SUBMARINE SCARP OFF CAPE MENDOCINO, CALIFORNIA.

by

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The significance of Cape Mendocino and the nearby area to navigators using these waters is a classic example of the use of submarine and shore configuration in position determination.

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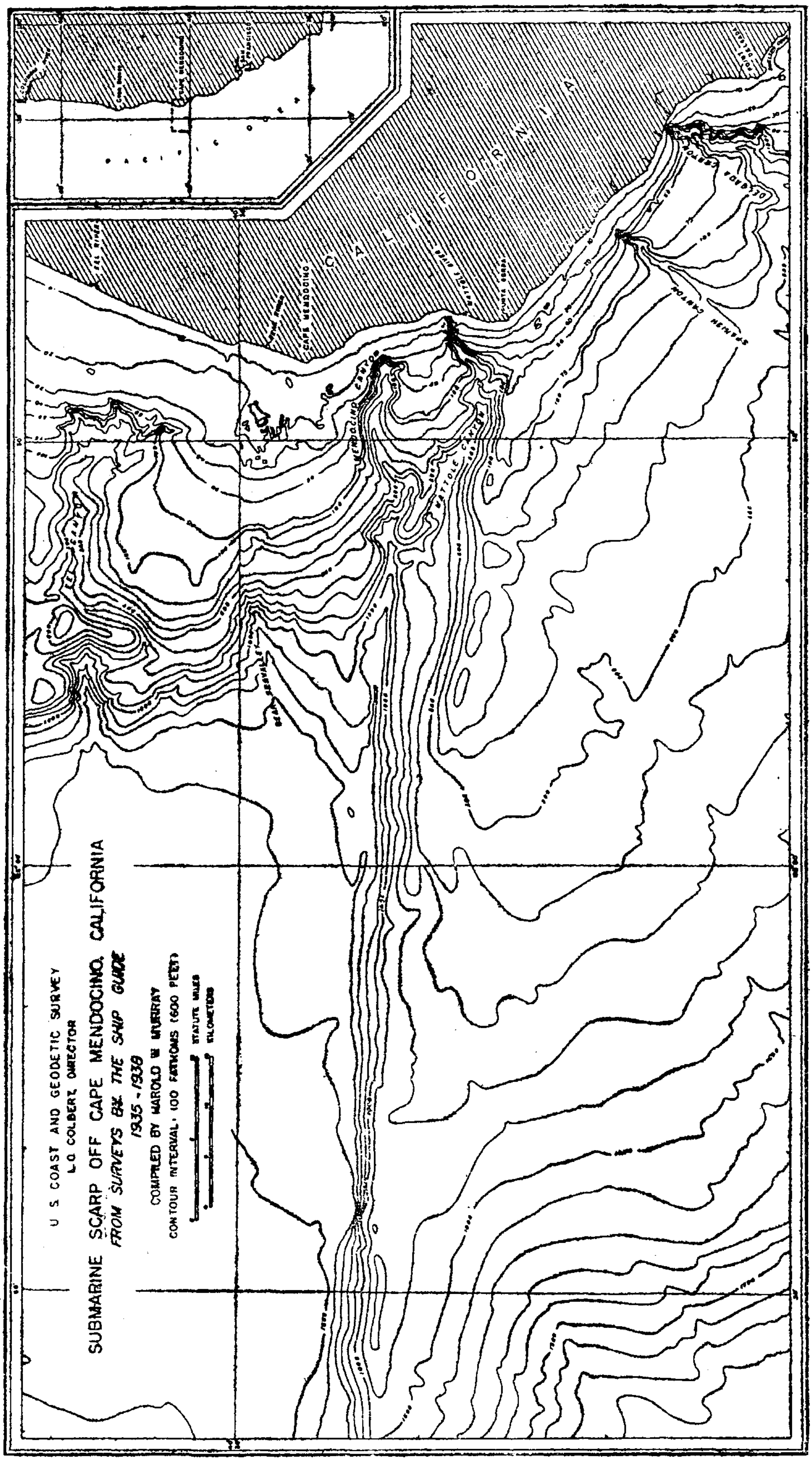
It was during a period of foggy weather in the year 1916 that the master of the steamer *Bear,* "when his reckoning put him about 15 miles northward of Cape Mendocino, began to take soundings to locate his position" and feel his way to the lightship anchored off the cape. The soundings immediately indicated that the vessel was proceeding over deep water of 100 fathoms or more. When the depths began to shoal from 80 fathoms to 34 fathoms and subsequent soundings showed substantially deeper water, it appeared from the published chart then in use that the vessel had safely passed the cape and the course was changed as usual. About an hour later the vessel stranded two miles north of the cape with a loss of six lives. The contributing factor in the disaster was that the misleading soundings had been obtained in a reported but unsurveyed and, consequently, inadequately charted submarine depression (Eel Canyon) several miles northward of Cape Mendocino.

Between the years 1899 and 1917, 15 wrecks or strandings occurred in this area and an additional 50 occurred at other points along the California coast. Accidents off the coast of Oregon and Washington in this period totaled 26 and 15 respectively. In each case the lack of hydrographic surveys, insufficient knowledge of currents, and inadequate charts were the contributing though not necessarily the sole factors involved.

Hydrography previously executed by the Coast and Geodetic Survey in the vicinity of Cape Mendocino, aside from earlier reconnaissance surveys, consisted principally of 1: 10,000 and 1: 20,000 scale surveys accomplished between the years 1872 and 1886. These surveys, generally speaking, extended from six to eight miles offshore and included the heads of all submarine depressions terminated within the above mentioned limits. All soundings were vertical casts and probably did not exceed 20,000 in number.

It was not until the years 1919 to 1921 that the Coast and Geodetic Survey Ships *Wenonah* and *Lydonia,* R.R. LUCKENS and E.H. PAGENHART commanding, surveyed the offshore area of Cape Mendocino and exposed the rather complex submarine topography existing offshore for a distance of at least 67 statute miles. The deeper offshore soundings, totaling about 6,500, were obtained by the laborious and time-consuming vertical cast method, horizontally controlled in part by dead reckoning and by three-point fixes on shore objects. The intensity of hydrography was naturally limited by the methods used, by the length of time available, and by the funds allotted to the vessels, but was accepted as adequate for the needs of navigation and the heretofore reported but mysterious Eel Canyon was now definitely surveyed and firmly secured within the confines of a geographic projection.

In 1935 the Coast and Geodetic Survey's plan of making modern and more intensely developed surveys, a project begun in 1932 at the southern limit of the State of California,


U S COAST AND GEODETIC SURVEY
L O COLBERT, DIRECTOR
SUBMARINE SCARP OFF CAPE MENDOCINO, CALIFORNIA
FROM SURVEYS BY THE SHIP GUIDE
1935 - 1938
COMPILED BY HAROLD W MURRAY
CONTOUR INTERVAL - 100 FATHOMS (600 FEET)
STATUTE MILES
KILOMETERS
CALIFORNIA
CAPE MENDOCINO
MENDOCINO CANYON
MATTOLE CANYON
MATTOLE RIVER
EEL RIVER
SPANISH CANYON
DELGADA CANYON
PUNTA GORDA
POINT DELGADA
PACIFIC OCEAN
SAN FRANCISCO

had progressed northward to the vicinity of Cape Mendocino. The submarine topography revealed in the waters contiguous to the cape, is shown by the submarine contours in the accompanying illustration.

The hydrography represented in the illustration was obtained at selected intervals during the period from 1935 to 1938 by the Coast and Geodetic Survey Ship *Guide*, F.H. HARDY, O.W. SWAINSON, and E.W. EICKELBERG, commanding. These surveys consisted of three series. One series of nine 1: 10,000 and one 1: 20,000 scale surveys, embracing the area between the shore line and the 20-fathom curve, consisted of 48,000 soundings. The second series was composed of one 1: 20,000 and three 1: 40,000 scale surveys extending from the 20-fathom curve to distances of three to seven statute miles offshore and consisting of about 25,000 soundings. The last series consisted of one 1: 120,000 scale survey with about 7,000 soundings extending from the last mentioned limits to more than 66 miles offshore. In all, a total of more than 80,000 soundings have been taken within the area of the illustration. The soundings obtained are principally echo soundings supplemented by vertical cast and hand lead soundings in the waters adjacent to the shore line. Horizontal control consisted of three-point fix angles on shore objects in the inshore area and radio acoustic ranging in the offshore area.

The contour interval shown on the illustration is 100 fathoms (600 feet) for depths of 100 to 1,800 fathoms. In depths less than 100 fathoms the 10—, 20—, 30—, 40—, 50—, and 75-fathoms contours are shown. The contour interval used in the 1: 120,000 scale survey previously mentioned was 25 fathoms, or four times greater. This insured a more accurate contour delineation in areas where echo soundings were practically continuous on rather widely-spaced sounding lines.

The diversity of submarine topography expressed in the illustration is self-evident. Heading the list is the long submarine scarp one-half to one mile in height extending more than 66 statute miles from shore. The western extremity of this feature has not as yet been ascertained. Portions of the face of the scarp plunge downward to the north with a steepness of from 24 to as much as 100 per cent. The downward slope of the top of this scarp, measured from the closed 200-fathom contour to the closed 800-fathom contour, is 1.7 per cent. However, from the western extremity of the 800-fathom contour to the western limit of the 1,000-fathom contour (outside the limit of the illustration), the rate of descent has increased to 3.9 per cent. The ocean bottom to the north and northeast of the scarp is quite flat and about one and three-fourths miles below the surface of the ocean, whereas the bottom to the south of the scarp slopes gently southwestward at a rate of 3.8 to 7.6 per cent accompanied by a depth change of from one-fifth to two miles. This scarp with the three types of contrasting topography constitutes a submarine feature too unusual to possess a known rival on the entire West Coast.

The 100-fathom contour closely approximates the limit of the continental shelf which is broader on the north than on the south. The continental slope beginning at the 100-fathom contour slopes away in the broader areas at a rate of about 4.3 per cent just above Spanish Canyon and is as great as 11 to 19 per cent on either side of Bear Sea-valley where it is considerably shorter in length. Here again contrasting topography is presented in that the rate of slope on the north is about three to four times greater than that to the southward.

Submarine canyons are well entrenched on either side of the scarp and protrude several miles into the continental shelf. Mattole and Delgada canyons to the southward of the cape are remarkable in that they extend so close to shore. Eel Canyon on the north has a broad head about five miles wide with five pronounced tributaries. It traverses a distance of 32 statute miles between the 30— and 1,400-fathom contours. The bottom gradient between the 75— and 900-fathom contours, a distance of about 25 miles, is from 5.0 to 3.0 per cent. At the 900-fathom contour the bottom slopes steeply to a depth of 1,300 fathoms with gradients as great as 30.3 per cent after which it lessens to about 2.4 per cent. The submarine knoll existing near the mouth of the canyon, around which the stream channel has had to travel 11 miles, is a phenomenon in deflection of submarine canyon courses. This knoll will evoke an interesting discussion as to whether it is younger or older than the canyon, or contemporary with a portion of the canyon's history. The fact that the mouth of the canyon including that portion of the canyon just eastward of the knoll approaches a straight line would imply, for example, that the canyon was fault-controlled

and that the knoll was a subsequent intrusion occurring at some time after the canyon was well established.

Bear Seavalley is about 18 miles long between the 75— and 1,400-fathom contours. Its gradient is about 14 per cent down to the 500-fathom contour, thence 30 per cent to a depth of 1,000 fathoms after which it levels out from 11 to as low as 2.9 per cent. The name of this feature was supplied by the writer, all other names shown on the illustration being in use on the later editions of the Coast and Geodetic Survey charts of this area. The term "seavalley", however, is a recent decision of the United States Board on Geographical Names and is applied to submarine depressions that are of valley form but unaccompanied by steep adjacent parallel walls such as are found in canyons.

Although outside the scope of this article, it is nevertheless of practical interest to note that another recent decision is "seamount". This new term is being applied more frequently off the West Coast and is used to denote a submarine elevation of mountain form. As a specific example, the first feature to receive this designation was a submarine mountain discovered by the Coast and Geodetic Survey Ship *Guide* in 1933 about 75 miles west of Point Piedras Blancas, California. This feature rises from a depth of 1,900 fathoms to 729 fathoms and has a net elevation above the ocean floor of 1,171 fathoms or 7,026 feet. It was named "Davidson Seamount" in honour of George DAVIDSON (1825-1911) of the U.S. Coast and Geodetic Survey.

Mendocino and Mattole canyons join at a depth of around 900 fathoms. Their lengths inshoreward from this point are 14 miles to the 40-fathom contour and 18 miles to the 10-fathom contour respectively. Two alternate outlets into the broad region of the 1,400 fathom contour are possible: one where Bear Seavalley enters, and the other about nine miles farther westward. The total lengths, in the case of the longer Mattole Canyon, to the two outlets are about 39 and 48 miles. Mendocino Canyon is more direct and has a gradient of about 6.4 per cent from a depth of 200 to 1,100 fathoms after which it levels out to about 2.2 per cent. The gradient along the major portion of Mattole Canyon is about 5.4 per cent or slightly less. Portions of the side walls of these two canyons are similar and yet contrasting. Near the apex of the 400-fathom contour, Mendocino Canyon has a steep wall slope of about 49 per cent on the north side, whereas Mattole Canyon has its steeper side slope of about 52 per cent of the south side where the face of the scarp serves as a side wall. In the same vicinities the opposing walls of each canyon are also similar in that they have lesser slopes of 21 and 16 per cent respectively.

Spanish and Delgada canyons are only partially shown on the illustration. Spanish Canyon is fairly straight and has a gradient of about 7.2 per cent from the 30— to the 300-fathom contour after which it lessens to about 2.4 per cent. Delgada's gradient is about 15 per cent from the 10— to the 100-fathom contour, thence 11 per cent to the 200-fathom contour after which it changes to about 2.7 per cent.

The contouring of several features represented in the illustration has revealed the desirability of additional development for further geological and seismological researches. Such additional development will necessarily be more comprehensive than that needed for purposes of navigation and will be accomplished by the Coast and Geodetic Survey Ship *Guide*, E.W. EICKELBERG commanding.