

## **SOUND VELOCITY CORRECTIONS FOR THE NORTH SEA SURVEYOR**

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### **INTRODUCTION**

There is a mass of learned information about the velocity of sound in sea water. There are various formulae relating to temperature and salinity, and various ways of calculating the mean velocity for the water column.

The formulae, needless to say, give different answers, but does it matter? This article takes a simplified look at velocity corrections for the surveyor on the Continental Shelf — to which Matthews Tables do not apply — and has a special application to the North Sea.

### **Formulae**

To take three formulae, one or other of which is preferred by such British authorities as the Institute of Oceanographic Sciences or the Hydrographic Department, we have :

1) A. B. WOOD, 1941 [1] :

$$V = 1410 + 4.21 T - 0.037 T^2 + 1.14 S$$

2) W. D. WILSON, 1960 [2] :

$$V = 1449.2 + 4.623 T - 0.0546 T^2 + 1.391 (S - 35) (*)$$

3) C. C. LEROY, 1968, simplified [3] :

$$\begin{aligned} V = & 1492.9 + 3 (T - 10) - 6 \times 10^{-3} (T - 10)^2 \\ & - 4 \times 10^{-2} (T - 18)^{-2} + 1.2 (S - 35) (*) \\ & - 10^{-2} (T - 18) (S - 35) (*) + Z/61 \end{aligned}$$

where :

V = velocity of sound in metres per second;

(\*) This expression may be ignored if salinity is taken as 35 ‰.

T = temperature (centigrade);  
 S = salinity (parts per thousand);  
 Z = depth in metres.

The graph in figure 1 gives comparative curves based on temperatures and salinity in North Sea conditions. This shows that below 15 °C the differences are less than 3 metres per second. The practical surveyor need not worry about which is the most accurate. They are all accurate enough for him.

### Mean velocity for water column

For calculation of the mean velocity for the water column, a simple if somewhat unscientific method gives results well within the required accuracy. This is to mean the temperatures at each depth (either observed or scaled off a temperature profile diagram), and to use the mean temperature in the formula. A more correct method is to mean the velocities calculated separately for each depth, e.g., every 20 metres [4]. Let us see what errors the short cut might lead us into.

The table below shows velocities computed by LEROY'S simplified formula at each depth for a typical North Sea temperature profile in August, at a salinity of 35 ‰ (LEROY'S formula takes depth into account) :

Depth (metres)	Temperature (°C)	Velocity (m/sec)
0	14.1	1504.49
10	13.6	1503.01
20	13.1	1501.51
30	11.5	1496.19
40	9.0	1487.31
50	8.1	1484.08
60	7.5	1481.94
70	7.2	1480.93
80	7.0	1480.32
90	6.9	1480.09
100	6.9	1480.25
110	6.9	1480.42
120	6.9	1480.58
130	6.9	1480.75
Arithmetical mean . . .		1487.27

Using the mean temperature, 8.97°, and half the depth, i.e. 65 metres, for a single computation, the result obtained is 1487.61 m/sec.

### Effect of temperature and salinity on velocity

It is convenient to know a rule-of-thumb value for the effect on velocity of a 1° temperature change and of a 1 ‰ salinity change.

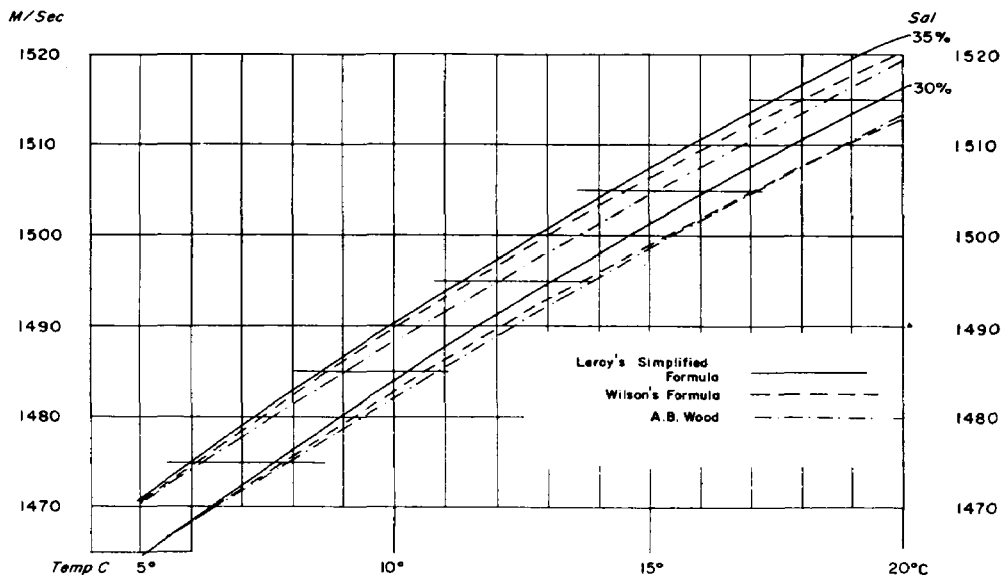


FIG. 1. — Sound velocity against temperature and salinity in the North Sea.

In North Sea conditions this is :

	Change	Effect (Approx.)	
Temperature	1°C	3.5 m/sec	<i>Increasing with temperature</i>
Salinity	1 ‰	1.2 m/sec	<i>Increasing with salinity</i>

In the North Sea salinity may be taken as 35 ‰ except off the Norwegian and Danish coasts, and even there the effect on velocity is unlikely to exceed 5 m/sec. At 35 ‰ the expressions relating to salinity in WILSON'S and LEROY'S formulae are zero and may be ignored.

Taking the velocity as about 1500 m/sec, a change in velocity of 15 m/sec will result in a 1 % error in sounding. With these simple figures it is easier to appreciate what is, and what is not, significant.

**Sounding corrections in the North Sea**

It is usually the practice to adjust the echo sounder to the velocity determined by one of the following methods :

- a) Mean surface temperature and salinity from charts;
- b) Observed surface temperature and salinity;
- c) The bar check at about 20 metres.

In the North Sea these methods will give acceptable accuracy in the months from November to April, during which there is no significant variation of the temperature with depth. But from May to October a thermocline develops (being most marked in August) when a difference in temperature of 6 or 7 °C exists. The thermocline is generally between depths of 20 and 40 metres.

By taking only surface temperatures into account, errors in sounding of 1 % can occur, the velocity invariably being too high and the recorded sounding too deep.

Diagrams based on German investigations [5] show temperature profiles in the North Sea for every month of the year at every degree of latitude from 56° 30' N to 61° 30' N, in the form of cross sections along parallels of latitude.

By extracting temperatures at every 20 metres of depth for every degree of longitude, the author has computed mean velocities (using LEROY'S simplified formula) for the months May to October. These mean velocities have been collated on chartlets (figs. 2-7), showing :

- a) Mean velocity for the water column;
- b) Depth in metres for which this has been computed.

#### **Use of the charts**

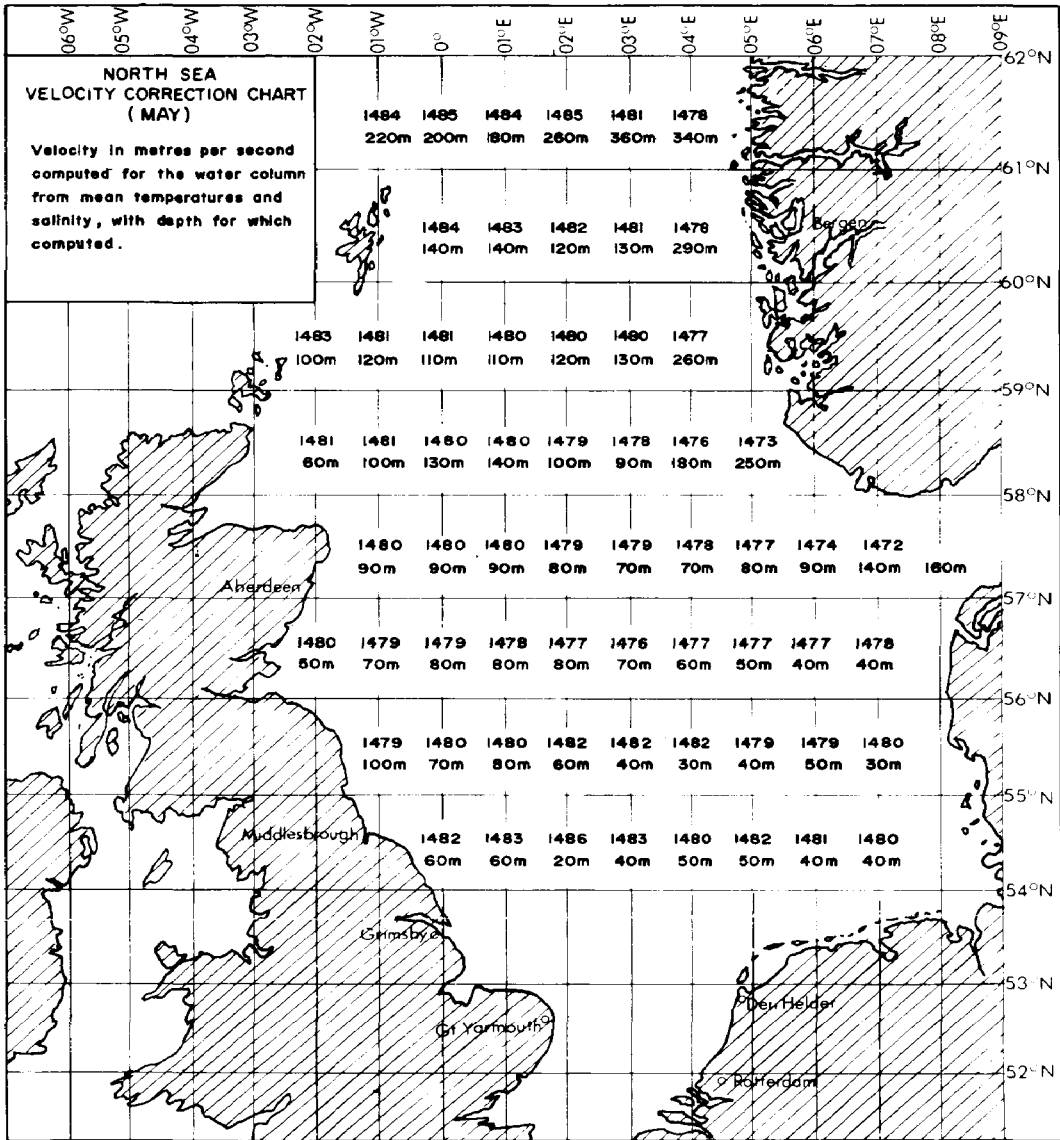
1. During the months May to October, the velocity may be taken from the chart for the month.

2. During the winter, when the thermocline is absent, the velocity may be computed or scaled off the graph, using the mean surface temperature for the month [5].

3. Where a thermocline exists, greater depths will have a greater effect on the mean velocity as compared with the surface velocity, because of the larger proportion of colder water. Therefore when using the charts in an area where depths vary within a one degree square, such as the Norwegian Trench, the depth for which the mean velocity is computed must be compared with the actual depth. If the actual depth is greater, the velocity will certainly be less, and vice versa.

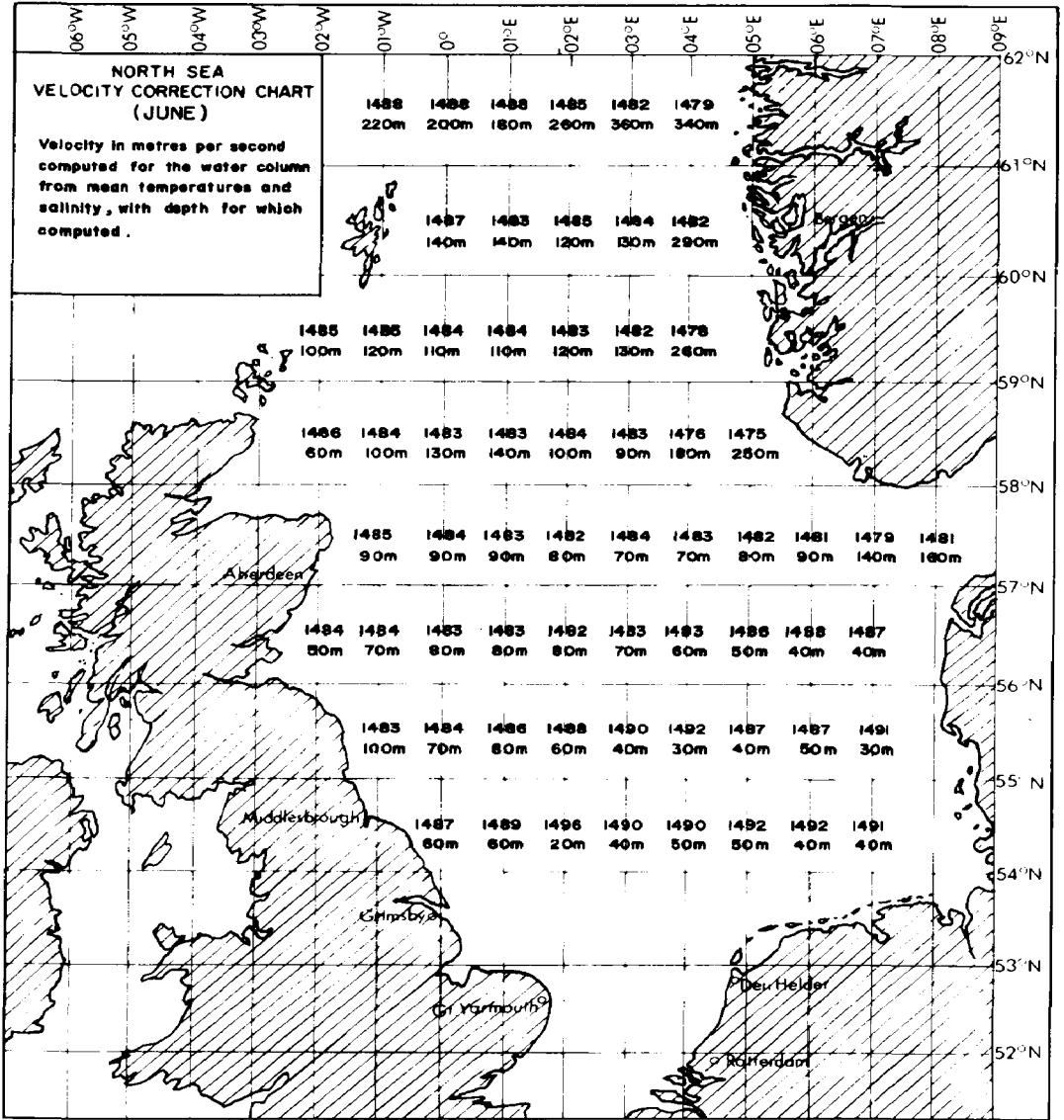
#### **Temperature observations**

Significant deviations from mean temperature can occur, not only at the surface but at depth. Where highest accuracy is required, the temperature profile must be measured at every 10 or 20 metres, and the actual velocity computed or scaled off the graph (fig. 1), using the mean temperature for the whole water column. Generally, observations need not be taken below 50 metres depth, where the temperature is likely to remain constant for practical purposes.



MAY

FIG. 2



JUNE

Fig. 3

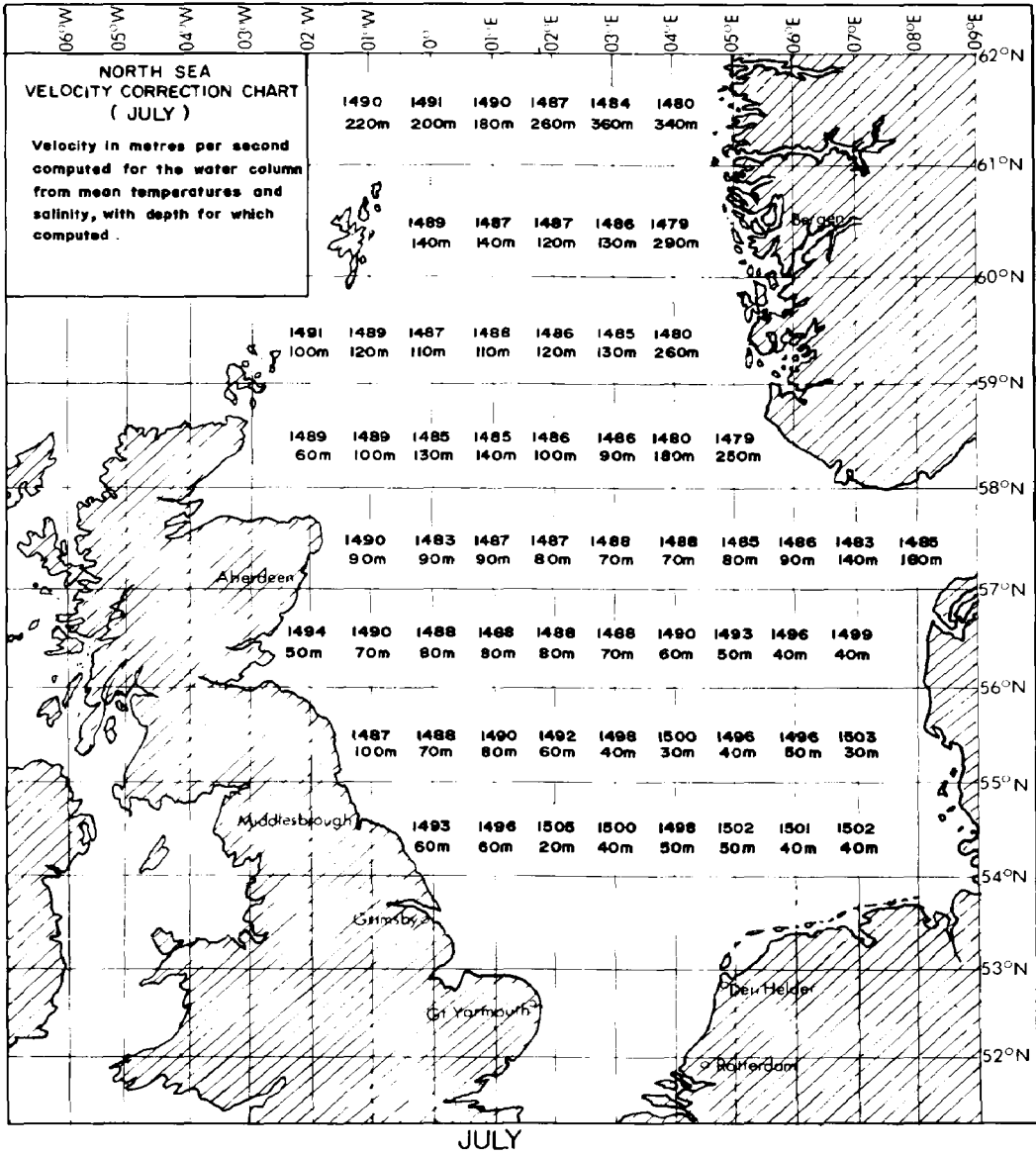
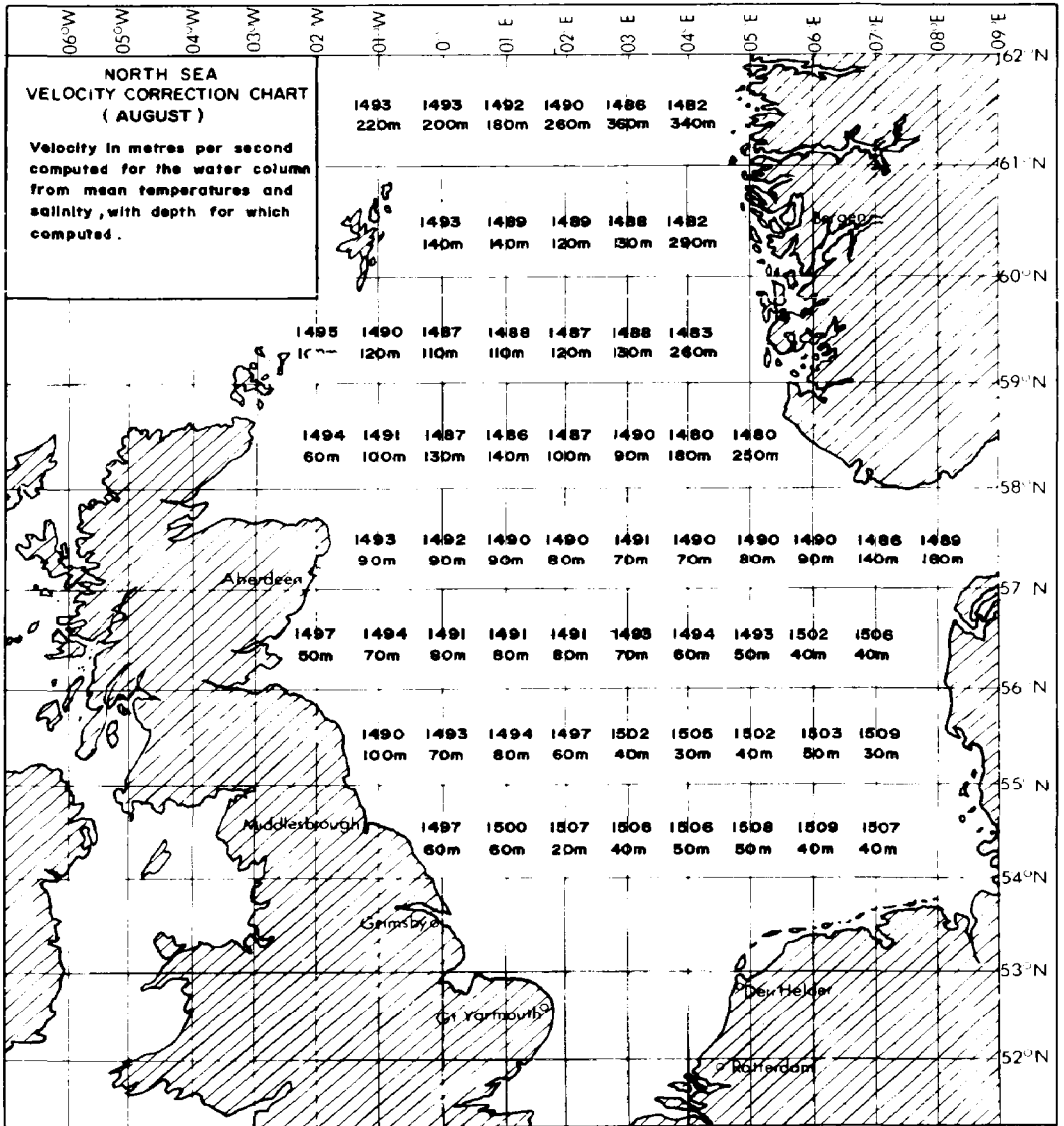


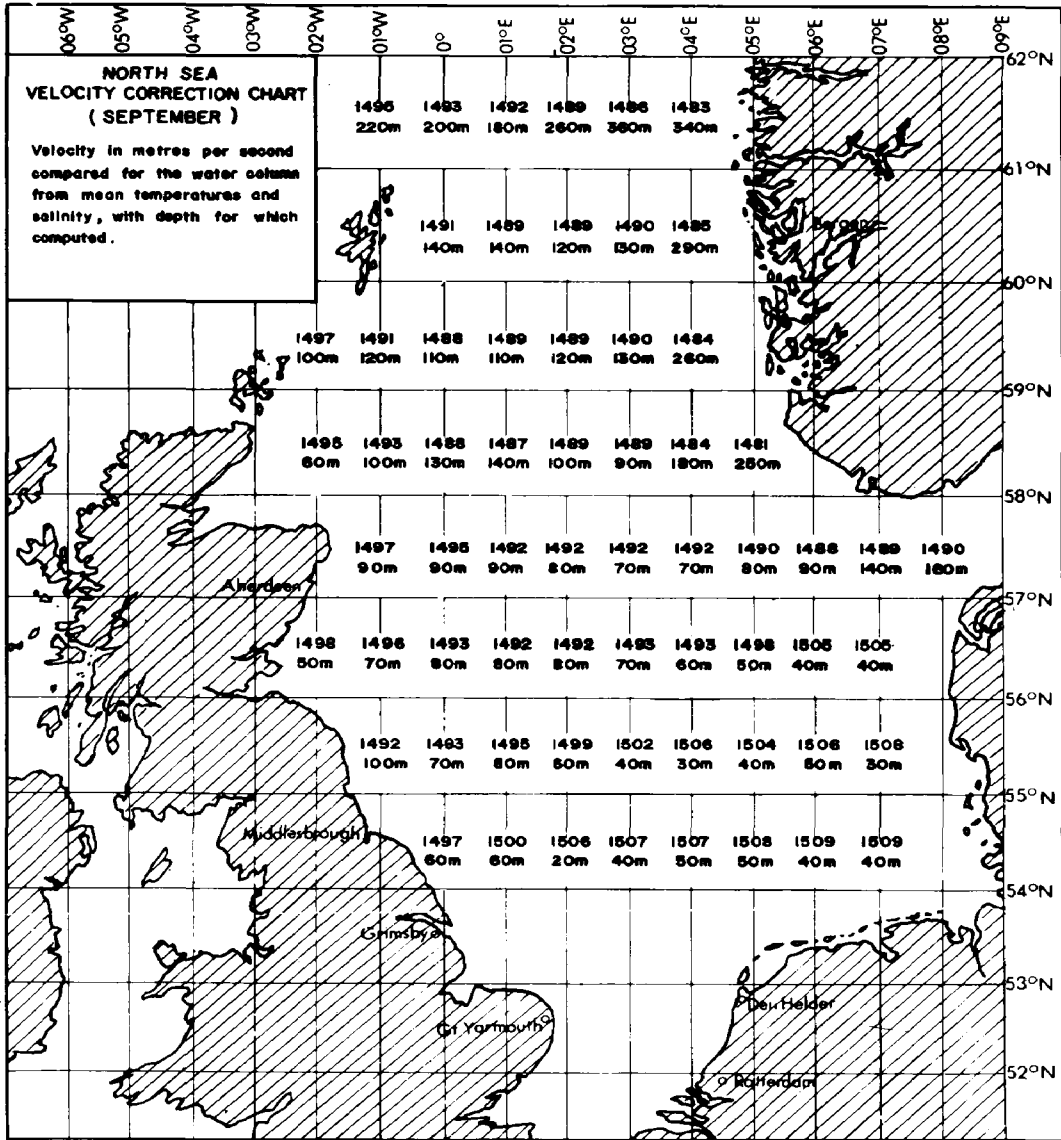
FIG. 4



AUGUST

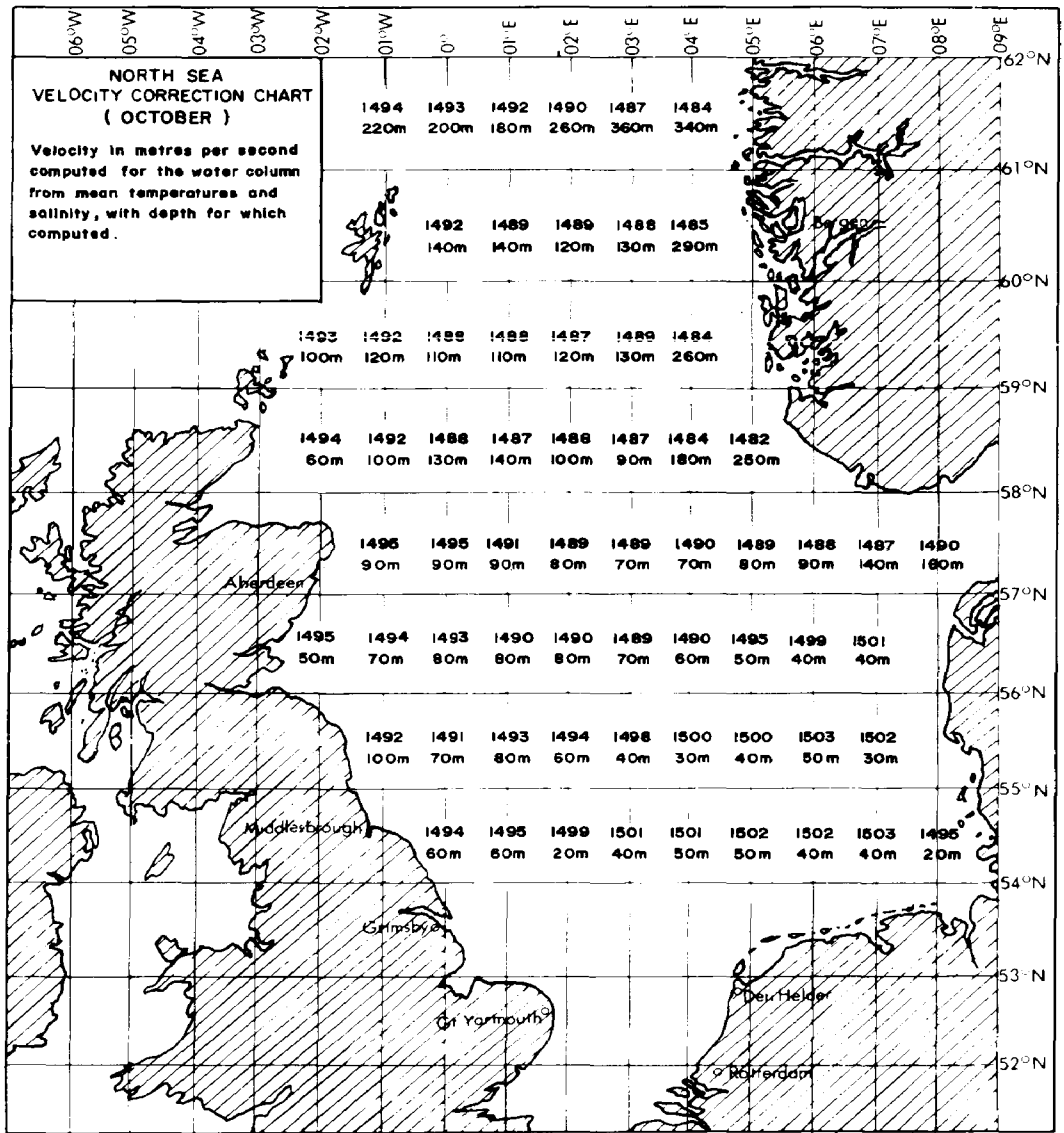
Fig. 5





SEPTEMBER

FIG. 6



OCTOBER

FIG. 7

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### **"THE BRITISH ARE COMING A BIT CLOSER**

The British Isles soon will be moved about 190 meters (600 feet) nearer to Europe.

A British admiral has discovered that existing charts and maps, some dating to 1795, are not quite accurate. Photos taken by six orbiting U.S. navigation satellites show that the maps need to be redrawn and the British Isles moved fractionally nearer the European continent.

Rear Admiral David HASLAM said that the Scilly Isles also would be moved on the new maps — about 74 meters farther west and 64 meters north. And the Shetland Islands also are affected. They will be moved 63 meters west.

Admiral HASLAM discovered Haslam's Reef off the Pacific Solomon Islands and the Haslam Patches in the Gulf".

From "*Herald Tribune*", Paris, 26 Aug. 1977.