DETERMINATION OF VELOCITY OF SOUND IN SEA WATER IN CAPE COD BAY

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I. TEST LINE FIXED FROM SHORE OBJECTS

by
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The velocity of sound in sea water was determined in Cape Cod Bay the latter part of September, 1930, by the following method: One ship, the *Oceanographer*, fired the bombs while cruising near the eastern shore of Cape Cod Bay. She determined her position by sextant fixes on triangulation stations on shore each time a bomb was fired. The observers took their angles over the spot where the bomb was dropped. The other ship, the *Lydonia*, acted as hydrophone station, while anchored near the western shore of Cape Cod Bay. She determined her position by sextant fixes on triangulation stations on shore each time she recorded the explosion of a bomb. The position of the hydrophone was determined, at each bomb explosion, by measured angles and distances from the spot on the ship where sextant angles were taken to the magnetophone.

The *Oceanographer* plotted the positions of the bombs on a 1:20,000 scale projection, constructed on an aluminium sheet, and a point, *A*, was assumed near the average position of the bombs. The *Lydonia* computed the positions of the hydrophone and a point, *B*, was assumed near the average position. The distance between points *A* and *B* was computed. The component of the difference between each position and the assumed position *A* or *B* along the line between *A* and *B* was determined and added to or subtracted from the line *A* - *B* for each bomb distance. Each distance divided by the elapsed time in seconds gave the velocity per second. The average of all good values was 1474.6 metres per second.

Temperatures and salinities were measured at both ends of the line and averaged. Using the mean temperatures and salinities, the theoretical bottom velocity is 1481.7 metres per second. This is 7.1 metres per second greater than the test velocity.

Using the means of temperatures and salinities at each end of the line, however, does not take into consideration the fact that the temperatures are lower in the deeper water between the two ships. During the tests taken in the fall of 1931 along the same line, temperatures and salinities were taken all along the line while the tests were in progress. The temperatures at the ends of the lines were about the same as those of the previous year. An average of all the temperatures along the line gave a temperature 2.6° C. lower than the means of the temperatures at the ends of the lines. Applying a correction of — 1.73° C., determined by using a bottom temperature curve averaged from the 1931 curves, to the means of the temperatures at the ends of the line for the 1930 test gives a theoretical bottom velocity of 1475.0 metres per second. This is 0.4 metres greater than the test velocity.

II. WIRE BASE TEST LINE.

by
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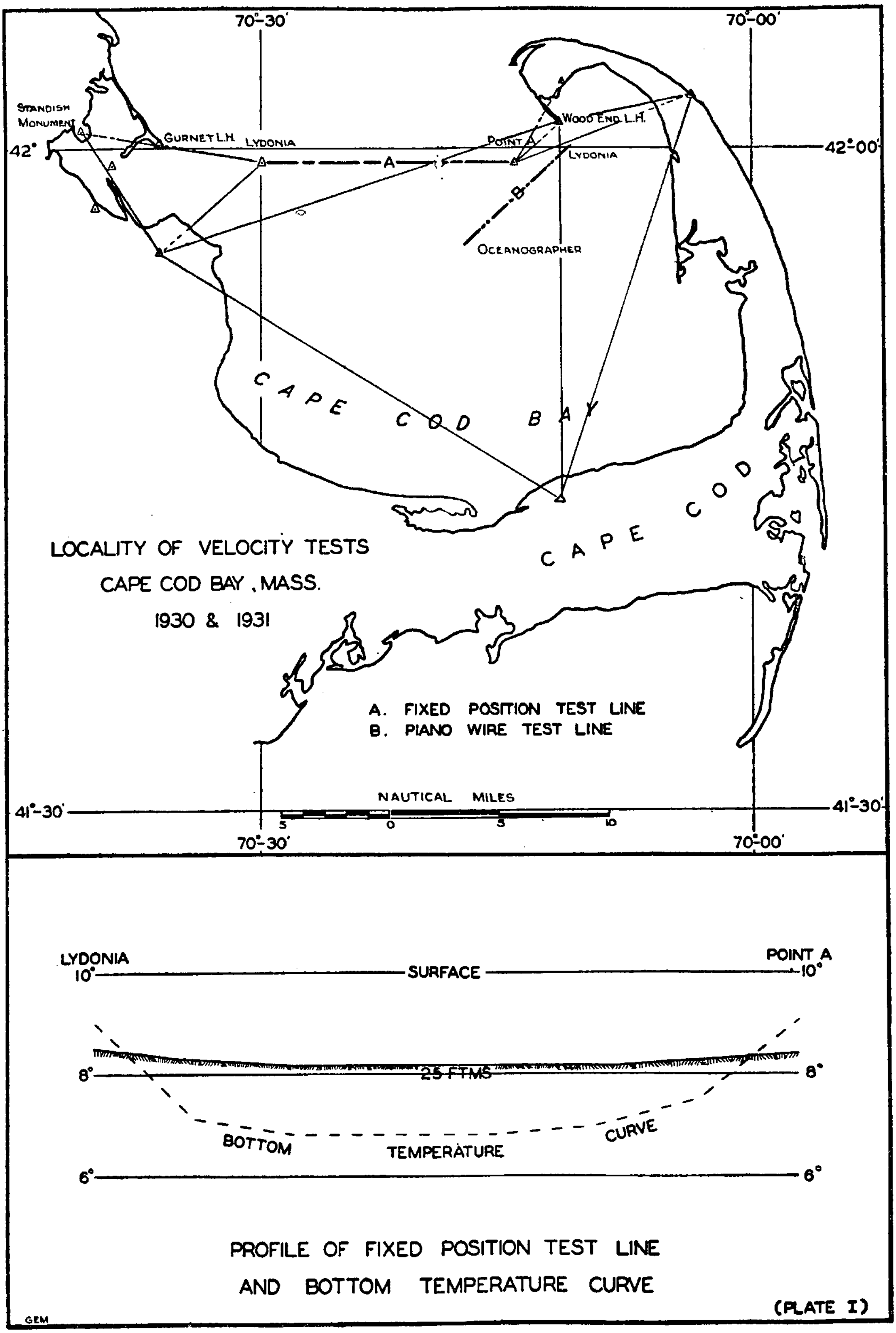
The purpose of the test was to establish data for the determination of a velocity of sound to be used on Georges Bank during the present field season and to enhance the experimental data on the speed of sound through sea water by a comparison between actual and theoretical velocities.

The test was made May 21, 1931, in Massachusetts Bay off Provincetown

Since this is thought to be the first successful determination of the velocity of sound by the above method, a detailed description of the methods employed will be given :


70°-30'
70°-00'
STANDISH MONUMENT
GURNET L.H.
LYDONIA
POINT A
WOOD END L.H.
LYDONIA
42°
42°-00'
A
B
OCEANOGRAPHER
CAPE COD BAY
CAPE COD
LOCALITY OF VELOCITY TESTS
CAPE COD BAY, MASS.
1930 & 1931
A. FIXED POSITION TEST LINE
B. PIANO WIRE TEST LINE
NAUTICAL MILES
5 0 5 10
41°-30'
41°-30'
70°-30'
70°-00'
LYDONIA
POINT A
10°
SURFACE
10°
25 FTMS
8°
8°
BOTTOM TEMPERATURE CURVE
6°
6°
PROFILE OF FIXED POSITION TEST LINE
AND BOTTOM TEMPERATURE CURVE
GEM

(PLATE I)

The *Lydonia* hove to, heading directly into the wind and having the end of the piano wire from the sounding machine of the *Oceanographer* attached to their bow by a spring, and drifting their magnetophone astern at a constant distance on a float.

The *Oceanographer* steamed directly into the wind at a speed of about six knots paying out the piano wire from the sounding machine over a registering sheave. Tension on the wire was kept constant at about 50 lbs. by watching the marks on an accumulator spring set horizontally at the forward end of the sounding boom and applying the brake of the sounding machine accordingly.

The *Oceanographer* was kept on the same course, 226° true, during the entire run. Bearings taken on the *Lydonia* at each bomb were consistently 180° off the bow, showing that the ship was not set to either side of her course by wind or current during the run.

All bombs were thrown overboard from the same position at the rail of the quarter deck, and at as near as possible the same distance and direction from the ship, and the registering sheave was read at exactly the instant each bomb hit the water. Since the fuse interval was nearly the same for all bombs, it was assumed that the effect of the current on them before their explosion would be the same for all bombs.

From previous experiments on the *Lydonia* it was determined that bombs of this type sink about 3 ½ feet per second. This would give an average depth of explosion of all bombs at about 10 fathoms.

To eliminate all uncertain corrections such as the scope of the magnetophone of the *Lydonia*, etc., it was not intended to use the portion of the wire from the *Lydonia* to the first bomb and no attempt was made to measure this distance. It was intended that the computations be made from a combination of differences between bombs and it was assumed that the magnetophone floated at the same distance from the *Lydonia* during the bombing.

Thirty bombs were fired at intervals of about two and a half minutes along the line. The first four bombs were not recorded or numbered and were omitted from the computations. All bombs were half pints. Bombs were numbered consecutively from 1 to 25 and the numbers in the bomb record correspond with numbers used in the computations. Bomb N° 12 was omitted as there was no sheave reading for it.

A mean of the accepted velocity determinations from the test gives 1476.5 metres per second. The theoretical bottom velocity is 1476.1 metres per second, or 0.4 metres less than the test velocity.

CONCLUSIONS.

The following conclusions might be mentioned as derived from the foregoing test:

1. It is a comparatively simple method of making velocity tests in remote localities where the visual fix method is not possible.

2. This method might easily be employed by one vessel using a launch equipped with a portable R. A. R. set as one end of the base.

3. It is believed that, under good conditions, the wire could be laid out and recovered without loss.

4. This method is not dependent upon good visibility for seeing shore signals.

5. It is felt that the mean of a large number of bomb differences, even though taken over a short base, will be more accurate than a few bombs over a longer base which depends upon sextant angles and graphic plotting for its determination.

6. The results of this test seem to be further evidence supporting the theory that the sound wave travels at a rate corresponding to the theoretical velocity of the mean bottom temperature.