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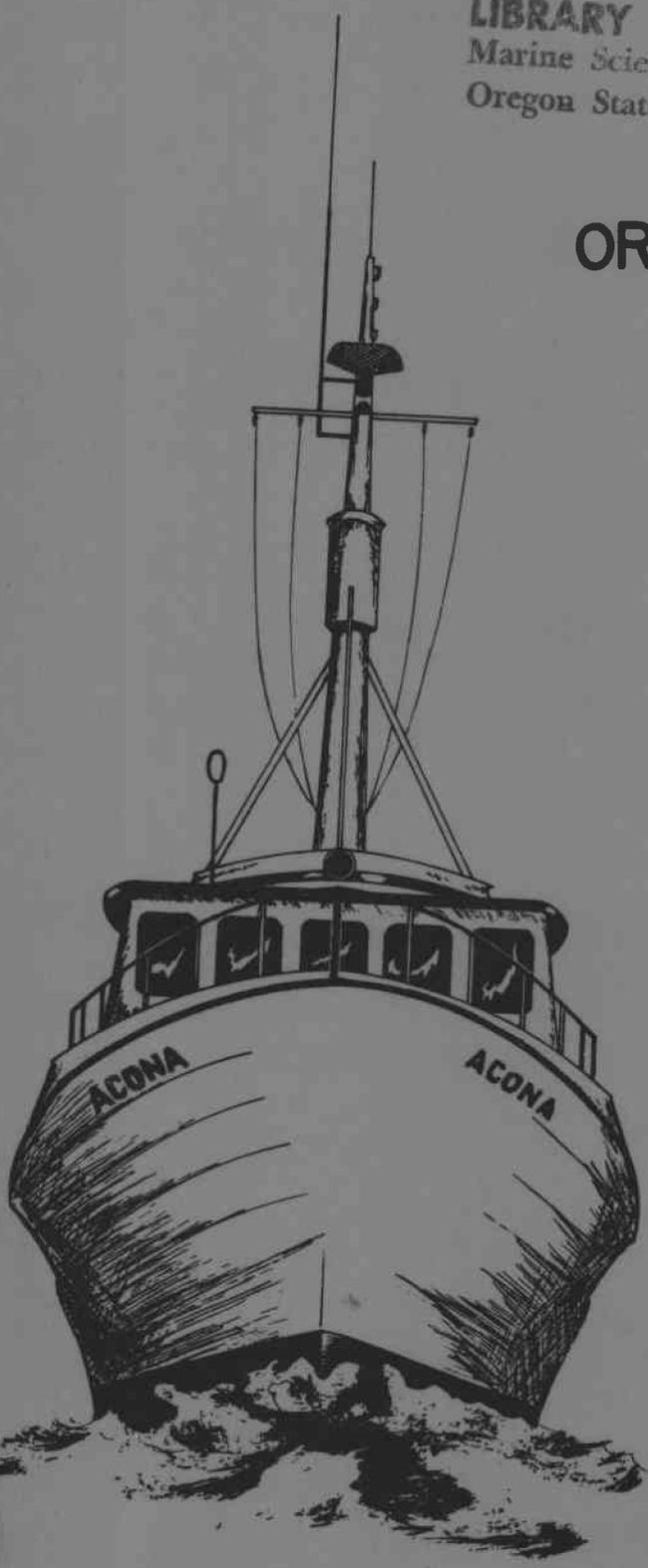
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Nearshore Marine Gravity Range, Newport, Oregon

Wilbur A. Rinehart and Joseph W. Berg, Jr.

Office of Naval Research
Contract Nonr 1286(02)
Project NR 083-102

National Science Foundation
Grant No. G 24353

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Data Report No. 9 Reference 63-16
July 1963

DEPARTMENT OF OCEANOGRAPHY

GEOPHYSICS RESEARCH GROUP

OREGON STATE UNIVERSITY

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by

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Wayne V. Burt
Chairman

This report is preliminary to a final technical report. It is requested that permission be obtained from the Geophysics Research Group of the Department of Oceanography, Oregon State University, to use the included data for purposes other than gravity meter calibrations.

NEARSHORE MARINE GRAVITY RANGE,

NEWPORT, OREGON

by

Wilbur A. Rinehart and Joseph W. Berg, Jr.

Abstract

Gravity observations were made with the LaCoste-Romberg underwater gravity meter during July and August 1962 at 149 stations in an area 10 by 40 miles ($44^{\circ}10'$ to $44^{\circ}50'N$ latitude and $124^{\circ}07'$ to $124^{\circ}20'W$ longitude) off the north-central Oregon coast from Heceta Head to Depoe Bay. The primary purpose of this gravity survey was to establish a calibration range for a surface-ship gravity meter.

Reoccupation of selected stations indicate, with about a 90 percent degree of confidence, that the contour lines on the surface gravity map are accurate to 1.0 mgal.

Introduction

Anticipating the use of a surface-ship gravity meter off the West Coast of the United States by marine geophysicists, the Geophysics Research Group of the Department of Oceanography, Oregon State University, established a nearshore marine gravity range along the north-central Oregon coast whereby a surface gravity meter could be calibrated.

The geographic area of interest is bounded by the coordinates $44^{\circ}10'$ to $44^{\circ}50'$ north latitude and $124^{\circ}07'$ to $124^{\circ}20'$ west longitude (Figure 1). A total of 149 gravity stations were established, and ten of these were reoccupied to determine the precision of measurement. The station spacing averaged about three miles over the entire range and about one mile over the central portion off Newport, Oregon.

A LaCoste-Romberg underwater gravity meter was used for this survey. This meter is a self-leveling instrument having low drift characteristics and is read by remote-controlled electrical devices. The meter has been described fully in the literature (LaCoste, 1948). The U.S. Coast Guard provided ship time and personnel to assist with handling

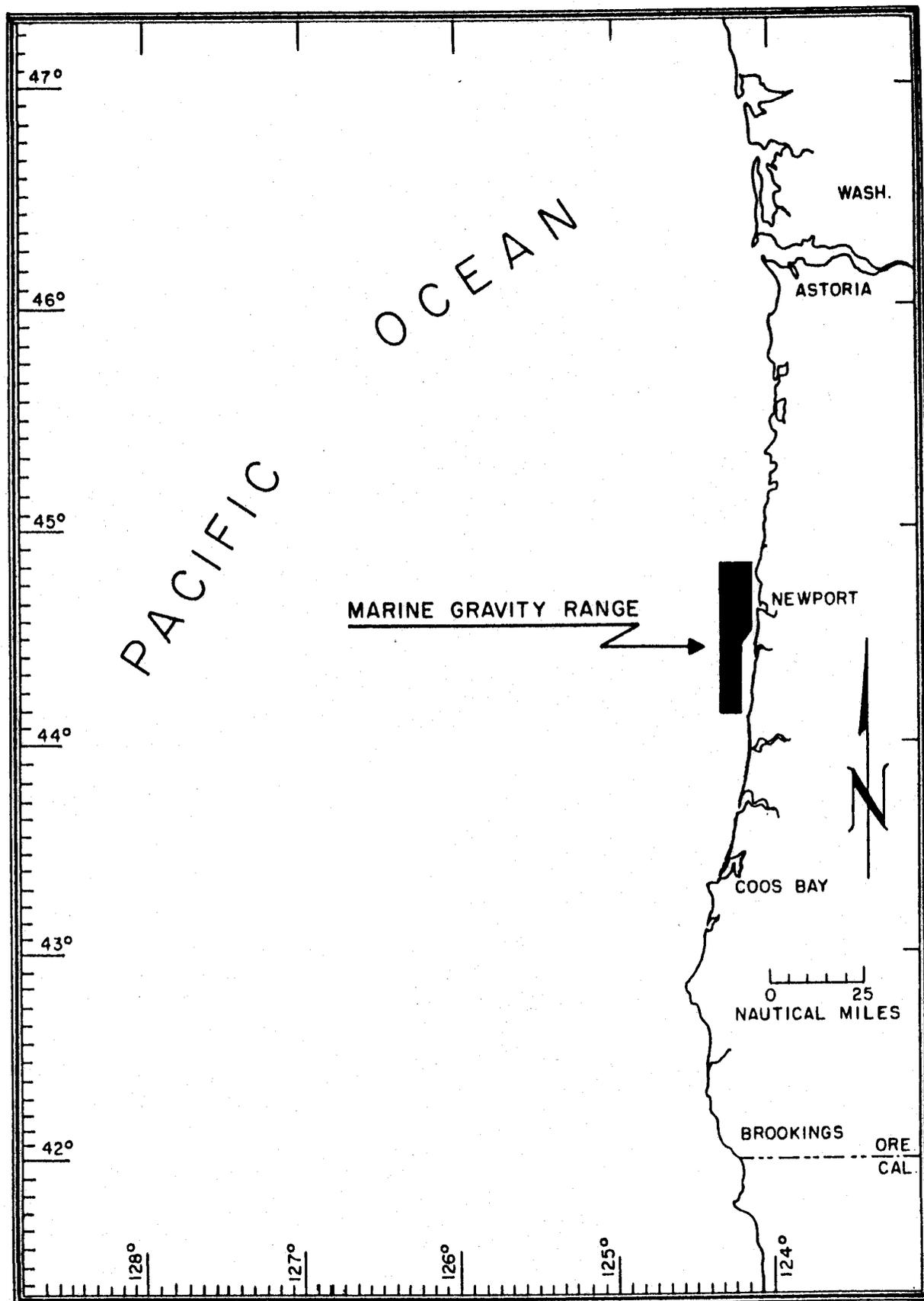


Figure 1. Index map showing the location of the marine gravity range.

the meter at sea. Gravity data were collected during two cruises from 7 to 14 July and 28 July to 1 August 1962 aboard the USCGC MODOC. The location of the gravity stations was obtained by radar ranges, visual bearings, and loran fixes. Depth of bottom at each station was read from a fathometer. Minimum depth was 20 fathoms; maximum depth was 50 fathoms.

Measurement Procedure

The primary base station for the gravity range is located near the west end of the paint locker at the U.S. Coast Guard Station, Newport, Oregon. The site is two feet south of the locker and is beneath an overhanging light by the locker door. Base ties between this station and stations in Woollard's airport network of gravity stations (Woollard, 1958; Behrendt and Woollard, 1961) located at the Corvallis, Eugene, and North Bend airports were made using a Worden gravity meter. The observed gravity at the Coast Guard base stations is 980610.4 mgals.

The base station at sea, Station 2, has the coordinates $44^{\circ}35.89'N$ and $124^{\circ}06.77'W$. This is located about three miles southwest of the Newport harbor entrance and 300 yards northwest of the sea buoy, in 20 fathoms of water. This base station was tied to the primary base by four observations. For drift control, this site was occupied at least three times a day, except when the gravity range was extended. In this case, Stations 176, 180, and 190 were established as temporary base stations.

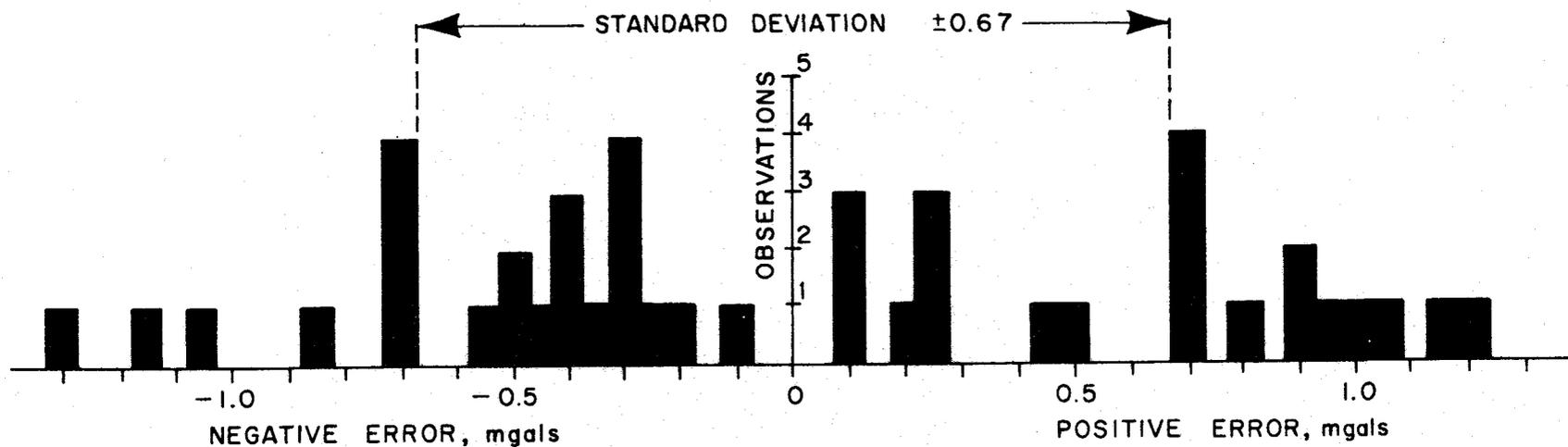
To control the drift of the instrument, all gravity stations in the range were established by making observations between times of two successive sea base readings. The average time between sea base readings was about seven hours.

At each station a temporary reference marker was provided so that the ship could be maneuvered without the danger of dragging the meter on the bottom. The marker consisted of a toy balloon attached to a ten-pound-test nylon monofilament line lowered with a three-pound lead weight. When the marker was in place, the gravity meter was lowered to the sea bottom, read, and recovered. The fact that it was necessary to reoccupy only seven stations because of ship movement indicates that the reference marker method was worthwhile.

Data Reduction

Gravity observations for all stations are listed in Table I. Included are the latitude, longitude, depth, observed gravity, and surface gravity of each station. The observed gravity is the drift-corrected meter reading multiplied by the scale constant (0.1057 mgals/scale division). Surface gravity has been obtained by correcting the observed gravity for free air lift to the surface and for depth of water.

a. Error analysis for all repeated stations



b. Gravity values at Station 2.

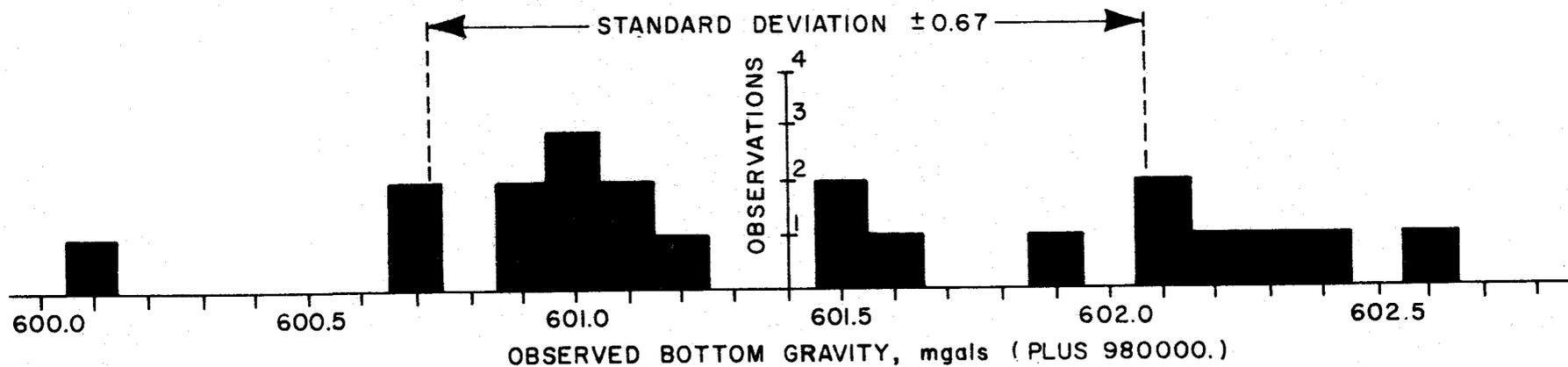


Figure 2. Histogram of the frequency distribution of the measurement errors of the gravity observations.

A drift curve was used to correct the readings for the drift of the meter. This curve was computed by the method of least squares using the meter readings from Station 2, corrected for slight difference in depth and position. The meter drift was found to be approximately 0.07 mgal per day.

The observed gravity for each station was referred to a mean sea level datum by subtracting the product of the free air correction (0.094 mgal/ft) and the depth (ft) from the observed bottom gravity. A correction was made for the water column by twice adding the gravity of an infinite slab of water of density 1.03 gm/cm^3 and thickness equal to the depth to the observed gravity corrected for free air lift to the surface. The topographic relief of the bottom is small, and corrections for it were not applied to the data.

Forty-four readings were included in the statistical analysis of the reliability of the data. In addition to the 21 made at Station 2, 23 readings were made by occupying nine other stations¹ two or more times. Small corrections were made to each of these meter readings to account for meter drift and for changes in depth and position. The gravity values for these repeated stations were analyzed to check the precision of the data.

The frequency distribution of errors of observations at all these repeated stations with respect to the mean values at these stations is presented in Figure 2a. The statistical error for all these observations, disregarding sign, is 0.57 mgal. The standard deviation is 0.67 mgal. Of the 44 readings, 48% had errors less than 0.5 mgal, 73% less than 0.8 mgal, and 86% less than 1.0 mgal.

The frequency distribution of gravity values with respect to the mean value at Station 2, where 21 readings were made, is presented in Figure 2b. The mean value at this station is 980601.4 mgal, and the standard deviation is 0.67 mgal. At this station 57% of the readings had errors of less than 0.5 mgal, 81% less than 0.8 mgal, and 90% less than 1.0 mgal.

The nearshore marine gravity range is presented in Figure 3. The surface gravity values obtained from these data reduction methods were plotted and contoured using a 5 mgal contour interval.

Conclusion

The estimates of precision of the data given above indicate that the contour lines on the surface gravity map (Figure 3) are accurate to one mgal with a 90 percent degree of confidence. If a ship carrying a

¹ Stations No. 4, 8, 26, 56, 84, 131, 176, 180, 190

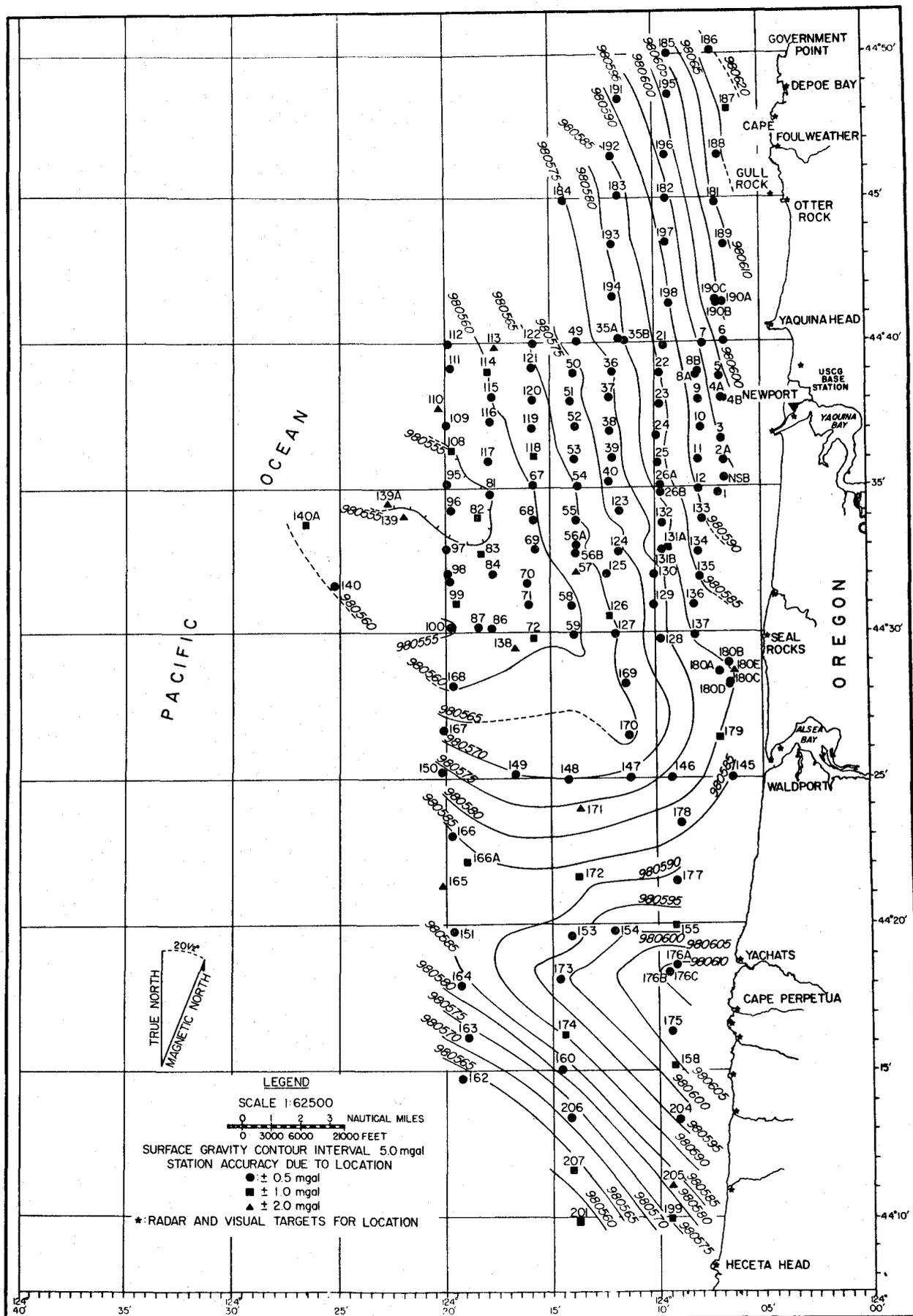


Figure 3. Marine gravity range off Newport, Oregon

surface gravity meter sails west from Newport, Oregon, to $124^{\circ}20'$, a distance of about 10 miles, a gravity difference of 49 mgal will be encountered. This range of gravity values is believed to be satisfactory to calibrate a surface gravity meter in moderate seas.

Acknowledgments

The A and M College of Texas loaned the underwater gravity meter to the Geophysics Research Group. LaCoste and Romberg Co. gave needed assistance and operating instructions. Mr. James Whitcomb and Mr. Arthur Albin assisted at sea. The U.S. Coast Guard provided ship time and space aboard the USCGC MODOC. The work was sponsored by the Office of Naval Research, Contract No. Nonr 1286(02), Project No. 083-102, and the National Science Foundation, Grant No. G 24353.

References

- Behrendt, J. C., and G. P. Woollard, 1961. An evaluation of the gravity control network in North America, Geophysics, 26(1): 57-76.
- LaCoste, L. J. B., and A. Romberg, 1952. Force measuring device, U.S. Patent 2,589,710, March 18, 1952.
- Woollard, G. P., 1958. Results for a gravity control network at airports in the United States, Geophysics, 23(3): 520-535.

Table I. List of Gravity Stations

Station Number	Latitude ° ' ''	Longitude ° ' ''	Depth* Feet	Observed Gravity mgal.	Surface Gravity mgal.
NSB**	44 35.29	124 06.75	90	980598.9	980592.8
1	44 34.80	124 07.000	107	601.2	593.9
2A	44 35.89	124 06.77	114	602.4	594.6
2A'	44 35.89	124 06.77	114	602.1	594.4
2B	44 35.89	124 07.07	114	602.4	594.6
2B'	44 35.89	124 07.07	114	603.0	595.5
2B''	44 35.89	124 07.07	114	602.6	594.8
2C	44 35.87	124 07.12	109	603.2	595.8
2D	44 35.88	124 06.92	106	602.6	595.3
2E	44 35.97	124 06.75	104	603.7	596.6
2F	44 36.06	124 06.74	110	603.0	595.5
2G	44 35.88	124 06.92	101	603.4	596.5
2H	44 35.96	124 06.98	116	603.4	595.5
2I	44 35.95	124 06.92	110	603.5	595.8
2J	44 35.87	124 07.21	110	603.2	595.7
2K	44 35.88	124 07.03	120	602.6	594.4
2L	44 35.97	124 07.04	141	603.0	593.4
2M	44 35.96	124 07.14	116	602.2	594.3
2N	44 35.99	124 07.07	116	602.9	595.0
2Ø	44 36.02	124 06.91	121	602.8	594.5
2P	44 36.06	124 06.88	110	602.6	595.2
2Q	44 35.98	124 07.20	126	602.7	594.2
2R	44 36.07	124 01.00	114	602.6	594.8
3	44 36.64	124 06.88	119	603.6	595.5
4A	44 38.05	124 06.87	131	604.4	595.5
4B	44 38.05	124 06.78	136	607.2	597.9
5	44 38.79	124 06.98	135	607.9	599.0
6	44 40.03	124 06.77	128	610.8	602.1
7	44 39.94	124 07.72	146	606.5	596.6
8A	44 38.88	124 08.06	144	602.2	592.4
8B	44 38.99	124 07.97	157	603.0	592.4
9	44 38.00	124 07.91	143	602.0	592.3
10	44 37.04	124 07.82	143	601.9	592.2
11	44 35.95	124 07.97	138	600.4	591.0
12	44 34.91	124 07.95	132	599.4	590.4
21	44 39.87	124 09.63	154	597.3	586.8
22	44 38.96	124 09.84	153	595.3	584.9
23	44 37.85	124 09.81	152	593.9	583.6
24	44 36.78	124 09.95	158	593.2	582.5
25	44 35.83	124 09.92	151	593.8	583.5
26A	44 35.07	124 09.81	152	592.2	581.9
26B	44 34.82	124 09.81	146	602.2	581.2
35A	44 40.12	124 11.73	196	591.3	578.0
35B	44 40.06	124 11.45	194	593.2	580.0
36	44 38.98	124 12.05	197	587.8	574.4
37	44 38.10	124 12.18	191	587.5	574.1

Station Number	Latitude °	Longitude °	Depth Feet	Observed Gravity mgal.	Surface Gravity mgal.
38	44 36.95	124 12.18	191	980585.5	980572.5
39	44 36.02	124 12.05	185	585.3	572.7
40	44 35.20	124 12.25	190	583.9	571.0
49	44 40.06	124 13.75	217	588.0	573.2
50	44 38.95	124 13.90	228	583.7	568.2
51	44 37.99	124 14.20	210	582.4	568.1
52	44 37.12	124 13.81	203	581.5	567.7
53	44 36.00	124 13.85	215	581.1	566.5
54	44 35.04	124 13.71	215	579.9	565.3
55	44 33.90	124 13.80	215	579.0	564.4
56A	44 33.06	124 13.80	210	577.4	563.1
56B	44 32.75	124 13.87	216	578.0	563.7
57	44 32.03	124 13.81	216	575.6	560.9
58	44 30.92	124 14.00	216	574.6	559.1
59	44 29.92	124 13.92	210	573.5	559.2
67	44 35.08	124 15.86	230	575.7	560.1
68	44 33.89	124 15.82	236	575.5	558.5
69	44 32.92	124 15.74	232	574.6	558.8
70	44 31.67	124 16.14	229	574.2	558.7
71	44 30.97	124 16.08	228	573.8	558.7
72	44 29.82	124 15.78	222	573.8	558.3
81	44 34.78	124 17.88	269	573.1	554.8
82	44 34.00	124 18.44	269	572.1	553.8
83	44 32.69	124 18.30	269	573.7	555.4
84A	44 31.98	124 17.76	256	574.2	556.8
84B	44 31.98	124 17.76	255	574.2	556.9
86	44 30.13	124 17.80	249	576.9	560.0
87	44 30.17	124 18.43	242	574.2	557.7
95	44 35.13	124 19.44	245	570.8	554.1
96	44 34.23	124 19.71	252	570.9	553.7
97	44 32.91	124 19.94	247	572.3	555.5
98	44 31.99	124 19.90	265	573.6	555.6
99	44 31.00	124 19.50	242	573.6	557.1
100	44 30.17	124 19.74	254	571.8	554.5
105	44 31.72	124 19.77	266	573.6	555.5
108	44 36.31	124 19.71	233	570.7	554.9
109	44 37.18	124 19.92	232	571.2	555.4
110	44 37.73	124 20.29	241	572.1	555.7
111	44 39.11	124 19.72	250	573.9	556.9
112	44 39.97	124 19.83	256	575.3	557.9
113	44 39.82	124 17.60	250	578.1	561.1
114	44 39.00	124 18.00	249	576.6	559.7
115	44 38.11	124 17.75	240	576.5	560.2
116	44 37.29	124 18.86	248	575.3	558.5
117	44 35.91	124 17.92	250	573.3	556.1
118	44 36.09	124 15.82	230	577.9	562.3
119	44 37.08	124 15.90	235	578.1	562.1
120	44 38.20	124 15.89	235	578.6	562.7
121	44 39.12	124 15.90	234	580.5	564.6

Station Number	Latitude ° ' ''	Longitude ° ' ''	Depth Feet	Observed Gravity mgal.	Surface Gravity mgal.
122	44 39.95	124 15.85	234	980581.0	980565.1
123	44 34.19	124 11.71	178	584.2	572.1
124	44 32.80	124 11.82	184	581.7	569.2
125	44 32.00	124 12.33	189	579.4	566.5
126	44 30.56	124 12.24	188	577.5	564.7
127	44 29.95	124 11.93	176	576.2	564.3
128	44 29.78	124 09.83	150	583.7	573.5
129	44 30.96	124 10.04	155	584.4	571.8
130	44 31.98	124 10.07	155	585.8	573.2
131A	44 32.94	124 09.48	157	590.4	579.3
131B	44 32.82	124 09.75	145	588.7	578.9
132	44 33.79	124 09.75	163	588.1	577.0
133	44 33.89	124 07.79	133	598.2	589.1
134	44 32.79	124 08.00	133	596.0	586.9
135	44 31.88	124 07.96	124	593.6	585.1
136	44 30.95	124 08.20	133	591.0	581.9
137	44 29.90	124 08.18	127	589.0	580.4
138	44 29.44	124 16.69	237	574.3	558.2
139A	44 34.47	124 22.68	204	568.4	554.6
139	44 34.04	124 21.95	199	569.4	555.9
140	44 31.58	124 25.21	165	571.9	560.7
140A	44 33.79	124 26.56	213	576.5	562.0
145	44 25.02	124 06.48	77	590.8	585.5
146	44 25.00	124 09.36	142	586.4	576.7
147	44 25.04	124 11.28	169	583.0	571.5
148	44 24.96	124 14.20	204	584.1	570.2
149	44 25.10	124 16.69	225	585.8	570.5
150	44 25.20	124 20.20	231	591.8	576.1
151	44 19.77	124 19.65	248	603.9	587.0
153	44 19.60	124 14.10	211	607.9	593.6
154	44 19.63	124 12.05	170	610.2	598.6
155	44 19.96	124 09.18	140	606.6	597.0
158	44 15.15	124 09.31	132	613.8	604.8
160	44 15.06	124 14.56	211	596.6	582.3
162	44 14.71	124 19.22	255	580.0	562.6
163	44 16.12	124 18.95	249	589.9	573.0
164	44 17.92	124 19.24	248	599.9	583.0
165	44 21.30	124 20.13	229	603.4	587.8
166	44 23.02	124 19.71	223	600.9	585.8
166A	44 22.13	124 18.98	228	602.0	586.5
167	44 26.63	124 20.11	231	583.0	567.3
168	44 28.17	124 19.62	225	574.9	559.6
169	44 28.26	124 11.46	170	577.0	565.5
170	44 26.45	124 11.30	205	577.7	563.8
171	44 23.94	124 13.61	204	590.0	576.2
172	44 21.63	124 13.74	199	600.8	587.2
173	44 18.11	124 14.63	204	612.9	599.0
174	44 16.23	124 14.41	210	604.6	590.3
175	44 16.31	124 09.42	138	616.5	607.2
176A	44 18.59	124 09.18	156	621.2	610.6

Station Number	Latitude °	Longitude °	Depth Feet	Observed Gravity mgal.	Surface Gravity mgal.
176B	44 18.36	124 09.50	144	980621.0	980611.2
176C	44 18.36	124 09.50	148	621.4	611.3
177	44 21.48	124 09.12	141	601.4	591.8
178	44 23.47	124 08.88	141	592.8	583.2
179	44 26.40	124 07.05	114	587.9	580.1
180A	44 28.64	124 07.00	105	587.0	579.8
180B	44 28.93	124 06.60	98	586.8	580.1
180C	44 28.27	124 06.53	110	586.4	578.9
180D	44 28.22	124 06.54	127	586.9	578.3
180E	44 28.68	124 06.31	81	586.0	580.5
181	44 44.83	124 07.03	160	620.8	609.9
182	44 44.96	124 09.45	198	607.0	593.5
183	44 45.08	124 11.71	225	598.0	582.7
184	44 44.90	124 14.27	256	592.0	574.6
185	44 50.00	124 09.24	198	620.5	607.1
186	44 50.11	124 07.19	174	630.7	618.9
187	44 48.02	124 06.44	164	628.0	616.9
188	44 46.45	124 06.91	159	623.9	613.1
189	44 43.40	124 06.68	132	617.6	608.7
190A	44 41.38	124 06.78	132	614.4	605.5
190B	44 41.35	124 07.05	133	613.0	604.0
190C	44 41.93	124 07.12	153	613.5	603.1
191	44 48.37	124 11.60	250	608.5	591.5
192	44 46.42	124 12.00	225	600.8	585.5
193	44 43.39	124 12.00	188	594.2	581.5
194	44 41.58	124 12.00	212	593.0	578.6
195	44 48.55	124 09.22	211	615.3	600.9
196	44 46.47	124 09.40	204	610.8	597.0
197	44 43.45	124 09.45	186	603.8	591.2
198	44 41.36	124 09.35	175	601.3	589.4
199	44 09.95	124 09.43	136	586.0	576.8
201	44 09.85	124 13.72	207	570.5	556.4
204	44 13.46	124 09.08	131	604.9	596.0
205	44 11.07	124 09.40	131	591.1	582.2
206	44 13.42	124 14.15	218	586.5	571.1
207	44 11.59	124 14.06	218	577.8	563.0
NPCG***	44 37.50	124 03.32	20*	609.9	609.9
NPCG	44 37.58	124 03.32	20*	610.7	610.7
NPCG	44 37.58	124 03.32	20*	610.7	610.7
NPCG	44 37.58	124 03.32	20*	610.7	610.7
NPCG	44 37.58	124 03.32	20*	610.4	610.4

* Refers to mean sea level. Land station NPCG elevation above mean sea level.

** NSB designates a preliminary station positioned near the sea buoy.

*** NPCG designates the base station located at the Coast Guard station, Newport, and described in this report as the primary base station.

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