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HYDROGRAPHY
COMMITTE

A FIELD INTERCOMPARISION BETWEEN A MINIATURE CTD AND THE NEIL BROWN SERIAL 1223 CTD- PROFILER

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ABSTRACT

During a survey in Lofoten in may 1989 a new miniature CTD which is being developed at the Inst. of Marine Research was mounted to the ship`s ordinary serial 1223 CTD- profiler on 10 different CTD- stations. Using the NB CTD as a reference and compensating for differences in sampling rate, the data presented from the two instruments when being in the same water volumes were compared. The experiments showed occational differences in the measurements of maximum 0.18 degr. C in temperature and 0.18 mmho/cm in conductivity.
If the miniature CTD is calibrated against the NB CTD and the water is homogenous,the differences in reading between the two instruments may be reduced to within +/- 0.02 degrees C and +/- 0.025 mmho/cm.

INTRODUCTION

The Neil Brown CTD- profiler has become a standard instrument in Norwegian research vessels for fast acquisition of high quality hydrographic information .
When operated in accordance with procedures given by *Blindheim* (1) , the in -field data precision is regarded to be:

-Conductivity:	+/- 3/1000 mmho/c
-Temperature	+/- 3/1000 degrees C
-Depth	+/-2.0 m (Total range 6000m)

At the ICES- meeting in 1988 , *Gytre* (2) described a new

miniature "personal" CTD instrument.
This instrument is basically shaped as a 60 mm thick, 450 mm long molded polyurethane cylinder containing electronic interfacing, processing, memory and displaying circuits. During operation data are processed and recorded inside the instrument . The recorded data may be wieved from a built in display or transferred to a PC for processing. Alternatively the data may be fed directly to a computer via cable.
The MINI- CTD can be programmed by the user to present CTD,STD CTDc or STDc data. (c= sound velocity). During the intercomparision the CTDc- mode was selected.
During a survey in Lofoten with M/S G.O. SARS during may 1989, a prototype of this instrument was tested against the ship`s standard Neill Brown serial 1223 CTD- profiler.

BASIC INSTRUMENT PROPERTIES
The Neil Brown profiler and the miniature CTD are quite different in design.
Fig. 1 illustrates the most significant differences. Basically the NB CTD is designed to generate a vast amount of high speed raw data which are transmitted to a deck unit and computer via cable.
The MINI- instrument is designed to measure,process and record a moderate amount of raw or processed data at a programmable repetition rate ranging from from one measurement each 5. second to one measurement every 3 hour. Although the instrument was initially designed for environmental monitoring in bouys, it can also be be used for profiling.

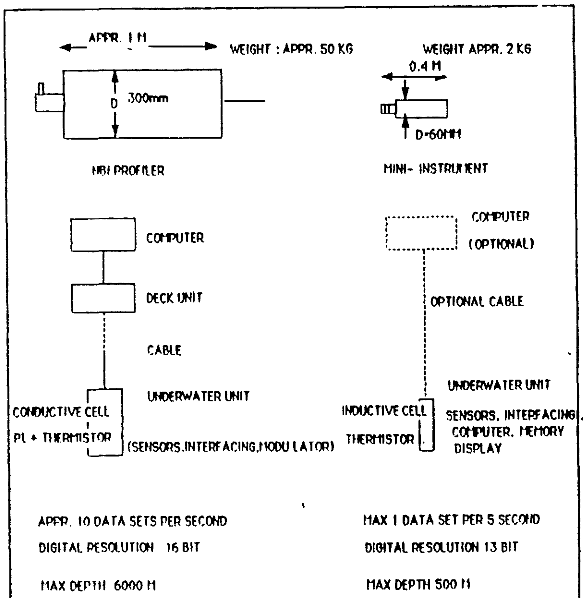

FIG. 1 BASIC DESIGN DIFFERENCES

Fig. 1 Basic differences in design

When in use the NB CTD must be operated with a winch from a relatively large vessel, while the MINI instrument is is small enough be operated from boats of any size without a winch.
Fig. 2 shows how the MINI- instrument was mounted close to the

the NB CTD by fixing it to the protective cage that surrounds the NB CTD .

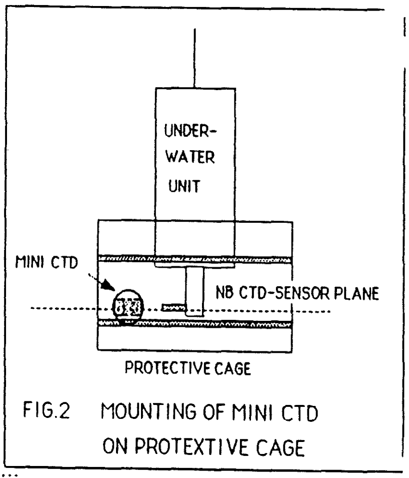

Fig. 2 Sensor positions during the measurements.

During the experiments the MINI - instrument was programmed to measure and record at its fastest possible recording rate- each 5 second.

To eliminate the dynamic effects of differences in sampling rate, and to be sure to intercompare data from the same water masses,the winch was stopped at each 10 meter for 10-20 seconds. During this interval the NB CTD data were read and noted down from a display in the deck unit.

After each profiling the recorded data in the MINI- CTD memory were transferred to a PC from which the CTD-data that corresponded to to stable depth - readings were sorted out and noted down.

Fig. 3 shows a typical data against time - diagram showing the " plateaus" generated by each stop. The intercalibration data were collected from these flat regions.

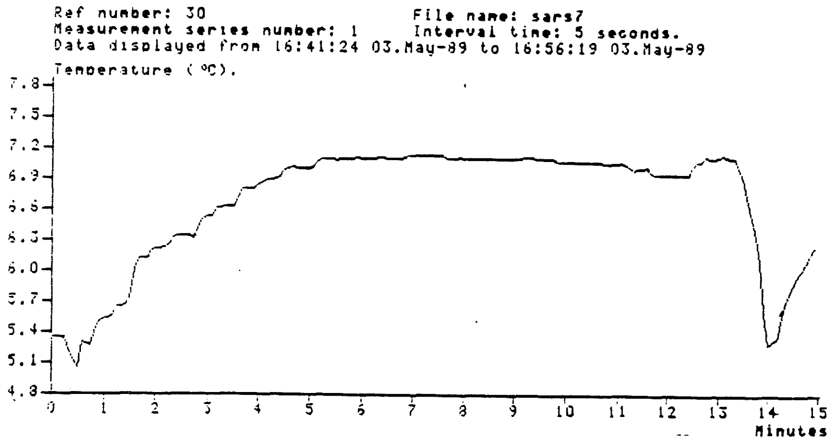

Fig. 3 Data-time printout showing stops for each 10 m.

CALIBRATION CONTROL.

Before the survey started, the actual calibration of the MINI-CTD temperature, conductivity and pressure sensors were checked in

3 points against the laboratory standards used by Inst. of Marine Research.
Table 1 shows the results.

Referance	MINI CTD	DIFFERENCE	
24.385	24.461	-0.076	MMHO/CM
42.270	42.349	-0.079	"
45.940	45.811	+0.129	"
+0.600	+0.580	+ 0.02	DEGR. C
15.080	15.030	+0.05	"
25.090	25.010	+0.08	"
0.00	0.01	-0.01	dbar
98.1	98.3	-0.02	"
181.3	181.8	-0.05	"

During the C and T- calibration control, which was done in well mixed, stable water
bath, the displayed variations in temperature and conductivity were observed to be within +/- 0.01 degrees C and +0.01 mmho/cm respectively.

Fig. 4 illustrates the temperature and conductivity calibration errors that were observed.
In particular the initial conductivity calibration proved to be inaccurate for high conductivity values.The resident calibration equations were not adjusted at this time.

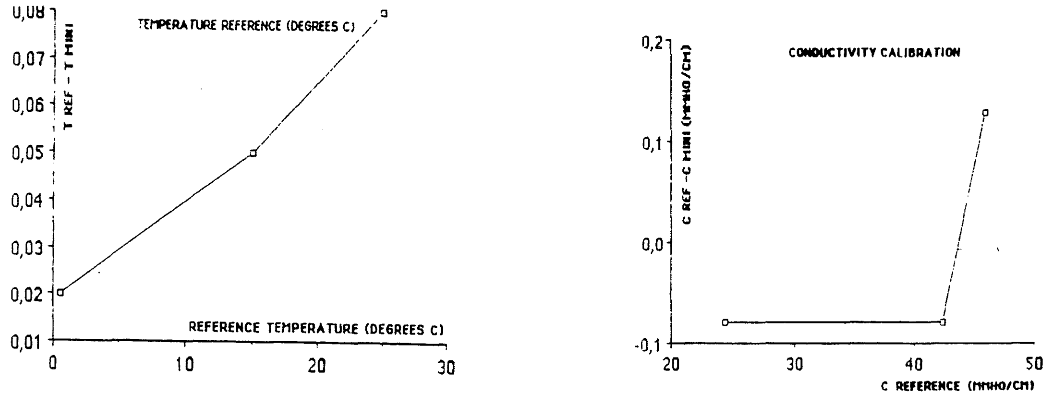

Fig. 4. Observed calibration errors.

During the survey a total of 10 intercomparings were made. The Lofoten region is relatively shallow (50-300 m) so the full depth range could not be tested on this occasion.

Fig. 5 shows the PC printouts for temperature and conductivity against depth for a typical station.(SARS7). The corresponding readings from the NB CTD are marked for each 10 m stop.

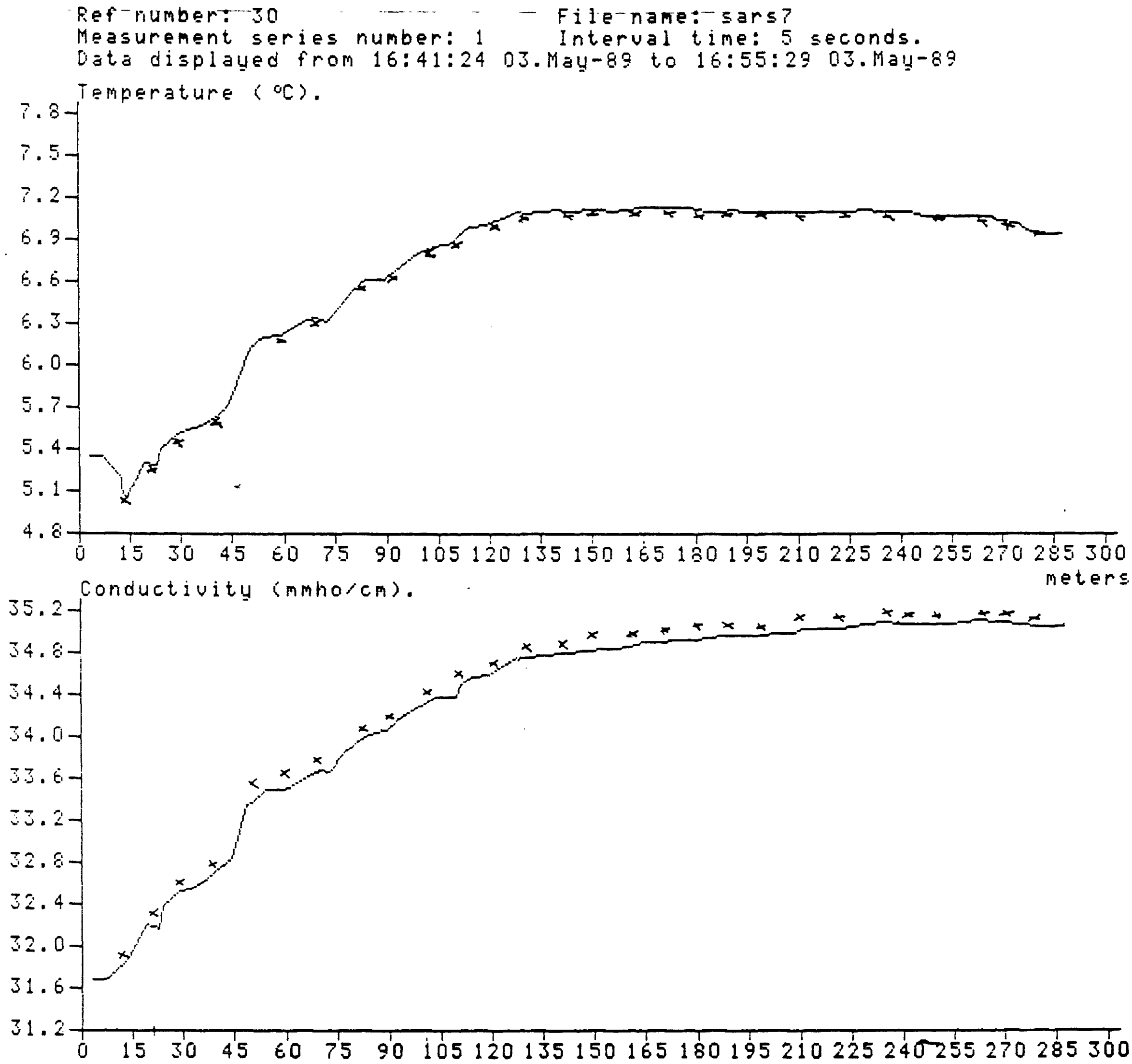

Fig. 5 Printout of a typical CTD-station inside the Lofoten basin made with the MINI-CTD. The corresponding NB CTD observations are marked with crosses.

Fig6,7 and 8 show the observed differences in temperature, conductivity and depth between the NB CTD and the MINI-CTD in station SARS7. These differences were typical also for stations SARS1-SARS6.

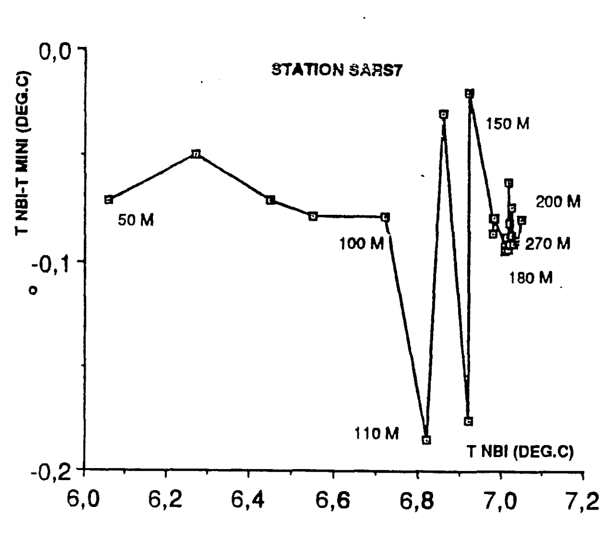

Fig. 6 Differences in temperature

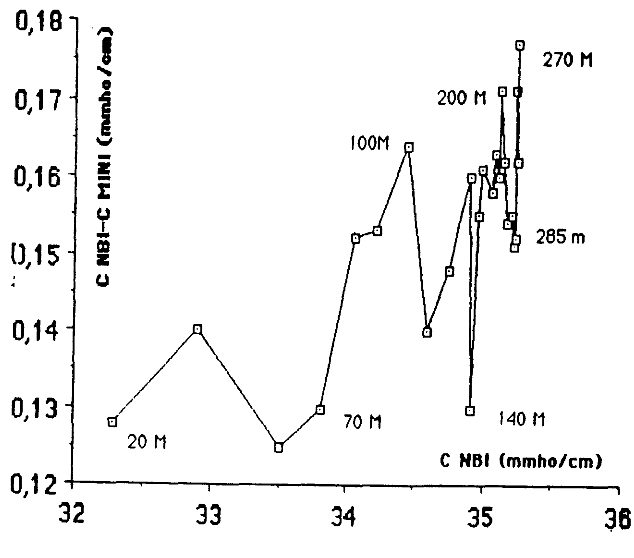

Fig. 7 Differences in conductivity

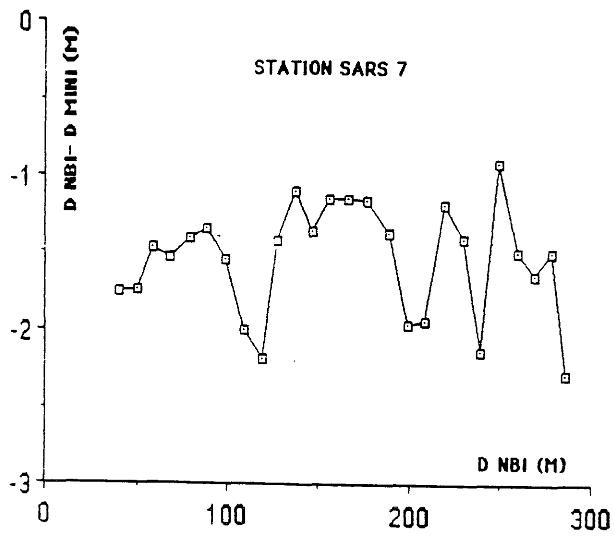

Fig. 8 Difference in depth readings.

Intercomparing of the pressure sensors was not very meaningful since the pressure sensor in the NB CTD covers 6000 m and the MINI pressure sensor just covers 500 m. The ship`s continuous motions also makes a direct intercomparision inaccurate. Fig.7 basically shows that the pressure data from the NBCTD had an offset of appr. 1.6 m . (In the MINI- instrument the depth is automatically initialised to zero when the instrument is started)

According to the initial calibration control, conductivities around 34 mmho/cm are presented 0.079 mmho/cm too high.
During the intercomparings made, the MINI- instrument showed appr. 0.13 mmho/cm too high conductivity.
Fig. 6 and 7 show that temperature readings could differ up to +/- 0.1 degrees C and conductivity could differ up to 0/- 0.025 mmho/cm. The largest differences were observed in regions were the changes with respect to depth were large.

IN FIELD CALIBRATION ADJUSTMENT .

In the MINI CTD the conductivity is calculated by the internal microprocessor from a equation of the form
C= D+ENc +FNc exp2. (1) where Nc are the conductivity bits and D,E and F are calibration coefficients. Modifications to these coefficients can be easily made from a PC via the instrument`s RS-232-communication plug.

After the SARS7- station had been recorded, 0.130 was subtracted from constant D in eq. (1) .
Fig.8 shows the observed anomalies in conductivity in the next station - SARS8 (bottom depth 80 m) Clearly the two conductivity sensors showed a good correlation in the homogenous water near the bottom.

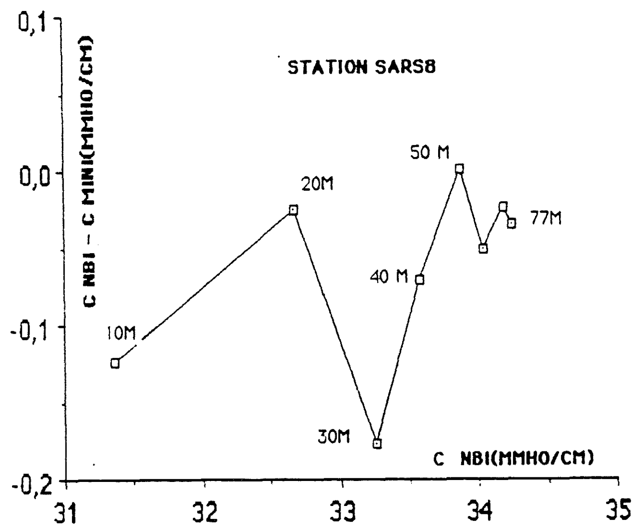

Fig9 Differences in conductivity reading after offset adjustment.

SOUND VELOCITY
Sound velocity is often a convenient "fringe benefit" parameter in in oceanic research. In the MINI CTD the sound velocity is calculated by the internal microprocessor from salinity, temperature and pressure.
Fig.10 shows an excample of computed sound velocity profile .

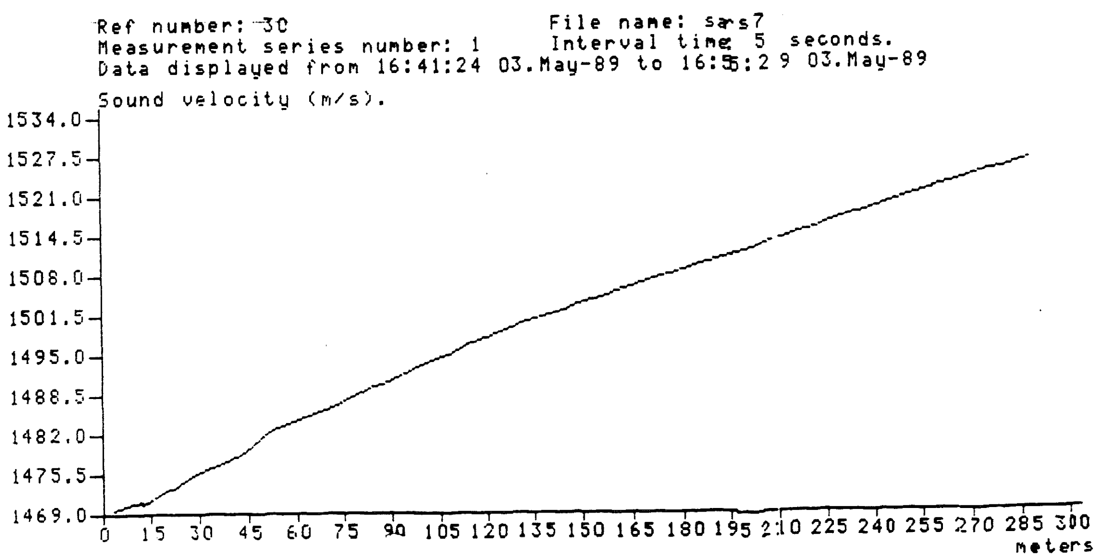

Fig. 10 Computed sound velocity profile

DISCUSSION

An intercomparision in the field shows how two different instrument react to the same environment at the same time. Different results may be caused by different calibration, different quality in sensor design and signal processing, different dynamic response or nonequal interferences from the mooring.
From the calibration control, a permanent offset of appr. 0.03 degrees C and 0.078 mmho/cm could be expected around +7 degrees C and 34mmho/cm. According to fig. 5 and fig. 6, the observed offsets were appr. 0.07 degrees C and 0.15 mmho/cm respectively .These offsets were typical for the 7 first intercomparisions (when the calibration coefficient were still unchanged).
To sort out the reasons for the observed permanent offsets, a more thorough check of the laboratory calibration routines must be made. However,such repetititve offsets are very easy to remove.
A large part of the observed scatter in data around the offset values - which represent the ultimate differences- may be due to variations in response to moving water.
When the ship goes up and down due to waves, the instruments are also pulled up and down . The temperature sensor used in the MINI-CTD has a longer time constant than the temperature sensor in the NB CTD, and this may cause dynamic errors .
The conductivity sensor used in the MINI CTD has a larger diameter than the diameter in the NB CTD. Therefore the flow rates through the two sensors cannot be equal. When measuring in stratified water,these factors have to generate small differences in the observed temperature and conductivity data.

CONCLUSIONS

The tests carried out in Lofoten were made in a region with limited span in seawater parameters. Within this limitation, the inter-comparisons showed that the conductivity data delivered from the originally calibrated MINI CTD followed the data from the NB-CTD with a conductivity dependent offset from appr. 0.13-0.18 mmho/cm. In homogenous water the scatter around the offset was appr.+/-0.02 mmho/cm .
For temperature the corresponding numbers were - 0.02- -0.18 degrees C and +/- 0.02 degrees C.
Stable or predictable offsets may be easily removed by making changes in the MINI-CTD calibration parameters.
The scatter is caused by basic differences in the two instrument`s design and sensor quality and can only be reduced by statistical methods.

References:

1 Blindheim J. "Procedures for collecting and processing of hydrographic data in Norway." (ICES C.M. 1985/C:1 Hydrography Committee)

2 Gytre T. " Automatic calibration of the sensors used in a miniature STD-instrument." (ICES CM 1988 / C:24 Hydrography Committee.