°13.0'S	48°17.0'E
162	10/8	18.7	1255	11°47.0'S	49°13.0'E
163	10/9	06.0	2824	11°08.5'S	50°10.5'E
164	10/9	14.8	3186	10°31.0'S	50°56.5'E
165	10/10	10.7	4376	08°30.0'S	51°49.0'E

Station	Date	Time	Depth	Latitude	Longitude
166	10/10	21.8	3661	07°26.5'S	52°43.5'E
167	10/11	09.1	3652	06°27.0'S	53°09.0'E
168	10/11	22.6	3217	05°05.0'S	53°56.0'E
169	10/16	15.4	3253	03°40.0'S	56°15.5'E
170	10/17	01.4	4071	03°56.5'S	57°39.0'E
171	10/17	10.9	4175	04°07.5'S	58°56.0'E
172	10/17	21.0	3363	04°22.0'S	60°24.0'E
173	10/18	05.8	3683	04°34.0'S	61°35.5'E
174	10/18	15.0	3921	04°44.4'S	62°51.5'E
175	10/19	01.5	4020	04°59.0'S	64°18.0'E
176	10/19	10.9	3581	05°14.0'S	65°32.0'E
177	10/19	20.5	3241	05°27.0'S	66°51.0'E
178	10/20	00.7	3230	05°46.0'S	68°13.0'E
179	10/20	16.4	3466	05°54.0'S	69°30.0'E
180	10/21	00.7	3736	06°60.5'S	70°38.5'E
181	10/21	06.3	2366	06°15.0'S	71°10.5'E
182	10/21	15.6	2142	07°30.5'S	70°38.5'E
183	10/22	00.4	1798	08°31.0'S	70°13.0'E
184	10/22	08.5	2999	09°29.5'S	69°47.0'E
185	10/22	18.2	3846	09°30.0'S	68°25.5'E
186	10/23	03.6	2507	09°30.0'S	67°05.0'E
187	10/23	11.2	4016	09°30.0'S	65°44.0'E
188	10/23	22.0	3266	09°30.0'S	64°18.0'E
189	10/24	06.8	3206	09°30.0'S	63°03.0'E
190	10/24	16.1	1717	09°36.0'S	61°39.0'E
191	10/25	00.0	1019	09°41.0'S	60°18.0'E
192	10/25	05.9	2215	09°51.0'S	59°12.0'E
193	10/25	13.5	3857	10°00.0'S	58°00.5'E
194	10/25	22.0	4111	10°12.5'S	56°51.0'E
195	10/26	06.8	3769	10°14.0'S	55°40.0'E
196	10/26	15.4	4307	10°15.5'S	54°29.5'E
197	10/27	00.7	4649	10°17.0'S	53°18.5'E
198	10/27	09.3	4534	10°17.5'S	52°08.0'E
199	10/27	16.7	3087	10°19.5'S	51°18.0'E
200	10/28	01.4	4298	11°25.0'S	51°06.5'E
201	10/28	11.2	4054	12°35.0'S	50°56.0'E
202	10/28	20.1	3301	13°43.5'S	50°46.5'E
203	10/29	04.6	2372	14°53.0'S	50°38.5'E
204	10/29	11.1	3998	15°21.5'S	51°20.0'E
205	10/29	20.3	4519	15°28.0'S	52°36.0'E

Station	Date	Time	Depth	Latitude	Longitude
206	10/30	06.5	4601	15°39.5'S	53°58.0'E
207	10/30	16.8	4585	15°51.5'S	55°15.0'E
208	10/31	03.3	4492	16°10.0'S	56°32.0'E
209	10/31	13.4	4135	16°31.0'S	57°45.5'E
210	10/31	23.3	0309	16°43.5'S	59°06.0'E
211	11/1	10.1	2527	17°43.0'S	58°50.0'E
212	11/1	20.4	2833	18°50.0'S	58°12.0'E
213	11/2	03.7	0660	19°40.5'S	57°40.0'E
214	11/5	13.0	4384	20°05.5'S	56°08.0'E
215	11/6	01.4	3072	21°11.0'S	54°45.5'E
216	11/6	10.8	4351	21°46.5'S	53°34.5'E
217	11/6	20.1	4738	22°23.0'S	52°23.0'E
218	11/7	05.9	4971	23°02.0'S	51°06.5'E
219	11/7	17.2	4896	23°32.0'S	50°13.0'E
220	11/8	02.9	3980	24°08.0'S	48°58.5'E
221	11/8	12.4	2156	24°47.5'S	47°38.0'E
222	11/9	12.1	3848	25°42.5'S	43°35.0'E
223	11/9	20.8	4106	25°44.5'S	42°16.5'E
224	11/10	05.5	4212	25°41.5'S	40°58.5'E
225	11/10	14.2	4177	25°47.0'S	39°46.0'E
226	11/10	23.1	3928	25°48.0'S	38°21.0'E
227	11/11	07.7	2205	25°51.5'S	37°10.5'E
228	11/11	15.5	1686	25°49.5'S	35°58.0'E
229	11/11	22.0	0497	25°51.0'S	34°37.0'E
230	11/12	06.1	??	25°55.0'S	33°20.0'E
231	11/23	15.9	4804	32°30.0'S	11°02.0'E
232	11/24	03.0	5027	32°28.5'S	09°05.0'E
233	11/24	14.8	4963	32°29.0'S	07°14.0'E
234	11/28	14.8	4362	17°07.0'S	04°48.0'W
235	12/3	17.0	5728	08°19.3'S	23°47.5'W
236	12/6	17.0	187	03°55.0'S	37°33.0'W
237	12/6	20.1	271	03°24.0'S	37°35.5'W
238	12/6	23.8	3040	02°46.5'S	37°38.0'W
239	12/7	03.5	3235	02°12.5'S	37°38.0'W
240	12/7	07.0	3508	02°36.5'S	37°39.5'W
241	12/7	10.6	4389	01°03.0'S	37°39.0'W
242	12/7	14.2	4422	00°25.0'S	37°37.5'W
243	12/7	17.3	4451	00°01.0'N	37°57.5'W
244	12/7	20.9	4662	00°28.0'N	38°27.0'W

DISCIPLINES

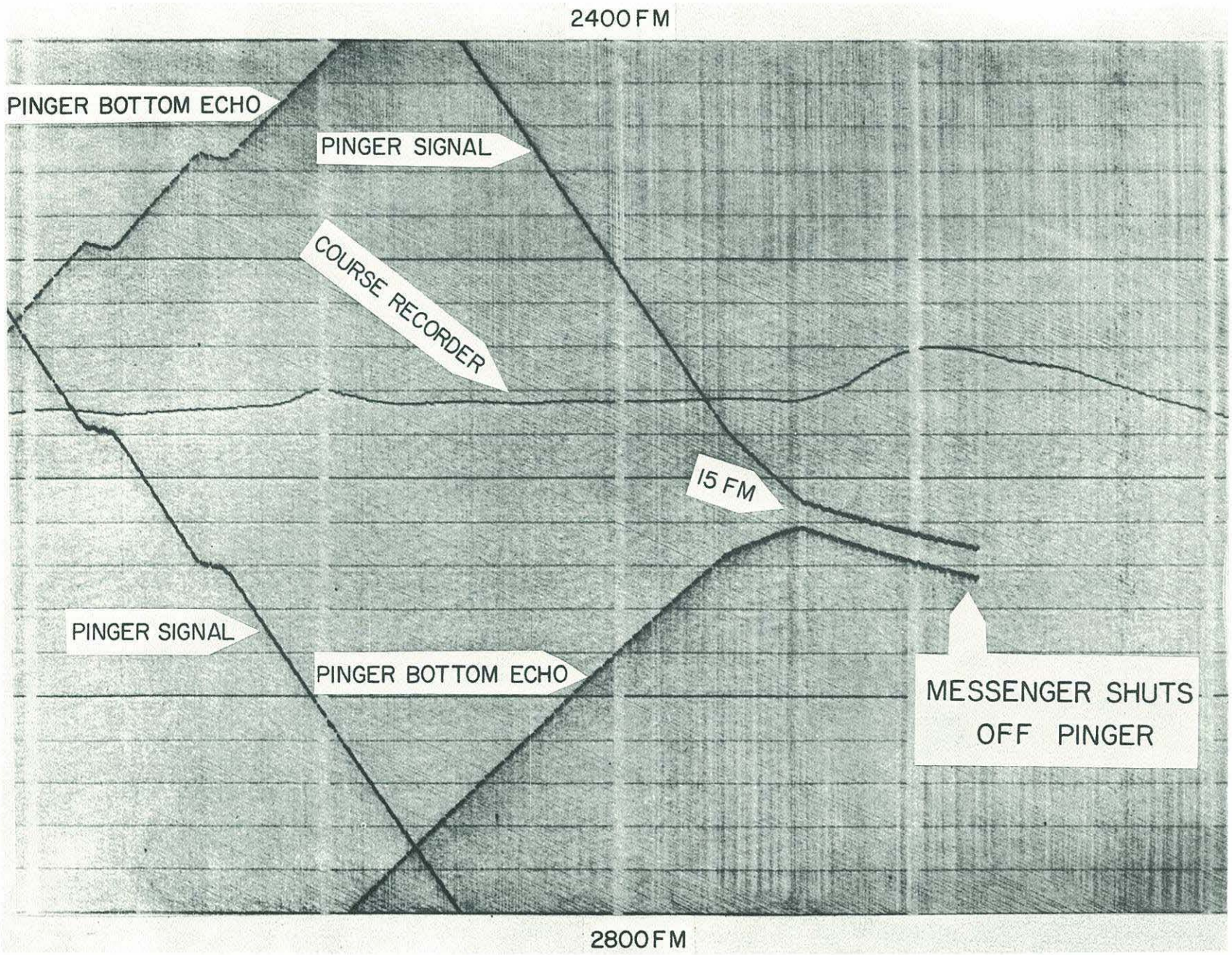
Bathymetry. Hourly bathythermographs were taken throughout the cruise. Surface samples for salinity determinations were collected; the air temperature, dew point, wind speed and direction, cloud cover and barometric pressure were also recorded hourly.

Hydrography. During the cruise, 183 stations were taken in the Indian Ocean, 10 in the Red Sea, 14 in the Great Bitter Lake, 12 in the Mediterranean, and 14 in the Atlantic. At each water samples were collected and the temperatures recorded at standard depths from the surface to the bottom. The salinity of each sample was determined by electroconductivity measurements with a salinometer or, for those samples from the Red Sea and the Great Bitter Lake, by Knudsen titration.

Chemistry. Each sample was analysed to determine the concentration of various chemical components. Oxygen, inorganic phosphate, nitrate and nitrite concentrations were determined on board. Samples for silicate, total phosphate and organic phosphate were stored for subsequent analysis on shore. Between Monaco and Colombo, ammonia concentrations were measured and the turbidity of each sample determined by light scattering. In addition, large volume samples of sea water from various depths were taken by scientists from the International Laboratory of Marine Radioactivity to be measured for zinc, copper and chromium ion concentrations.

Biology. Van Dorn casts were taken at each station so that measurements of phytoplankton concentration and chlorophyll content and therefore of productivity might be made. Studies of the incorporation of $C^{14}O_2$ into organic compounds by phytoplankton under the prevalent conditions were carried out. Plankton tows for zooplankton were frequently made. Part of these collections was preserved for chemical composition studies. The remainder, obtained with the standard Indian Ocean net, is being sent to the IIOE Laboratory in Cochin, India for taxonomic work. A bird log was maintained by several observers on board and report has been submitted on the birds recorded at sea and of the relationships noted between the concentration of birds and the nutrient composition of the surface waters. A landing party on Cocos Island of the Cargados Carajos group made ornithological observations and collected biological material.

Radioactivity Studies. For the first time in the deep sea, in-situ measurement of the natural radiation, uncontaminated by cosmic radiation, was accomplished. An instrument capable of recording ambient radiation for periods of two hours was successfully lowered to depths of 4000 meters. In addition, M. Galliot of the Centre Scientifique de Monaco measured the ambient radiation at lesser depths and at the surface. Biological materials were collected for subsequent determination of radioactivity content. To obtain values of the natural radiation



EXAMPLE OF PINGER CUT-OFF ASSURING THE COMPLETION OF AN HYDROGRAPHIC CAST AND CONFIRMING THE DEPTH OF CAST.

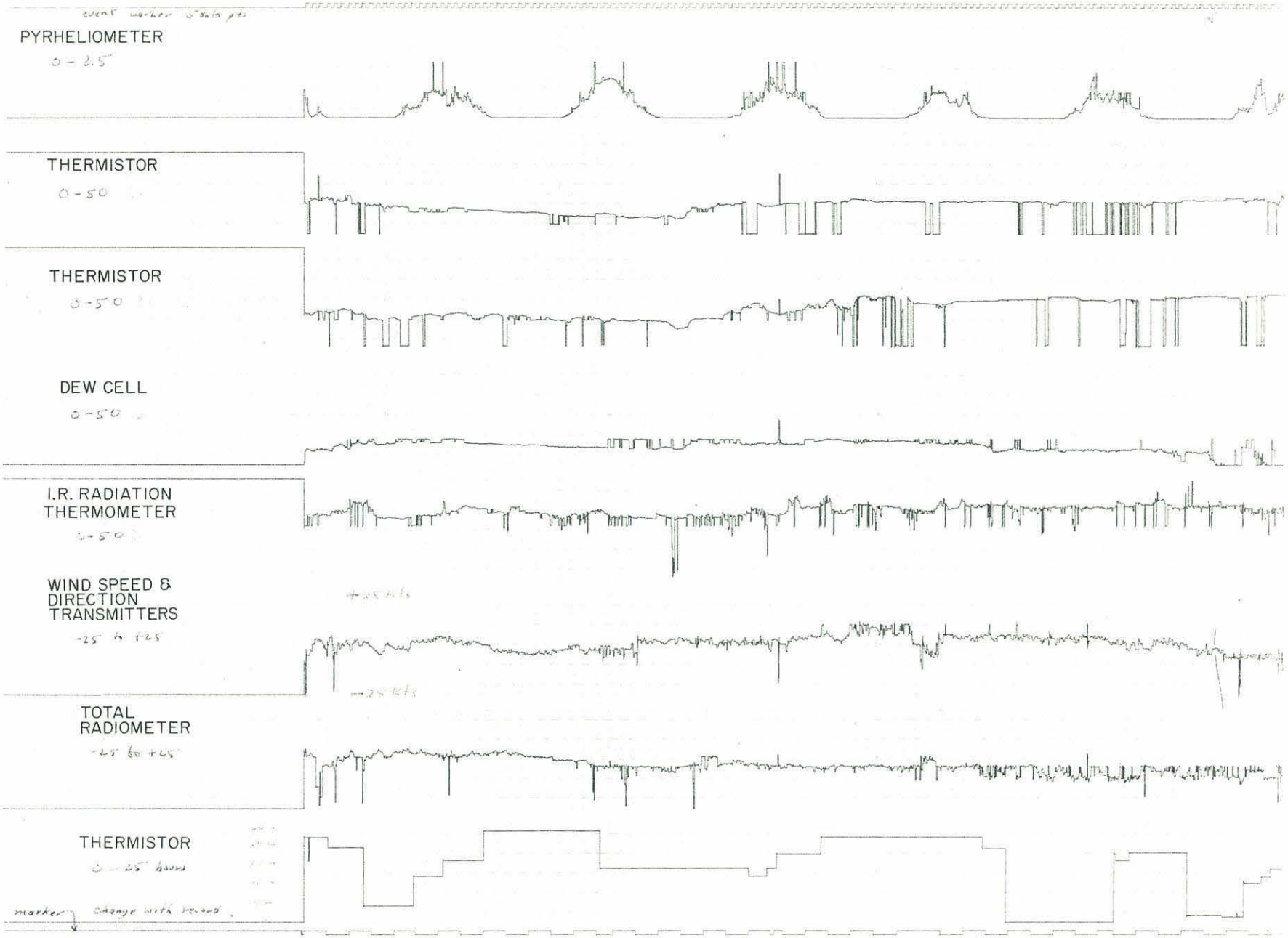
at all depths of the sea has long been an aim of the Centre Scientifique de Monaco.

Bottom Profiles. Continuous bottom profiles, recording depth and features of the bottom topography were made by the Precision Graphic Recorder. By means of a pinger acting as a sound source below the bottom bottle, this instrument made possible the determination both of the distance between the cast and the bottom and of the time of arrival of the messenger at the pinger.

Magnetometer Measurements. At all times a Proton Precision Magnetometer was streamed behind the ship. Continuous measurements of the magnetic field were thereby obtained. These data are now being processed.

Wave Studies. A wave recorder was mounted in the ATLANTIS II and wave stations were taken at each hydrographic station. The output of the recorder was sampled, digitized and punched on paper tape and then analyzed by a digital computer.

Evaporation Studies. At each hydrographic station, the evaporation of a surface sample was measured by determining salinity changes over a period of time. These data are now being analysed with a computer to determine the relative effects of air temperature, water vapour pressure, wind speed and other relevant variables upon evaporation.



A PORTION OF COMPUTER-PROCESSED RECORD FROM METEOROLOGICAL DATA SENSED AND STORED ON TAPE BY MEANS OF THE UNIVERSITY OF MICHIGAN METEOROLOGICAL SYSTEM.

Meteorology. A representative of the U. S. Weather Bureau was on board throughout the cruise. Meteorological observations, including those from weather baloons were routinely made and the data were transmitted to the Weather Bureau. A weather facsimile provided weather maps of the Indian Ocean area from a station transmitting in Nairobi. In an emergency this instrument can also be used as a Precision Graphic Recorder. The University of Michigan Meteorological System was programmed for various meteorological parameters.

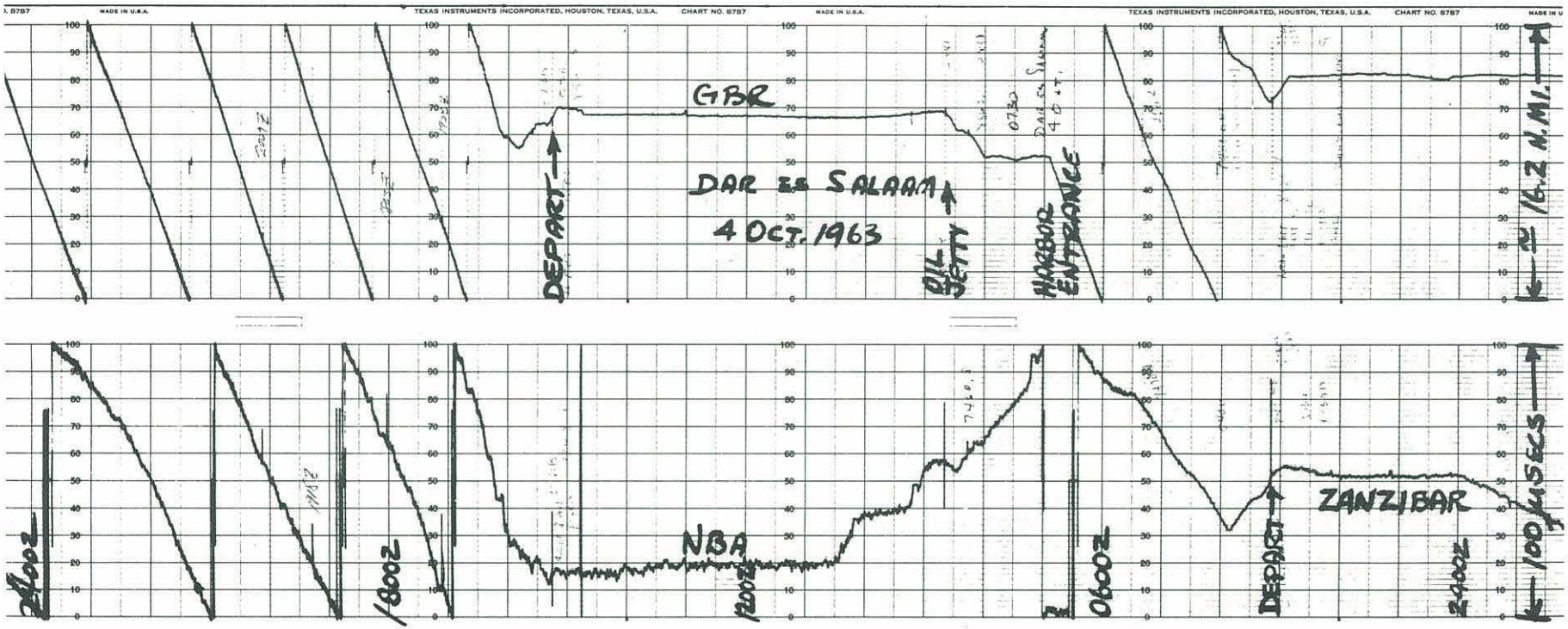
Cloud Studies. A camera mounted on the top deck took pictures of the cloud cover over a wide area of the sky every five minutes during daylight hours.

Rain Water Analysis. Although considerable rainfall during the Southwest Monsoon period had been anticipated, only a very small amount of rain was actually recorded. Samples were collected and analysed for sodium and potassium ion content by means of flame photometry.

Solar and Net Radiation. Solar and reflected radiation were recorded continuously by radiometers.

Current Measurements. Ocean currents were measured with Braincon direct read-out current meters. Fixed buoys or land forms located by radar were used for reference.

Navigation. Throughout the Expedition a new system of navigation which can be employed in those parts of the oceans remote from the usual radio aids was tested. It is based



VLF RELATIVE NAVIGATION
RECORD OF REFERENCE STATIONS NBA AND GBR
RECEIVED IN ZANZIBAR AREA 4 OCTOBER 1963

upon the difference between the phase angles of very low frequency (VLF) signals transmitted from carrier-stabilized stations and the phase angle of a signal generated on board the vessel. Movement relative to a prior position is recorded. The data obtained compared favorably with the track of the ship. Since the system allows for the detection of relative positional changes of ± 0.1 miles during short time periods, it should find a useful application in the future in determining the drift of the ship during hydrographic stations and current measurements.

Sound Velocity Measurements. Underwater sound velocity studies were undertaken with the Precision Velocimeter.

SHIP OPERATION AND PERFORMANCE

In performance the ATLANTIS II vindicated the hopes of the designers and builders in proving to be a highly versatile, efficient and comfortable vessel for oceanographic research. She successfully fulfilled the exacting demands placed upon her. The two 700 SHP steam engines performed well during the 30,000 mile track of the cruise as did all other components of the ship's machinery

A particularly important asset of a research vessel is an ability to maneuver with great flexibility at slow speeds. Frequently during hydrographic stations, heavy seas or currents may cause the wire of the cast to form a large angle from the vertical. On the ATLANTIS II a very small wire angle can be maintained during stations. Maneuverability under such conditions is greatly increased by two rudders and four foot diameter bow thrusters, which permit lateral motion from the bow. Auxiliary bridges, one of which is located directly over the hydrographic platform, obviate the necessity of constant communication between the bridge and science deck while on station. The mate on watch can thereby perform all the necessary ship maneuvers on the spot.

Other special features incorporated to facilitate research at sea also met with general approval. The anti-roll tanks proved their worth on the few occasions when rough weather

was encountered. The ship had been designed to be as quiet and as vibration-free as possible. In performance the aims of the designers and builders were fulfilled. No acoustical research was undertaken during Cruise 8 and the facilities for quiet ship operation were therefore not used. The voltage remained constant and no difficulties were encountered while operating either the computer or the spectrophotometers. Other useful features included: winches with a precision control whereby speed and braking could be controlled with one lever; repeaters of the recording meters for the winches in the laboratories and on the bridge; an intercommunications system; a bow observation chamber with six glass ports; outlets for compressed air, oxygen, nitrogen, (helium), propane, sea water and fresh water at several locations; an internal elevator; an articulated rotating crane for lifting objects between shore and ship and from deck to deck.

Air conditioning throughout the ship ensured comfortable working and living temperatures in the tropical regions. An excellent collection of books and of music on tape, as well as the quiet, congenial atmosphere of the Martin Pollack Memorial Library contributed significantly to the maintenance of the morale of the scientific staff and crew during the long voyage.

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DEPTH	TEMPERATURE	SALINITY	SIGMA T	SPECIFIC VOLUME	SPECIFIC VOLUME ANOMALY	POTENTIAL TEMPERATURE	VELOCITY OF SOUND
1.0000000	28.0100000	36.3170000	23.4030000	.9771300	449.1800000	28.0100000	1542.9000000
10.0000000	28.0400000	36.3200000	23.3950000	.9771200	452.2300000	28.0370000	1543.1000000
20.0000000	28.0100000	36.3200000	23.4050000	.9771000	454.2400000	28.0050000	1543.2000000
30.0000000	28.0400000	36.3330000	23.4050000	.9770800	456.9100000	28.0320000	1543.4000000
50.000000	28.020000	36.3530000	23.426000	.9770200	460.4300000	28.0070000	1543.7000000
74.0000000	27.9700000	36.3630000	23.4500000	.9769600	464.5400000	27.9510000	1544.0000000
99.0000000	27.1700000	36.4030000	23.7400000	.9766100	441.0700000	27.1450000	1542.8000000
149.0000000	19.7700000	35.5540000	25.2630000	.9748200	285.3400000	19.7420000	1524.400000
198.0000000	15.7300000	35.3240000	26.0760000	.9738000	204.8500000	15.6980000	1513.1000000
296.0000000	12.6000000	35.2830000	26.7100000	.9727600	144.5800000	12.5590000	1504.5000000
395.0000000	11.4500000	35.2560000	26.910000	.9721400	127.220000	11.3980000	1502.100000
493.0000000	10.7800000	35.2640000	27.0400000	.9716000	116.8300000	10.7180000	1501.4000000
592.0000000	10.3900000	35.2930000	27.1320000	.9710900	109.960000	10.316000	1501.600000
788.00000	8.880000	35.1750000	27.2940000	.970800	96.0350000	8.7897000	1499.1000000
985.000000	6.8300000	35.0370000	27.4920000	.9690200	76.1030000	6.731200	1494.3000000
1191.0000000	6.1900000	35.0320000	27.5740000	.9680500	69.809000	6.0746000	1495.2000000
1488.0000000	4.7100000	34.9370000	27.6800000	.9666600	58.8420000	4.5799000	1494.0000000
1785.0000000	3.3400000	34.8400000	27.7470000	.9652900	49.8770000	3.1995000	1493.0000000
2180.0000000	2.5200000	34.7870000	27.7800000	.9635700	45.3000000	2.3562000	1496.1000000
2576.0000000	2.0900000	34.7670000	27.7990000	.961890	42.9150000	1.8976000	1500.9000000
2969.0000000	1.7800000	34.7480000	27.8090000	.9602500	41.48500	1.5566000	1506.1000000
3363.000000	1.7000000	34.7410000	27.8090000	.9586400	42.1520000	1.4390000	1512.5000000
3658.0000000	1.680000	34.7410000	27.8110000	.9574600	42.9150000	1.3885000	1517.4000000
3955.000000	1.6700000	34.7380000	27.8090000	.9562700	43.7740000	1.3463000	1522.500000
4250.0000000	1.6700000	34.7360000	27.8070000	.9551100	44.8230000	1.3129000	1527.6000000
4422.0000000	1.6700000	34.7370000	27.8080000	.9544400	45.3000000	1.2929000	1530.5000000

PLACE DATA TAPE ON PHOTO-READER, COMPUTE TO GO.

DATA HANDLING

Considerable advances and improvements in the methods of processing data on board ship were made during the IIOE cruise of the ATLANTIS II. Two small desk computers of Mathatronics, Inc. facilitated arithmetical operations. The installation of a computer, the G 15 model of the Control Data Corporation made feasible the processing of large quantities of data at sea. It was used to calculate temperature and depth corrections, and sigma t's. Data from the wave stations were recorded on tape by the computer which later reproduced these graphically for subsequent analysis of wave components. The G 15 was also programmed to compute specific volumes, specific volume anomalies, potential temperatures and the velocities of undersea sound from the input values of temperature, depth, salinity and sigma t and to draw graphs of the potential temperature versus salinity.

The successful operation of this computer at sea supports the feasibility of performing these and other calculations during future cruises. At present considerable data, such as radiation intensity, are recorded graphically. Evaluating these is laborious and time-consuming. It is suggested that such instruments be redesigned to permit simultaneous recording of data on tape. They could then be integrated hour by hour or day by day by the computer or reproduced graphically if desired.

SCIENTIFIC STAFF

Scientists from the Woods Hole Oceanographic Institution were pleased to welcome aboard visiting scientists from other institutions in North America and abroad. The presence of these scientists, representing eight nations, comprising Canada, Egypt, France, Germany, Great Britain, Greece, Nationalist China, Monaco and Sweden imparted an international atmosphere.

The position of Chief Scientist was occupied by Mr. Arthur Miller for the greater duration of the cruise. Dr. Paul Fye, Director of the Woods Hole Oceanographic Institution, and Dr. Columbus Iselin, Henry B. Bigelow Oceanographer, fulfilled these responsibilities between Lourenco Marques and Capetown and between Capetown and Woods Hole respectively.

Those scientists participating in the entire voyage were: Frank Allstrom, J. Ronald Anastasi, Robert Bruneau, William Byrd, John Cooper, C. Dana Densmore, Robert Munns, Roger Pocklington of the University of British Columbia, Robert Risebrough, Robert Stanley and Richard Wagner of the U. S. Weather Bureau.

The American scientists participating in certain tracks of the voyage comprised: Mr. Robert Alexander (Woods Hole-Colombo), Dr. John Bruce (Colombo-Seychelles), Mr. Arnold Gordon, Lamont Geological Laboratory (Woods Hole-Colombo), Mr. Paul Hammond (Colombo-Woods Hole), Dr. Earl Hays (Aden-

Zanzibar), Mr. John Laird (Woods Hole-Lourenco Marques), Mr. Max McLean, Office of Naval Research (Woods Hole-Monaco), Dr. David McGill (Bombay-Zanzibar), Dr. Carl Mennekens, Deputy Science Director, ONR, London (Mauritius-Lourenco Marques), Mr. Charles Rose (Woods Hole-Lourenco Marques), Mr. Leonard Shodin (Woods Hole-Monaco), Mr. Maxwell Silverman, Scripps Institution of Oceanography (Woods Hole-Monaco, Mauritius-Woods Hole), and Dr. Jess Stanbrough (Zanzibar-Lourenco Marques).

Scientists from foreign institutions were: Dr. Henry Charnock, National Institute of Oceanography, England (Monaco-Port Said), Dr. Paul Tchernia, Laboratoire d'Oceanographie Physique, Paris (Aden-Bombay), Dr. Tsu-You Chu, National Taiwan University, Taiwan, and Secretary, Chinese Committee on Oceanic Research (Bombay-Zanzibar), Dr. Gunter Dietrich, Oceanographic Institute, University of Kiel, Germany (Monaco-Port Said), Dr. Stig Fonselius, Laboratoire Internationale de la Radio-activite, Monaco (Monaco-Colombo), M. Jean Galliot, Centre Scientifique de Monaco (Monaco-Zanzibar), Mr. Peter Herring, R.R.S. DISCOVERY (Zanzibar-Capetown), Mr. Dimitrios Maleas, Laboratoire Internationale de la Radioactivite, Monaco (Monaco-Colombo), and Prof. Selim Marcos, University of Alexandria (Suez Canal).

Mr. Baird Bryant, Mr. Stuart Day and Mr. Robert McArty of Seneca Productions, New York filmed sequences on board

the ATLANTIS II during the crossing between Woods Hole and Monaco which were included in a film on oceanography produced for the Office of Naval Research.