REFRACTION ON GEORGES BANK 1931.

by

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Observations were taken in 1931 on Georges Bank to determine what effect the difference in temperature between the surface water and the air temperature at the observer had on refraction. The dip to the horizon was measured and compared with the computed dip under normal conditions of the atmosphere. The difference between the observed and the computed dip was assumed to be due to refraction resulting from the difference between air and water temperatures.

INSTRUMENT USED.

A PULFRICH "horizon meter" was used to measure the dip of the horizon. In this instrument the horizons to the left and right of the observer are reflected through mirrors to an eyepiece in such a way that when the horizons are in coincidence the dip of the horizon may be read on a micrometer screw. This instrument is described in detail in an article by Captain E. MOLL in the May 1931 issue of the *Hydrographic Review*.

This instrument takes practice to use effectively because the horizons appear as vertical lines, and the rocking motion of the wrist required to keep the horizons in coincidence while the ship is rolling and pitching differs from that used with a sextant and feels awkward at first.

Discrepancies in successive readings indicated that the dip of the horizon can be measured within an accuracy of two-tenths of a minute in arc. The greatest fault found with this instrument was that the index error changed from day to day. To eliminate this error, the instrument was read in a direct and in a reversed position, and the initial reading subtracted from the average reading. Even this may not have eliminated error due to shifting occurring between direct and reverse readings. The readings on a single day, however, indicate that such errors were slight.

METHOD OF OBSERVING.

Observations were taken at three heights of eye, at 14 ½ feet on the forecastle deck, at 24 ½ feet on the navigation bridge, and at 32 feet on the flying bridge. At each height of eye two sets of observations were made at right angles to each other, and a third set in whatever direction the horizon appeared best. It was hoped to determine by this manner of observing whether the refraction varied in different parts of the horizon. The errors of observation, however, were greater than any differences found between sets taken at right angles.

At the same time the dip was observed, the temperature of the surface water and of the air at the height of the observer was taken, and the barometric pressure and the humidity on the bridge were noted. The temperature of air and water were taken with a centigrade thermometer standardized by the Bureau of Standards.

RESULTS.

The results of these observations are somewhat incomplete and unsatisfactory. The results plotted on graph paper give a scattered pattern through which no definite curve can be drawn. To compare the results obtained on Georges Bank with those given by Koss' formula, Dip $= 1.82 \sqrt{h} - 0.003\, h - 0.41\, \Delta$ (h equals the height of eye and Δ equals the temperature of the air minus the temperature of the water), a dotted curve based on the third term of Koss' formula was drawn on graph paper, and a full line paralleling Koss' curve was drawn averaging the results obtained on Georges Bank. This curve is 0.40 of a minute below Koss' curve, indicating that the formula from $1^{\circ}\,\Delta$ to minus $1^{\circ}\,\Delta$, Centigrade, when applied to Georges Bank would have an added constant term, — 0.40. The formula would be as follows:

$$+\,\text{Dip} = 1.82 \sqrt{h} - 0.003\, h - 0.41\, \Delta - 0.40.$$

Incidentally, the curve based on the previous season's star sights has the same constant, —0.40. The formula for dip based on the curve of the previous season's star sights from plus 1° Δ to plus 6°, Fahrenheit, was

$$\text{Dip} = 1.82\sqrt{h} - 0.003\,h - 0.17\,\Delta - 0.40.$$

or expressing in degrees Centigrade,

$$\text{Dip} = 1.82\sqrt{h} - 0.003\,h - 0.30\,\Delta - 0.40.$$

It will be noted that the differences between air and water temperatures in 1931 were small compared with those of the season previous, usually being less than one degree centigrade. This was because the ship *Lydonia* worked in waters about 40 miles west of where she did the season previous and that much further from the Gulf Stream.

CONCLUSION.

The unsatisfactory results are considered due to two facts. First, the dip measuring instrument is not precise enough in measuring the dip. Second, the temperature of the water and air at the horizon and of the air along the line of sight are not actually known. It is assumed that the water temperature at the point in the horizon observed is the same as that observed at the ship and this may be true much of the time, but certainly not all the time in a shoal area of strong and changing currents such as Georges Bank.