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CALIBRATION OF ECHO SOUNDERS FOR OFFSHORE SOUNDING
USING TEMPERATURE AND DEPTH

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ABSTRACT

One of the difficulties confronting hydrographic surveyors in the past has been that of calibrating echo sounders to compensate for the varying velocity of sound in the water column. Mechanical methods such as bar checks, whilst adequate for shallow water bathymetry, were impractical and inaccurate for depths in excess of about 30 metres. This paper outlines a new and more satisfactory technique.

INTRODUCTION

The standard hydrographic surveying practice adopted for measuring water depth is to set the echo-sounder so that it reads the depth of water below the sea surface. To these depths is then applied a tidal correction to reduce soundings to a common datum.

The setting of the echo sounder to read the depth of water below the surface is achieved in two stages. Firstly the moment of transmission, represented by the transmission line on the trace, is set to the depth of the transducers below the water line. Secondly the speed of the echo sounder stylus is adjusted for the sound velocity in sea water. As variation in the speed of the echo-sounder stylus will affect the setting of the transmission line this procedure is repeated.

PRESENT METHODS

With most agencies the method used to check echo-sounders is the bar check. This method is quite satisfactory, and indeed is the ultimate, in shallow water down to the deepest depth at which a good clear echo can be obtained from the bar. For offshore work deeper than about 20 metres, it is usual to carry out a bar check to the deepest depth possible and accept the speed of the stylus thus found as the correct speed for the water column out to the edge of the Continental Shelf or approximately the 300-metre contour.

It is well known that good bar checks below 30 metres are most difficult to obtain. The weather must be calm, the sea smooth, and tidal streams slack; even with such conditions the process is most time consuming. With a ship bar this is particularly so. It is difficult to know from whence the echo is actually received, the bar itself can bend slightly, and it can be offset by current, drift and other variables. The thickness of the air pocket (Rubbazote, air filled hose, or enclosed angle iron) can be up to 5 cm thick and the point of reflection is in doubt. An error of 5 cm in the depth of the bar at 30 metres will give a false sound velocity of 2.5 metres/second which in turn will give a depth error of 0.5 metres in 300 metres. Although such an error is rather minor in itself, the erroneous speed setting may compound with the assumption that the sound velocity is the same all the way to the seabed to produce errors in excess of 3 metres in 300 metres.

The largest errors in sounding in deep coastal waters are caused by the assumption that the sound velocity obtained in the first 30 metres of the water column is correct for greater depths. This is usually not so. In general the sound velocity in the shallower depth is greater than that in the deeper water and therefore the error will give depths greater than the true depth. This is contrary to the standard practice of erring on the side of safety.

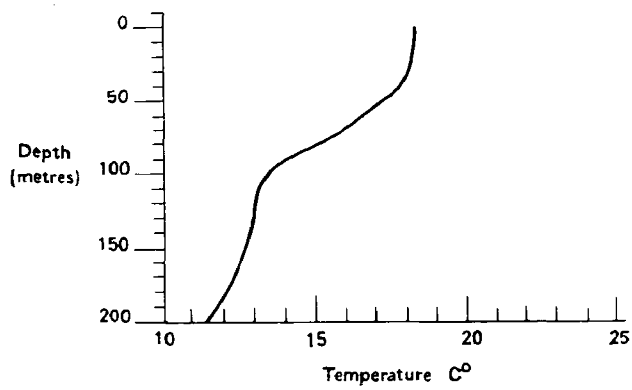

Fig. 1

Figure 1 shows a typical temperature/depth profile off the New South Wales Coast near the edge of the Continental Shelf.

It can be seen that in the first 30-40 metres, the depth to which a bar check would be carried out, the temperature is uniform. Thereafter it decreases rapidly, as does the sound velocity.

Measurement of the speed of sound

With modern echo-sounders the electronic governing arrangements give speeds much more stable (± 0.3 per cent) than those previously achieved with the old "make and break" type of governor. The bar check enables the echo sounder to be set correctly for the sound velocity only in the first 30 metres or so of the water column. If we are to benefit from the inherent accuracy of modern echo sounding equipment we must obtain an accurate sound velocity profile for greater depths.

The sound velocity in sea-water can be directly measured by a Velocimeter [1]. However such items obtained from commercial sources are expensive, and until they can be obtained more cheaply we must look to other methods.

One method is to compute the sound velocity by using Wilson's Equation (1960) [2] having observed salinity, temperature and depth. The last two parameters can be found by using a bathythermograph. Salinity presents more of a problem.

Measurement of salinity, depth and temperature

Apart from the use of sophisticated instruments, salinity can be found by using a hydrometer and the table given in Annex A; however an examination of cruise data of HMAS *Gascoyne* and *Diamantina* in the Continental Shelf areas of Australia since 1965 shows that the salinity in the Australian area is generally between 34.5 and 36.0 parts per thousand and that it changes only slightly with depth down to 300 metres.

It has been decided in the Australian Hydrographic Office that, failing other methods of ascertaining salinity, a salinity of 35 parts per thousand can be taken as standard in depths over 20 metres (i.e. where the bar check is not a satisfactory method of checking echo speed). Temperature and depth can be found using the appropriate bathythermograph : 450 feet down to 140 metres, 900 feet down to 280 metres, or an Expendable Bathythermograph (where such is fitted) for all depths.

Calculation of sound velocity

The method used to obtain the mean sound velocity for a column of water is that advocated by ULONSKA [1], that is, the arithmetic mean of a series of velocities obtained at fixed depth intervals. In the Australian Hydrographic Service a depth increment of 10 metres is used. Numerous approximations of Wilson's (1960) equation can be found; however the following has been accepted by the Hydrographer, R.A.N. :

$$C = 1449 + 4.6\,t - 0.055\,t^2 + 0.0003\,t^3 + (1.39 - 0.012\,t)\,(s - 35) + 0.017\,d$$

where :

C = Sound velocity in metres/second;
t = Temperature in degrees Celsius;
s = Salinity in parts per thousand;
d = Depth below surface in metres.

A programme for solving this formula and obtaining the arithmetic mean of the velocity profile to selectable depths has been written for the COMPUCORP 155 Surveyor Desk-top computer by the Hydrographic Office (Programme HO 0005).

PROCEDURE RECOMMENDED

The following procedure for setting an echo sounder for sound velocity depending on salinity, temperature and depth has been adopted by the Australian Hydrographic Service :

(a) Obtain a good bathythermograph cast from surface to seabed with the ship stopped. Obtain a surface reference temperature check (using bucket thermometer) to enable temperature correction to be applied.

(b) Compute mean sound velocity using programme HO 0005 with a salinity of 35 parts per thousand or observed salinity if available.

(c) Set the sound velocity on the echo sounder [3].

(d) Set the transmission line to the "depth" of the transducers below the waterline. On sets with common receive/transmit transducers (Atlas Deso 10) this can be done by direct measurement of draught at the transducers. On sets with separate receive- and transmit transducers (Kelvin Hughes MS26) this must be done by a shallow bar check.

CONCLUSION

The method of setting the echo sounder recommended above was implemented in HMAS *Moresby* during the 1973 survey season. After the echo had been set, and whenever the weather was satisfactory, a bar check was also taken. No measurable errors could be found.

The time taken to check the sound velocity daily once the echo had been initially set was no more than 10 minutes, of which the ship had to remain stopped for only so long as was needed to obtain the bathythermograph cast. By comparison, to bar check a ship echo-sounder even in perfect conditions takes at least 30 minutes.

The following extract from a report of survey in mid 1974 clearly illustrates the problems that can be encountered with ship bar checks and highlights the validity of the proposed method of setting the echo-sounder.

> "The Atlas Deso 10 was bar checked on three occasions, giving a speed of sound of 1497 metres per second. Unfortunately, a bathythermograph record was not taken until late in the season. With the accepted salinity of 35 ‰, a speed of sound of 1533.6 metres per second was computed. Sounding continued at 1497 metres/second until a full investigation of the situation could be conducted in calm water. In air, it was determined that the bar had a maximum sag in excess of 1 metre and at the distance from the centreline at which the transducer is situated, a sag of 0.6 metre. In still water, a sag of 0.3 metre was measured at the appropriate transducer distance. This, however, increased/decreased depending on whether the bar was being raised/lowered. Computing the results of the bar check with the mean of the presumed underwater sag i.e. 0.45 metre, gave a velocity of 1534 metres/second. All soundings taken by Atlas Deso 10 have been adjusted to 1534 metres/second".

REFERENCES

[1] ULONSKA, A. : A more accurate hydrographic survey by direct measurement of sound velocity in the sea. *International Hydrog. Review*, XLIX (1), Jan. 1972, pp. 71-80.

[2] VIGOUREUX, P. and HERSEY, J.B. : Sound in the sea. *The Sea*, Vol. 1, Chap. 12, p. 478. Interscience Publishers, 1960.

[3] Admiralty Manual of Hydrographic Surveying, Vol. II, Chap. 3, para. 4(b).

ANNEX A

SALINITY
(Parts per thousand)

Apparent specific gravity	Temperature °C														
	0	5	6	8	10	12	14	16	18	20	22	24	26	28	30
1.0150	19	19	19	20	20	20	20	21	21	22	23	23	24	25	25
1.0155	20	20	20	20	20	21	21	22	22	23	23	24	25	25	26
1.0160	20	21	21	21	21	21	21	22	22	23	24	25	25	26	27
1.0165	21	21	21	22	22	22	22	23	23	24	25	25	26	27	27
1.0170	21	22	22	22	22	23	23	24	24	24	25	26	27	27	28
1.0175	22	23	23	23	23	23	24	24	24	25	26	27	27	28	29
1.0180	23	23	23	23	24	24	24	25	25	26	27	27	28	29	30
1.0185	23	24	24	24	24	25	25	25	26	27	27	28	29	29	30
1.0190	24	24	24	25	25	25	26	26	26	27	28	28	29	30	31
1.0195	25	25	25	25	26	26	26	27	27	28	28	29	30	31	31
1.0200	25	26	26	26	26	27	27	27	27	28	29	30	31	31	32
1.0205	26	26	26	27	27	27	28	28	28	29	30	30	31	32	33
1.0210	27	27	27	27	27	28	28	29	29	30	30	31	32	33	33
1.0215	27	27	28	28	28	28	29	29	29	30	31	32	33	33	34
1.0220	28	28	28	29	29	29	30	30	30	31	32	32	33	34	35
1.0225	28	29	29	29	29	30	30	31	31	32	32	33	34	35	35
1.0230	29	29	29	30	30	30	31	31	31	32	33	34	35	35	36
1.0235	30	30	30	30	31	31	32	32	32	33	34	34	35	36	37
1.0240	30	31	31	31	31	32	32	33	33	34	34	35	36	37	37
1.0245	31	31	31	32	32	32	33	33	33	34	35	36	37	37	38
1.0250	32	32	32	32	33	33	33	34	34	35	36	36	37	38	39
1.0255	32	32	33	33	33	34	34	35	35	36	36	37	38	39	40
1.0260	33	33	33	34	34	34	35	35	35	36	37	38	39	39	40
1.0265	33	34	34	34	34	35	35	36	36	37	38	38	39	40	–
1.0270	34	34	34	35	35	36	36	37	37	38	38	39	40	–	–
1.0275	35	35	35	35	36	36	37	37	37	38	39	40	–	–	–
1.0280	35	36	36	36	36	37	37	38	38	39	40	–	–	–	–
1.0285	36	36	36	36	37	37	38	38	39	40	–	–	–	–	–
1.0290	37	37	37	37	38	38	39	39	40	–	–	–	–	–	–

(Extract from Kelvin & Hughes (Marine) Ltd., Publication M301RI : " MS26 Types A & F — Operation and Service Manual ").

AN EARLY COMMENDATION OF A SEA SURVEYOR

In December 1762 Rear Admiral COLVILLE under whose direction Mr. COOK, Master, had been surveying in North American waters wrote to the Secretary of the British Admiralty as follows :

"On this Occasion, I beg leave to inform their Lordships, that from my Experience of Mr. COOK's Genius and Capacity, I think him well qualified for the Work he has performed, and for greater Undertakings of the same kind : these Draughts being made under my own Eye I can venture to say, they may be the means of directing many in the right way, but cannot mislead any".

From "The Life of Captain James Cook" by J.C. BEAGLEHOLE, The Hakluyt Society, London 1974, recently received in the Bureau Library.