LABORATORY EVALUATION AND PRELIMINARY FIELD TRIALS OF NEW " WOCE STANDARD " IDRONAUT MK317 AND OS316 CTD PROBES.

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The MK 317 is a multi-parameter Conductivity, Temperature and Depth profiling unit (CTD) with a fast (50mS) Platinum resistance thermometer and a free flushing 3cm ceramic, four electrode, conductivity cell. (as used in the Neil Brown Instrument Systems, Inc. MKIII CTD) one of the units tested had redundant temperature and conductivity probes installed. Laboratory evaluations including shock tests on the pressure sensor, and both noise and calibration stability tests on conductivity and temperature sensors have been conducted at the SACLANT Underwater Research Center, oceanographic calibration facility. This facility has for three decades generated CTD calibrations that exceed WOCE standards in order to satisfy both NATO Navies and the Southern European Oceanographic Research community requirements Results are presented and compared from casts made with both the Mk 317 and OS 316 (in self recording mode) and SBE 911 plus or SBE 25 operating from the same deployment frame.

I Introduction

For many years the European community has, by means of funding instrumentation development and promoting the use of such equipment in Community funded Research projects, been encouraging European manufacturers to challenge the supremacy of North American oceanographic equipment manufacturers. This policy has made the incumbent North American companies both nervous and willing to participate in joint manufacturing ventures. This paper will review the evaluation of products from one such collaborative venture between Idronaut Srl of Milano Italy and General Oceanics Inc. of Miami, Florida. Equipment has been deployed during cruises from the R/V Alliance, February 1999 and B/O Garcia del Cid, May 1999. The performance of several different manufacturers' conductivity, temperature and depth profiling systems have been compared.

II Equipment

There are several different Idronaut CTDs involved in this evaluation. During the first cruise there were two instruments, a MK317 which had been adapted to handle data from an old Meerestechnik Elektronik sound velocimeter and an OS316. The comparison instrument was a SBE 911 plus. During the second cruise there were three Idronaut instruments, a MK317 with a

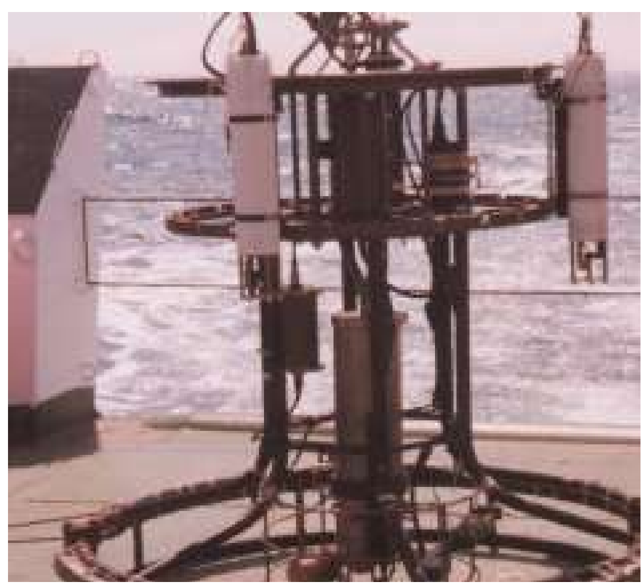

Figure 1: CTD array on board B/O Garcia del Cid

single temperature and conductivity sensor, a 316 with dual temperature and conductivity sensors and a MK318 with three conductivity sensors and one temperature sensor. The comparison instruments were a MKIIIC and an SBE 25. The instruments that were evaluated are tabulated in Table 1.

Table 1 Instruments reviewed

Instrument	Description
911 plus	Standard model SeaBird CTD
316	Idronaut internal recording Environmental CTD
317sv	Idronaut internal recording CTD, with GO MKIIIC conductivity cell and a Pt100 thermometer, modified to accommodate ME Sound Velocimeter
MKIIIC	Standard MKIIIC CTD
SBE 25	Standard internal recording SBE Model 25 CTD
317	Idronaut internal recording CTD with two GO MKIIIC conductivity cells and two Pt100 thermometers
318	Idronaut internal recording CTD with three GO MKIIIC conductivity cells and one Pt100 thermometer, unfortunately damaged prior to data collection
319	Idronaut internal recording Environmental CTD modified to accommodate dual conductivity and temperature sensors

On the second cruise a new MK 318 CTD with three conductivity sensors was physically damaged, beyond repair, without collecting any data.

All raw data collected have been presented unprocessed with the exception of the SeaBird data which has been processed according to the recommendation of SeaBird. See APPENDIX A for a description of the processing applied to the SeaBird instruments' data sets.

III Laboratory tests

Prior to the January cruise the CTDs were subjected to a routine calibration and also a

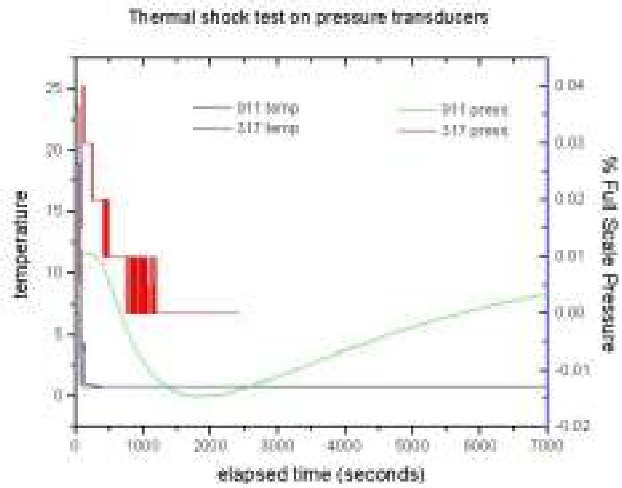

Figure 2 Thermal shock response

thermal shock test on the pressure transducers. The results of the thermal shock tests are presented as figure 2. The MK317 evaluated had an amplitude response that was initially greater than that of the 911 but the recovery time of the MK317 was less than 1,500 seconds compared to the 911 which was still not fully recovered after 7,000 seconds. The observed amplitude responses were equivalent to $\pm$ 1.2 decibar and 0.75 decibar for the MK317 and 911+ respectively. The apparent poor resolution of the 317 pressure sensor is a function of the data having been truncated at 0.1 decibar with a full scale of 1,000 decibar. The actual resolution of the instrument is 16 bit or 0.1 in 7,000.

Attempts at examining the noise and stability of sensors in the laboratory calibration tanks were inconclusive as the noise levels of the sensors were less than the noise created during the cycling of the baths. The authors have therefore attempted to compare the temperature and salinity signals during an actual cast. Figures 3 and 4 are graphic presentations of temperature and salinity over a 100 meter section of ocean.. The Idronaut two headed environmental probe, model 319, has noise equivalent to it's digitizing increment of 0.001 degrees, four of the sensors agree to within ±0.005 degrees over the 100 meter section plotted the fifth sensor is displaced by about 35 milli-degrees but has the identical form of the other sensors.

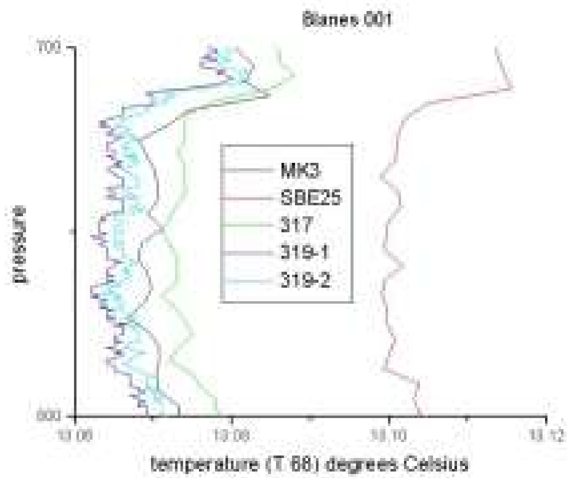

Figure 3 Temperature noise comparison

A comparison of salinity sensor performance was inferred from the salinity plot for the same section of the water column. Figure 4 illustrates the same digitizing noise in the

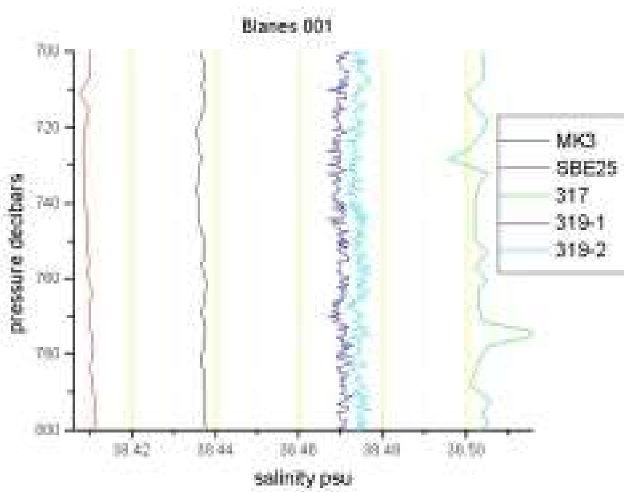

Figure 4 Salinity noise comparison

model 319 salinity sensors that was apparent in the temperature signals. The 319, MKIIIC and SBE 25 exhibit almost no evidence of, time constant mismatch, generated "salinity spiking" the excursions in the salinity profile of the 317 at 730 and 780 meters are however almost certainly generated by this phenomenon. A procedure will need to be developed to correct this problem.

IV Field results from R/V Alliance

The first two stations were conducted from the R/V Alliance on each of the two casts two water samples were taken and later analysed Tables 2 and 3 show the result of these calibration checks. Cast 1 intercompared a 316 and the 911 and cast 4 the second data set presented intercompared the 317sv and the 911.

Table 2 Water bottle comparison at Lerici #1

Instrument	Salinity psu	Pressure decibars	Salinity difference
Bottle 1	38.524	964	
Bottle 2	38.524	964	
911	38.520	964	- 0.004
316	38.526	964	+0.002

Figures 5, 6, and 7 show the inter-comparison of temperature, salinity and oxygen respectively.

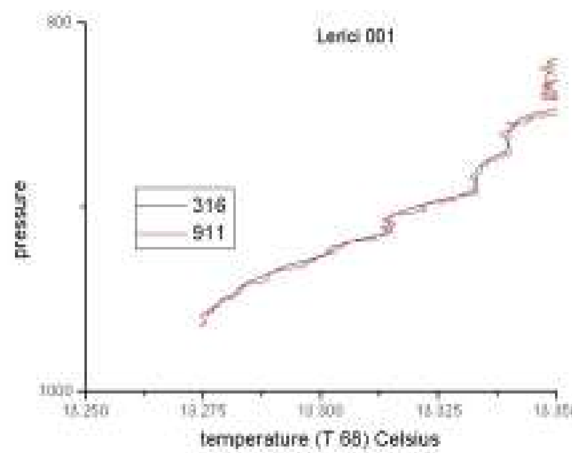

Figure 5 Temperature comparison

The temperature traces of the two probes are intertwined and show neither significant offsets nor gradients. Figure 6 is the equivalent presentation for salinity, the bottle data has already shown us that the instruments are in good absolute agreement.

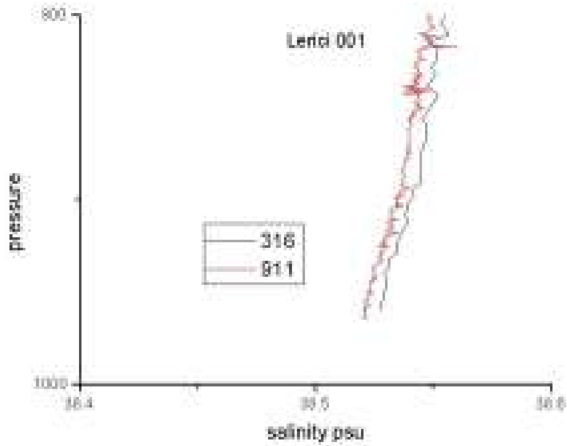

Figure 6 Deep salinity inter-comparison

It is interesting to note that there is a lot more noise or maybe structure in the 911 signal than is apparent in the 316 signal. There is an offset which the bottle data has shown to be of the order of 0.006 psu. Figure 7 shows the differences in measured dissolved Oxygen displayed as percent of saturation.

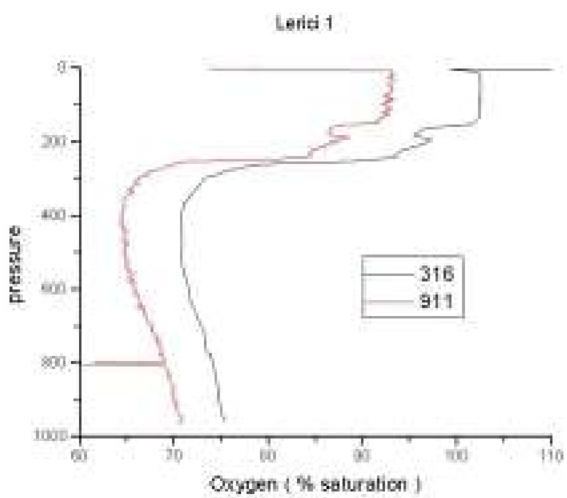

Figure 7 Differences in percent saturation of dissolved Oxygen.

The Oxygen data displays both an offset and a marked pressure dependence both of which may be readily corrected with data from a Winkler titration.

The second R/V Alliance station is described by Figures 8, 9 and 10 and the water bottle comparison is outlined in table 3 below.

Table 3 Water bottle comparison at Lerici #4

Instrument	Salinity psu	Pressure Decibars	Salinity difference
Bottle 1	38.573	608	+ 0.001
Bottle 2	38.571	608	- 0.001
911	38.578	608	+ 0.006
317sv	38.577	608	+ 0.005

Table 3 clearly illustrates that the salinity measurements are consistent and repeatable between the two instruments that are being compared, at least in the upper 1,000 meters of the water column.

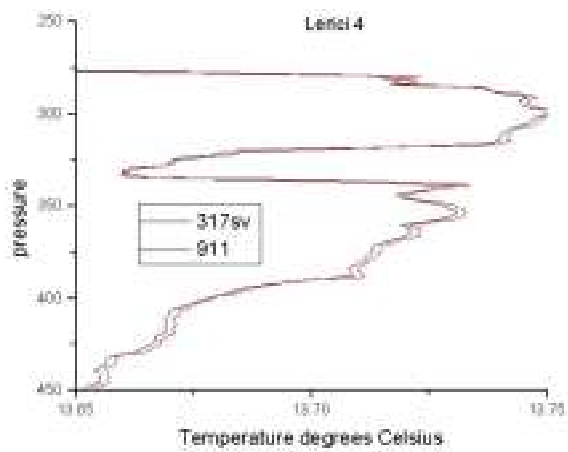

Figure 8 Temperature comparison Lerici #4

There is a small offset between the two temperatures of the order of 0.006 degrees, it appears to be uniform over the pressure range that was measured. Figure 9 illustrates the difference between salinities as measured by the two instruments.

The salinity indicated by the 911, Figure 9, appears to be about .002 to .003 psu higher than that measured by the 317sv.

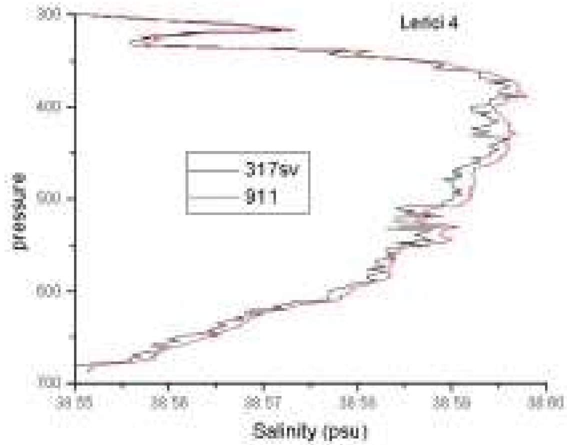

Figure 9 Salinity comparison Lerici #4

The calculated sound velocities, Figure 10, from both the 911 and the 317sv are indistinguishable from one another, and the value measured by the Merestechnik Elektronik probe differs only by a few tenths of

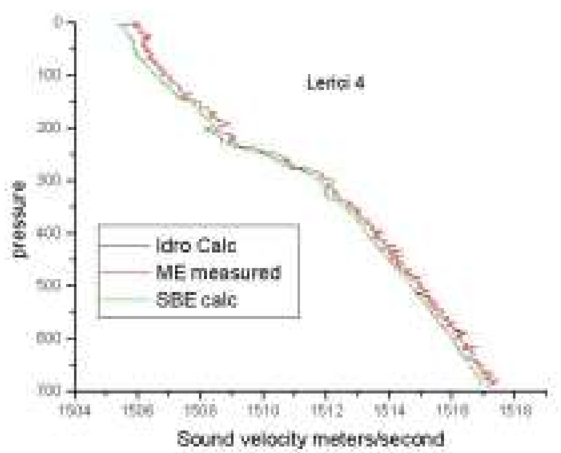

Figure 10 Sound velocity comparison

a meter per second from their common value. There is also a little more noise associated with the direct measured value.

V Field results from B/O Garcia del Cid

In May 1999 during a short cruise from Barcelona to the Blanes canyon we had a second opportunity to inter-compare Idronaut and other manufacturers CTDs. Figures 11, 12, 13 and 14 illustrate the results from this second cruise.

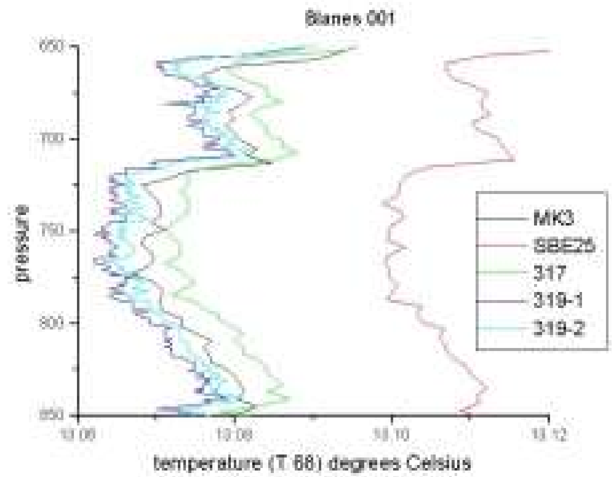

Figure 11 Temperature comparison Blanes #1

MKIIIC and Idronaut temperatures are grouped to the left of the graph with a total scatter of ± 0.005 degrees. The SBE 25 temperatures are offset by 35 milli degrees. The form of all of the profiles is however very similar except that the digitizer noise is noticeable in the 319 data.

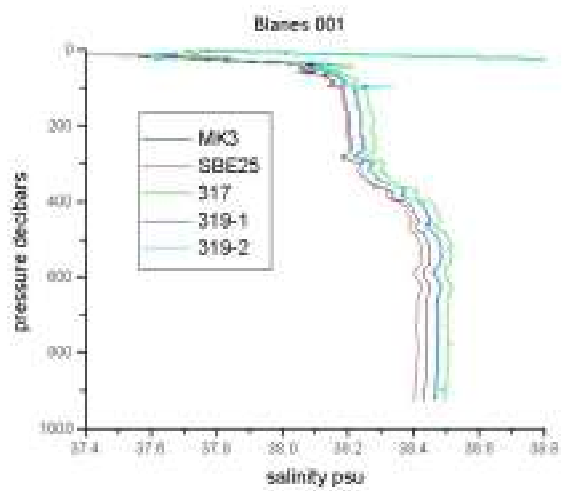

Figure 12 Salinity comparison Blanes #1

With the exception of the MKIIIC and SBE 25 all of the traces in Figure 12 are parallel with a fixed offset from top to bottom. Careful calibration against water bottles would make all of the profiles useful.

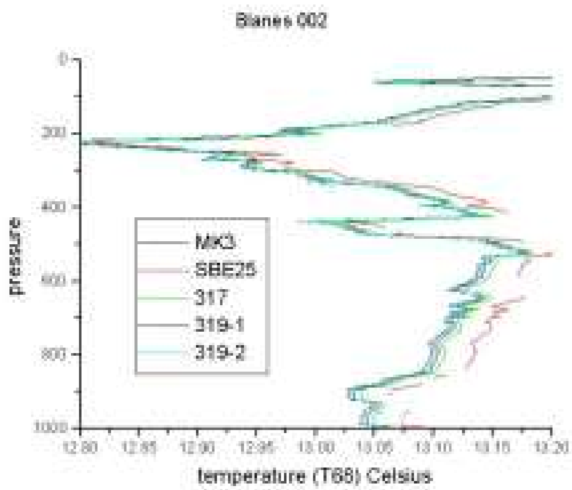

Figure 13 Temperature comparison Blanes #2

The curves from Figure 13 indicate that the SBE 25 temperature may have a significantly greater offset at depth than at the surface, this is probably the reason for the observed differences in the previous station's salinity offsets.

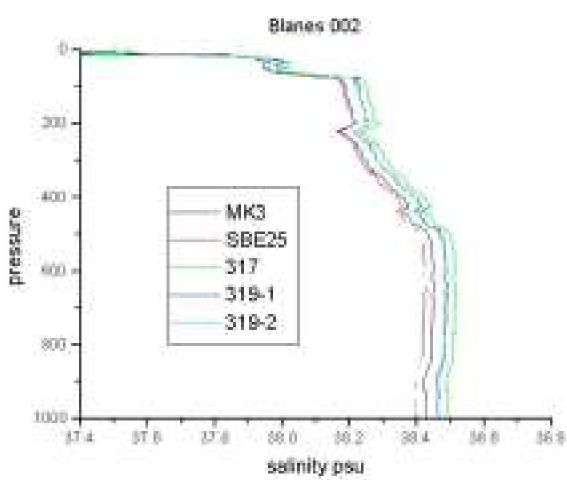

Figure 14 Salinity comparison Blanes #2

As in the first Blanes station the MKIIIC and SBE25 salinity signals appear to diverge with increasing depth the other traces are again parallel.

VI Conclusions

It is of course extremely unfortunate that one of the instruments that was to have been evaluated was inadvertently destroyed prior to producing any usable field data. It would have been very interesting to have inter-compared the new 24 bit Idronaut Mk 318 and the traditional MKIIIC and SBE 911.

The balance of the data collected has held few surprises. The 316 and 319 CTDs from Idronaut that are designed for environmental applications rather than oceanographic use have shown their limitation with digitizer noise at the 0.001 level. Their Pt100 thermometers and robust conductivity cells have certainly performed well providing correctable performance across the entire pressure field measured. It would be interesting to repeat the experiment with rigorous water sampling to compute both salinities and dissolved oxygen values. The MK317 sensors have compared favorably with the reference instruments in both of the field trials and also in the laboratory tests.

VII Acknowledgements

The authors are very pleased to acknowledge theOfficers and crew of both the R/V Alliance and the B/O Garcia del Cid without whose expertise and cooperation the project would not have been possible. We also would like to recognize Dr Jose Ignacio Diaz and Mr Mario Manriques of the Institut de Ciencias del Mar of Barcelona, Spain and their technical team onboard of the Garcia del Cid.

APPENDIX A

The following is copied verbatim from a SeaBird Electronics Inc. 911 plus manual, these instructions were followed carefully in processing the 911 data. [Capitalized names are programs that are run on the data as described.]

Standard processing of SBE 9/11 CTD Data

With oxygen

1. SEASAVE acquire the data at 24 hz.
2. DATCNV Convert the raw data to pressure, temperature, conductivity and parameters obtained from auxillary sensors such as dissolved oxygen current, dissolved oxygen temperature, and light transmission.
3. ALIGNCTD Advance oxygen 1 to 5 seconds relative to pressure
4. WILDEDIT check for and mark "wild" data points
5. CELLTM Conductivity cell thermal mass correction. Typical values are alpha = 0.03 and 1/beta = 7.0
6. FILTER Low pass filter pressure with a time constant of 0.15 seconds to increase pressure resolution for LOOPEDIT
7. LOOPEDIT Mark scans where the CTD is moving less than the minimum velocity or travelling backwards due to ship roll.
8. DERIVE Compute oxygen
9. BINAVG Average data into the desired pressure or depth bins
10. DERIVE Compute salinity, density, and other oceanographic parameters.