

Ascertaining depths for samples from hydrographic casts without CTD

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A fairly extensive study was conducted in the Arabian Sea in April-May 1995 to ascertain sample depths without CTD. It is shown that depths ($\leq 4000\text{m}$) derived using (i) only protected thermometer data, and (ii) wire angle ($\leq 35^\circ$) are within $\sim \pm 5$ percent of the thermometric depth in most cases.

Introduction

With the advent of the conductance-temperature-depth (CTD) systems and additional sensors for dissolved oxygen, light transmissometer, fluorometer etc. that go along with the water samplers (Niskin and Go-Flos in sizes ranging from 1.2 to 30 l), the collection of physical and chemical oceanographic data at sea has become simple and easy. Sending reversing thermometers mounted on to the Niskin/Nansen bottles to get accurate *in-situ* temperature and depth has more or less become a technique of the past. Still, for certain measurements/studies like radiocarbon, Ra isotope etc., (Broecker *et al.*, 1960; Moore *et al.*, 1985) one needs to collect 100 l (or more) water samples using Go-Flo and Gerard bottles (Gerard & Ewing, 1961) which can only be accomplished with the older method.

At the Physical Research Laboratory, ^{14}C and Ra isotope measurements using liquid scintillation (Bhushan *et al.*, 1994) and gamma spectroscopy methods respectively are being carried out to study circulation of water in the Arabian Sea (Somayajulu *et al.*, 1996) for which 100 l water samples are required. Due to the fact that both the surficial as well as deep water currents and powerful winds have a strong effect on the hydrographic wire with bottles sent to greater depths, ascertaining the correct sample depth becomes difficult. Standard methods in practice *viz.* using reversing thermometers as well as measuring the wire angles were adopted during a recent cruise in the Arabian Sea. The results of our efforts are documented in this technical note.

Experimental

During the 132nd cruise (April-May 1995) of the *FORV Sagar Sampada* of the Department of Ocean Development, six vertical profiles were collected using 100 l Go-Flo samplers. Each profile comprised of ten samples for ^{14}C and three for Ra isotopes. Based on the CTD casts, the important features in the water column and water masses were identified. Samples were

collected at the rate of two per cast using hydrographic winch with 4 mm diameter steel wire.

All available protected and unprotected thermometers from the ship and some from the National Institute of Oceanography (NIO), for which the test certificates were available, have been tested during a trial cast by fixing them on to 1.7 l Niskin bottles and comparing the data obtained with the depths obtained from the CTD. As a common practice, two protected and one unprotected thermometers were fixed in each rack which was attached to the Niskin bottle. Two casts were deployed; one using CTD and another by fixing Niskin bottles with thermometer to the wire at different depths. The wire angle (θ) for each cast was also measured. The cosine of the wire angles was used as one way of ascertaining the depth ($\text{Cos}\theta \text{ depth} = \text{Wire paid out (m)} \times \text{Cos}\theta$). After each cast, the temperature recorded by the protected and unprotected thermometers were read and depths were ascertained following standard methods (Sverdrup *et al.*, 1942).

Results and Discussion

Depths were obtained using two protected and one unprotected thermometers combination. Depths were also obtained by reading off the CTD depth corresponding to the temperature recorded by the protected thermometer. The two depths thus obtained are referred to as Thermometric depth and PT depth respectively and are given in Table 1. Except for one case, the thermometric depths are in very good agreement (deviation 0.9-4 percent) with CTD depth (Fig. 1). It is gratifying to note that protected thermometer alone can be used to obtain the depth of exposure of large volume water samples fairly accurately (deviation in PT depth from CTD depth = 0.5-4.6% in 75 percent of the cases, Table 1, Fig. 1).

As mentioned earlier, only two to four Niskin bottles with thermometers were used in each cast. Generally, two Niskins were fixed for each 100 l Go-Flo bottle, one 30 m above and another 30 m below the bottle. A minimum of four sets of protected and unprotected thermometers should be used so that the results of one set could be cross checked with others. This practice also safeguards against the failure of one or two sets, which can otherwise jeopardise the entire cast operation. For all the cases where the messengers tripped the bottle and thermometer rack, and thermometers worked well, the data are given in Table 2. Unfortunately in this cruise, due to excessive greasing of the wire, there were quite a few instances wherein the messengers got stuck and did not slide below a

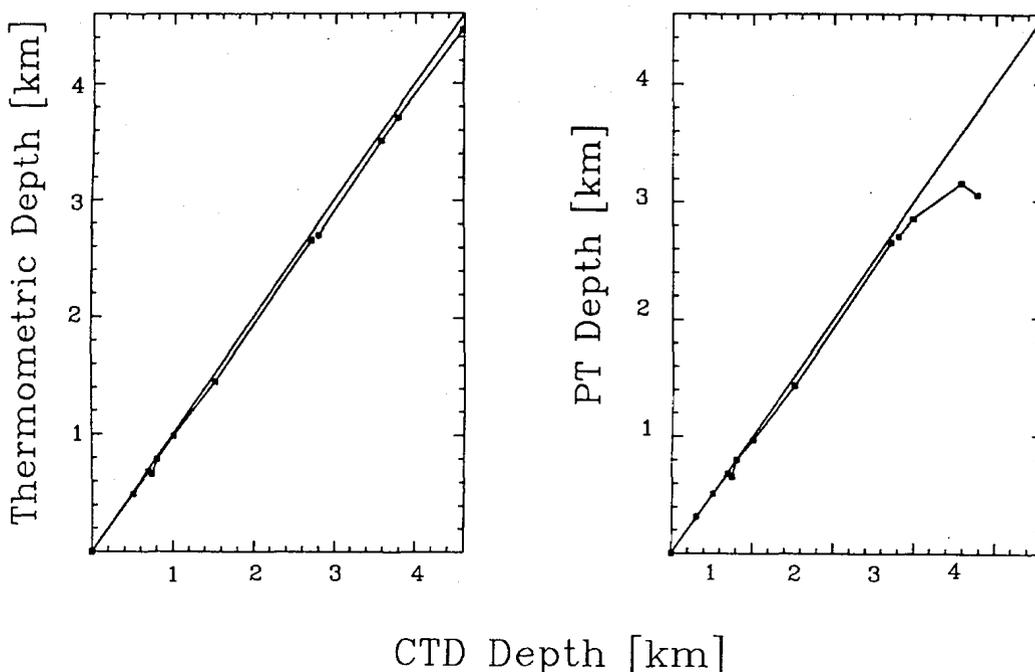


Fig. 1. Plots of Thermometric depth (left) and PT depth (right) as a function of 'CTD depth' (see also Table 1).

certain depth. In such cases, the bottles were operated closed at shallower depth during their ascent. Although

the depth of tripping could be established from thermometric as well as dissolved oxygen, salinity measurements, such data are not included for comparison in Table 2. It should also be noted that the wire angles varied from cast to cast and ranged from 5° to 56°. The maximum value was reached at a station where sea state varied between 5 and 6. However, during most of the casts (>50 in number for the entire cruise) the wire angle variations remained mostly within 25±10°. About 50 data points representing the wire angles 15° to 35° are used in Figure 2.

Table 1: Comparison of CTD and thermometric depths

CTD depth (m)	Thermometric depth (m)	PT depth (m)
309	-	315 (+1.9)
509	493 (-3.1)	515 (+1.2)
698	679 (-2.7)	683 (-2.1)
743	662 (-10.9)	659 (-11.3)
804	787 (-0.9)	800 (-0.5)
1009	987 (-2.2)	970 (-3.9)
1516	1448 (-4.5)	1435 (-5.3)
2714	2654 (-2.2)	2655 (-2.2)
2803	2695 (-3.9)	2706 (-3.5)
2990	-	2853 (-4.6)
3582	3504 (-2.2)	3154 (-11.9)
3783	3705 (-2.1)	3054 (-19.3)
4580	4462 (2.8)	-

Thermometric depth calculated using protected and unprotected thermometer data, PT depth using the temperature from protected thermometer and reading the corresponding depth using CTD data from the same station. Mean of the two values derived from two thermometers is used.

Number in paranthesis is deviation (%) from the CTD value.

- indicates no data available, P and/or UP thermometers did not work.

In an ideal situation where there is no disturbance of any kind, the wire paid out equals to the true depth of sampling. The three curves shown in Figure 2 represent the thermometric depth, the PT depth and the Cosθ depth, all three as a function of wire paid out. It is seen from the figure that there is not much variation in depths evaluated from one method to another. There is no particular pattern in the variation as a function of depth (Table 2).

In 59 percent of the cases, the positive deviations in the PT depth from the thermometric depths were observed whereas positive deviations occurred in 77 percent of the cases in Cosθ depths. In general, the departure by either/both methods from the thermometric depth is <~7 percent which is acceptable in this kind of study and where CTD cannot be used. In five cases when the deviations were high, the Cosθ depth deviated more compared to PT depth (Table 2).

In conclusion, we confirm the proven, age old observation that thermometric depth is a very good measure of the true sampling depth. The depths ascertained by protected thermometers as well as wire

Table 2 : Depths Ascertained during various casts of *Sagar Sampada* 132 cruise

Wire paid (m)	Wire angle ($^{\circ}$)	Thermometric depth (m)	PT depth (m)	Cos θ depth (m)
50	18	48	42(-12.5)	48(0)
90	22	83	75(-9.6)	83(0)
120	10	-	112	118
120	18	111	125(+12.6)	114(+2.7)
120	17	-	115	115
120	5	115	87(-24.3)	120(+4.3)
180	5	157	176(+12.1)	180(+14.6)
180	18	158	-	170(+7.6)
-	-	-	(+7.6)	-
180	10	-	150	177
190	22	188	189(+0.5)	176(-6.9)
250	22	225	238(+5.8)	232(+3.1)
270	17	-	245	258
270	10	243	240(-1.2)	266(+9.5)
320	35	247	260(+5.3)	226(-8.5)
330	10	305	320(+4.9)	325(+6.6)
330	11	-	315	324
330	18	306	304(-0.7)	314(+2.6)
350	34	264	265(+0.4)	290(+9.8)
400	32	-	355	339
410	34	307	310(+1.0)	340(+10.7)
460	32	376	421(+12)	390(+3.7)
500	47	321	318(-0.9)	341(+6.2)
520	28	438	448(+2.3)	459(+4.8)
550	34	418	420(+0.5)	456(+9.1)
550	35	466	460(-1.3)	450(-2.9)
610	34	488	488(0)	506(+3.7)
660	28	578	578(0)	583(+0.9)
670	42.5	499	470(-5.8)	494(-1)
720	28	578	578(0)	583(+0.9)
730	42.5	532	520(-2.3)	538(+1.3)
780	28	690	688(-0.3)	689(-0.3)
870	28	707	718(+1.6)	768(+8.7)
900	40	-	530	689
930	28	756	765(+1.2)	821(+8.6)
960	40	563	554(+1.6)	735(+30.6)
900	32	788	755(-4.2)	763(-3.2)
960	32	837	835(-0.2)	814(-2.7)
1000	45	553	567(+2.5)	707(+28)
1140	32	946	924(-2.3)	967(+2.1)
1360	32	-	1190	1153
1370	25	1189	1225(+3)	1242(+4.5)
1420	32	1213	1261(+4)	1204(+0.7)
1430	33	1230	1260(+2.4)	1199(-2.5)
1500	45	894	908(+1.6)	1061(+18.7)
1500	47	1004	1020(+1.6)	1023(+1.9)
1670	28	1360	1448(-6.5)	1474(+6.5)
1730	28	1480	1502(+1.5)	1527(+3.2)
1770	33	1542	1593(+3.3)	1484(-3.8)
1800	33	1567	1613(+2.9)	1510(-3.6)
1850	45	1022	1032(+1)	1308(+28)
2470	22	-	2350	2290
2530	18	2291	2315(+1.0)	2406(+5.0)
2860	32	2511	2528(+0.7)	2425(-3.4)
2920	32	2449	2493(+0.2)	2476(+1.1)
2950	18	2615	2660(+1.7)	2805(+7.3)
3010	18	2721	2734(+0.5)	2862(+5.2)
3070	28	2737	2665(-2.6)	2711(-0.9)
3130	28	2798	2815(+0.6)	2764(-1.2)
3600	28	3132	2952(-5.7)	3179(+1.5)
3630	28	3155	3030(-4)	3205(+1.6)
3630	28	3155	3030(-4)	3205(+1.6)
3650	18	3320	3323(0)	3471(+4.5)
3670	28	-	3240	3240
3670	28	-	3240	3240
3710	18	3378	3390(+0.4)	3528(+4.4)
3730	28	3376	3140(-7)	3293(+2.5)

Number in paranthesis is deviation (%) from thermometric depth.

- indicates that unprotected thermometer did not work

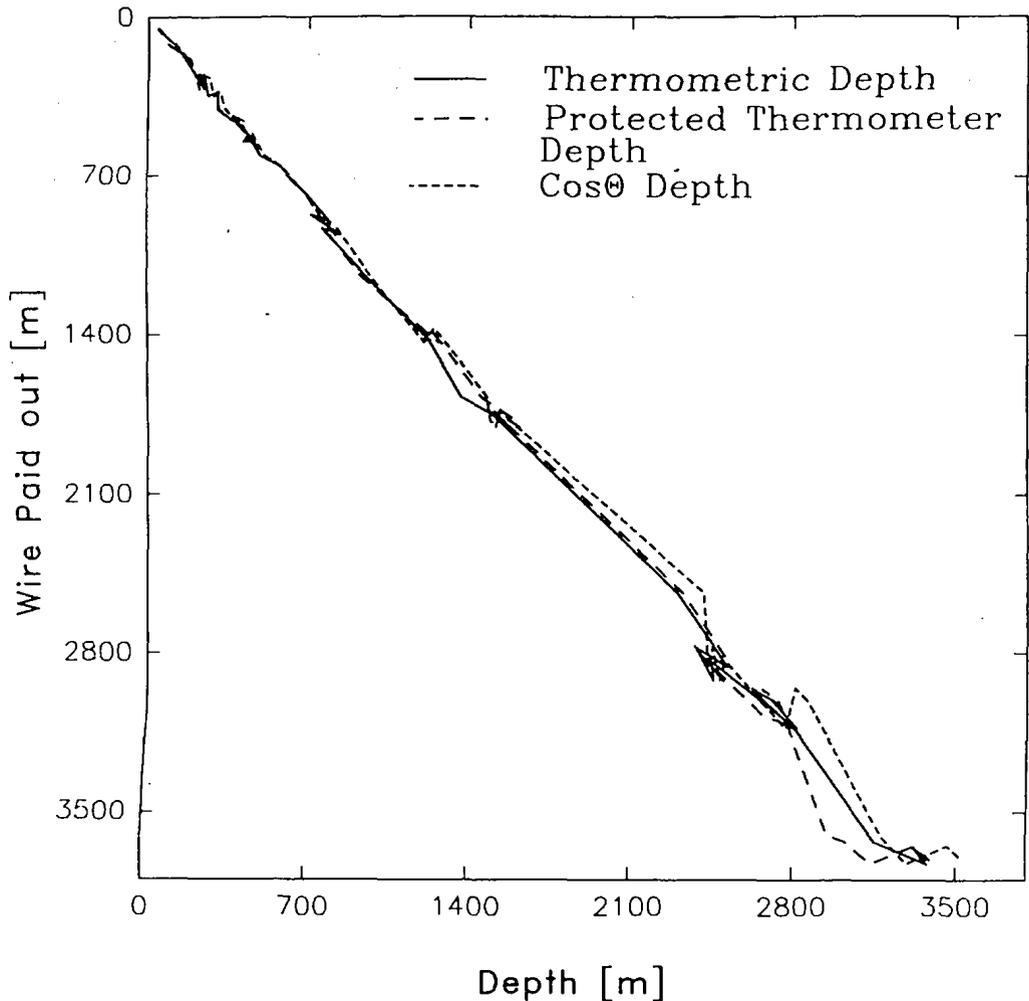


Fig. 2. Thermometric, PT and Cos θ depths as a function of wire paid (see Table 2 and text for details).

angles fall close to this. The largest deviations from thermometric depths came in the waters ≥ 1000 m. Both PT and Cos θ depths are fairly accurate with the latter prone to larger variations which generally occur at ≥ 1000 m. Even without CTD in the cast, sampling depths can be reasonably well ascertained by the techniques described here.

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