Joint European Research Infrastructure network for Coastal Observatories

ILC Evaluation report
Conductivity/Salinity
Temperature/Dissolved Oxygen

Annex to Deliverable D #1.6

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Involved Institutions: Ifremer
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1. Document description

REFERENCES

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The work that is described in this report is carried out by:

Ifremer

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The following members of the staff were involved:

F. Salvetat Head of the Metrology Laboratory

C. Le Bihan Deputy to the Head of the Metrology Laboratory

The work was carried out from the 8th to the 12th of October 2012.

Signature		**Approved**
F. Salvetat	G.Petihakis	P.Farcy
		
Date	Date	
13/06/2013	18/11/2013	

2. Introduction

Complemental to the first FCT workshop, the metrology laboratory of Ifremer Centre de Bretagne carried out a calibration experiment from the 8th to the 12th of October 2012. This experiment was promoted by the Jerico European project (JOINT EUROPEAN RESEARCH INFRASTRUCTURE NETWORK FOR COASTAL OBSERVATORIES), in the framework of a collaborative work proposed by the workpackage 4, “Maintenance and Calibration”, and the “Forum for Coastal Technologies”.

The purpose of this experiment was to compare the calibration methods used by different institutes or firms within an inter-laboratory comparison (ILC). In terms of metrology, this comparison will allow the laboratories to assess their performance with respect to the calibration of their sensors. The parameters under investigation were temperature, salinity (conductivity) and dissolved oxygen.

To simplify the process and to shorten the time devoted to the comparison, Ifremer proposed to carry out for each participant, a bilateral comparison (Ifremer vs participant) on one or several sensors owned by the participant. All comparisons were simultaneous.

The objective (institutes performance) was achieved by comparing the calibration results of the regular calibration of the sensors of the participants with the reference calibrations performed by the coordinating laboratory, the metrology laboratory of Ifremer.

The evaluation of the performance was carried out using the reported deviations and/or corrections and corresponding uncertainties of the participants with respect to the measured deviations/corrections and corresponding uncertainties by the reference laboratory. From these values, we could calculate the normalized errors (En scores). En scores ≤ 1 are satisfactory, whereas En >1 is rated unsatisfactory.

3. Main Report

Proposed protocol:

The proposed protocol for the reference calibration carried out at Ifremer with the participants is the following:

Date	Sensors	Description
Monday afternoon	All probes	- Installation of probes in the conductivity/temperature bath - Visit of metrology laboratory and nutrients laboratory
Tuesday morning	Conductivity/Salinity/Temperature	Calibration at salinity 35 and temperature 5°C
Tuesday afternoon	Conductivity/Salinity/Temperature	Calibration at salinity 35 and temperature 15°C
Wednesday morning	Conductivity/Salinity/Temperature	Calibration at salinity 10 and temperature 15°C
Wednesday afternoon	Conductivity/Salinity/Temperature	- Calibration at salinity 17 and temperature 15°C - Installation of probes in the oxygen bench
Thursday morning	Dissolved Oxygen/Temperature	Calibration at O2: 100% (air equilibrium or nitrogen/oxygen bubbling) and temperature 20°C (salinity: 0)
Thursday afternoon	Dissolved Oxygen/Temperature	Calibration at O2: 100% (air equilibrium or nitrogen/oxygen bubbling) and temperature 10°C (salinity: 0)
Friday morning	Dissolved Oxygen/Temperature	Calibration at O2: 50% (nitrogen/oxygen bubbling) and temperature 20°C or 10°C (salinity: 0)

Modification of the protocol:

After discussion with the participants, the schedule was modified as follows (modifications in blue):

Date	Sensors	Description
Monday afternoon	All probes	- Installation of probes in the conductivity/temperature bath - Visit of metrology laboratory and nutrients laboratory
Tuesday morning	Conductivity/Salinity/Temperature	Calibration at salinity 35 and temperature 5°C
Tuesday afternoon	Conductivity/Salinity/Temperature	Calibration at salinity 35 and temperature 15°C
Wednesday morning	Conductivity/Salinity/Temperature	Calibration at salinity 17 and temperature 15°C
Wednesday afternoon	Conductivity/Salinity/Temperature	- Calibration at salinity 10 and temperature 20°C - Installation of probes in the oxygen bench
Thursday morning	Dissolved Oxygen/Temperature	Calibration at O2: 100% (air equilibrium or nitrogen/oxygen bubbling) and temperature 20°C (salinity: 0)
Thursday afternoon		Calibration at O2: 50% (nitrogen/oxygen bubbling) and temperature 20°C (salinity: 0)
Friday morning		Calibration at O2: 100% (air equilibrium or nitrogen/oxygen bubbling) and temperature 10°C (salinity: 0)

All measurements were performed at Ifremer metrology laboratory. The measures were collected jointly by the participants and the coordinating laboratory, except for the measures of the CNR-ISMAR that needed post processing from Elio Paschini.

The participants were asked to give the coordinating laboratory the results of the regular calibration of the sensors in order to calculate the En scores.

Operating procedure:

The conductivity/temperature operating procedure and the devices used are described in the annex A. The dissolved oxygen operating procedure and the devices used are described in the annex B.

4. Stability testing

Due to the ILC protocol (sensors owned by the participants), no stability testing were performed on the sensors.

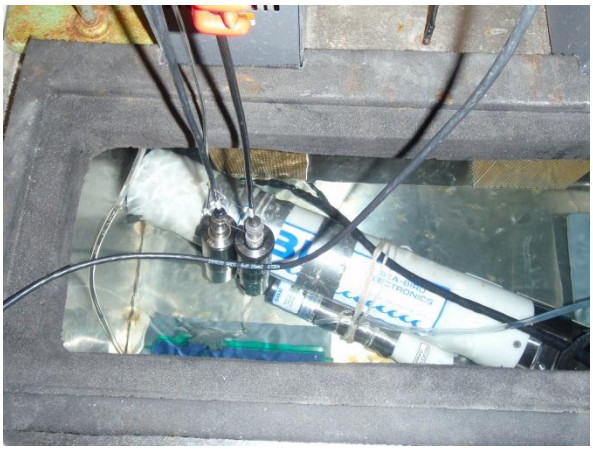
5. Participants and sensors

The 4 participating laboratories are:

- HCMR (Greece): Tanya Tsagaraki, Manolis Ntoumas and George Petihakis
  Sbe37-SIP CT sensor and Aandera 3830 DO optode
- CNR-ISMAR (Italy): Stefania Sparnocchia and Elio Paschini
  Sbe19 plus CTD sensor and Sbe43 DO sensor
- AZTI Tecnalia (Spain): Carlos Hernandez
  Sbe37-SMP CTD sensor
- NIVA (Norvège): Emanuele Reggiani
  Aandera 3830 DO optode

The participants

Conductivity and temperature ILC



Dissolved oxygen ILC

6. Results

6.1. Introduction

All participating laboratories have attended the reference calibration at Ifremer.

However, not all participants submitted their results with complete information:

- CNR-ISMAR did not send the results of the first level of temperature and conductivity (which needed post processing) and did not produce the results of the regular calibration of their sensor.
- NIVA did not produce the results of the regular calibration of their sensor.

6.2. Evaluation of the participant's results

The results of the participants should have been evaluated by means of:

- trueness errors,
- En scores

$$(E_n = \left| \frac{Trueness\ measured\ by\ participant - Trueness\ measured\ by\ coordinating\ lab}{\sqrt{((trueness\ uncertainty\ measured\ by\ participant)^2 + (trueness\ uncertainty\ measured\ by\ coordinating\ lab)^2)}} \right|)$$

However, as the participants displayed manufacturer calibrations without evaluation of the uncertainties of the calibration, it was impossible to calculate the En scores. When possible, we thus proposed an interpretation of the results based on the comparison of the trueness of the calibration.

Temperature and conductivity/salinity ILC

Trueness errors: (see annex C for a better view of the results)

AZTI Results:

Seabird SBE37SMP s/n 37SMP62077-8279 (AZTI)

Beginning :	09/10/2012
Temperature / conductivity sensor depth (cm):	29
Reference platinum resistance thermometer depth (cm):	35

Temperature				Salinity				Conductivity			
Reference	Sensor		Correction	Reference	Sensor		Correction	Reference	Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation			$Salinity_{read}$	Standard deviation		Mean	Mean $Cond_{read}$	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	(5)	(6)		(5-6)	(3) mS/cm	(4) mS/cm	mS/cm	(3-4) mS/cm
5.343	5.344	0.001	-0.001	35.262	35.253	0.001	0.009	33.995	33.987	0.000	0.007
15.367	15.368	0.001	-0.001	35.262	35.251	0.000	0.011	43.569	43.557	0.002	0.011
15.261	15.262	0.001	-0.001	17.177	17.170	0.000	0.007	22.668	22.660	0.001	0.008
20.270	20.271	0.000	-0.001	10.479	10.475	0.000	0.004	16.108	16.102	0.000	0.006

Calculated data

HCMR Results:

Seabird SBE37SIP s/n 37SIP63955-8310 (HCMR)

Beginning :	09/10/2012
Temperature / conductivity sensor depth (cm):	16
Reference platinum resistance thermometer depth (cm):	35

Temperature				Salinity				Conductivity			
Reference	Sensor		Correction	Reference	Sensor		Correction	Reference	Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation			$Salinity_{read}$	Standard deviation		Mean	Mean $Cond_{read}$	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	(5)	(6)		(5-6)	(3) mS/cm	(4) mS/cm	mS/cm	(3-4) mS/cm
5.343	5.347	0.001	-0.004	35.262	35.255	0.001	0.007	33.995	33.992	0.000	0.002
15.367	15.371	0.001	-0.004	35.262	35.256	0.001	0.006	43.569	43.565	0.001	0.004
15.261	15.264	0.001	-0.003	17.177	17.175	0.000	0.002	22.668	22.667	0.000	0.000
20.270	20.272	0.000	-0.002	10.479	10.479	0.000	0.000	16.108	16.108	0.000	-0.001

Calculated data

CNR Results:

Seabird SBE19plus 600m s/n 19P26248-4068 with Sbe39 s/n 1012 (CNR)

Beginning :	09/10/2012
Temperature / conductivity sensor depth (cm):	23
Reference platinum resistance thermometer depth (cm):	35

Temperature				Salinity				Conductivity			
Reference	Sensor		Correction	Reference	Sensor		Correction	Reference	Sensor		Correction
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	(1-2) °C	(5)	$Salinity_{read}$ (6)	Standard deviation	(5-6)	Mean (3) mS/cm	Mean $Cond_{read}$ (4) mS/cm	Standard deviation mS/cm	(3-4) mS/cm
5.343	-	-	-	35.262	-	-	-	33.995	-	-	-
15.367	15.369	0.001	-0.002	35.262	35.244	0.001	0.018	43.569	43.551	0.001	0.018
15.261	15.260	0.001	0.001	17.177	17.169	0.000	0.008	22.668	22.657	0.000	0.011
20.270	20.269	0.001	0.002	10.479	10.477	0.000	0.002	16.108	16.105	0.000	0.003

Calculated data

Comments:

Trueness comparison:

AZTI Results:

Seabird SBE37SMP s/n 37SMP62077-8279 (AZTI)

Temperature								
Ifremer calibration (10/2012)				Seabird calibration (12/2010)				
Reference	Sensor		Correction	Reference	Sensor		Correction	Correction deviation
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	(A) (1-2) °C	Mean t_{90} (3) °C	Mean t_{read} (4) °C	Standard deviation °C	(B) (3-4) °C	in temperature (A-B) °C
5.343	5.344	0.001	-0.001	4.5000	4.4999	-	0.0001	-0.0013
15.367	15.368	0.001	-0.001	15.0000	15.0001	-	-0.0001	-0.0010
20.270	20.271	0.000	-0.001	18.5000	18.5000	-	0.0000	-0.0012
-	-	-	-	23.9999	23.9999	-	0.0000	-

Calculated data

Conductivity								
Ifremer calibration (10/2012)				Seabird calibration (12/2010)				
Reference	Sensor		Correction	Reference	Sensor		Correction	Correction deviation
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	(A) (1-2) °C	Mean t_{90} (3) °C	Mean t_{read} (4) °C	Standard deviation °C	(B) (3-4) °C	in temperature (A-B) °C
33.995	33.987	0.000	0.007	32.6672	32.6673	-	-0.0001	0.0072
43.569	43.557	0.002	0.011	42.4366	42.4365	-	0.0001	0.0113
-	-	-	-	45.8710	45.8710	-	-	-
22.668	22.660	0.001	0.008	29.6117	29.6116	-	0.0001	0.0076
16.108	16.102	0.000	0.006	-	-	-	-	-

Calculated data

We can see a good agreement of the sensors in terms of temperature.

In conductivity, there is a discrepancy probably due to a drift on the conductivity sensor. However, this discrepancy is not surprising seeing the 2 years elapsed between the two calibrations.

HCMR Results:

Seabird SBE37SIP s/n 37SIP63955-8310 (HCMR)

Temperature								
Ifremer calibration (10/2012)				Seabird calibration (04/2011)				
Reference	Sensor		Correction	Reference	Sensor		Correction	Correction deviation
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	A (1-2) °C	Mean t_{90} (3) °C	Mean t_{read} (4) °C	Standard deviation °C	B (3-4) °C	in temperature (A-B) °C
5.343	5.347	0.001	-0.004	4.5000	4.5002	-	-0.0002	-0.0039
15.367	15.371	0.001	-0.004	15.0000	15.0000	-	0.0000	-0.0035
20.270	20.272	0.000	-0.002	18.5000	18.4999	-	0.0001	-0.0023
-	-	-	-	23.9999	24.0000	-	-0.0001	-

Calculated data

Conductivity								
Ifremer calibration (10/2012)				Seabird calibration (04/2011)				
Reference	Sensor		Correction	Reference	Sensor		Correction	Correction deviation
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	A (1-2) °C	Mean t_{90} (3) °C	Mean t_{read} (4) °C	Standard deviation °C	B (3-4) °C	in temperature (A-B) °C
33.995	33.992	0.000	0.002	32.7496	32.7496	-	0.0000	0.0023
43.569	43.565	0.001	0.004	42.5424	42.5424	-	0.0000	0.0039
-	-	-	-	45.9854	45.9855	-	-	-
22.668	22.667	0.000	0.000	29.6866	29.6866	-	0.0000	0.0004
16.108	16.108	0.000	-0.001	-		-	-	-

Calculated data

We can see a good agreement of the sensors in term of temperature.

In conductivity, there is a discrepancy probably due to a drift on the conductivity sensor. However, this discrepancy is not surprising seeing the 2 years elapsed between the two calibrations.

CNR Results:

As the CNR didn't provide any previous calibration results, t is not possible to make any comparison. However, we can see that the temperature sensor has a small trueness error.

Dissolved oxygen ILC

Trueness errors: (see annex D for a better view of the results)

HCMR Results:

Aanderaa optode 3975A s/n 1428 (HCMR)

Beginning : 11/10/2012

Temperature				Oxygen					
Reference	Sensor		Correction	Reference			Sensor		Correction
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	(1-2) °C	Nominal saturation %	Mean (3) µmol/l	Standard deviation µmol/l	Mean (4) µmol/l	Standard deviation µmol/l	(3-4) µmol/l
10.00	10.00	0.00	0.00	100	340.24	0.35	319.15	0.70	21.09
20.01	20.01	0.00	0.00	100	271.50	1.22	249.52	0.42	21.98
20.01	20.01	0.00	0.00	50	155.42	3.39	136.99	0.19	18.43

Calculated data

NIVA Results:

Aanderaa optode 3975A s/n 1125 (NIVA)

Beginning : 11/10/2012

Temperature				Oxygen					
Reference	Sensor		Correction	Reference			Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation		Nominal saturation	Mean	Standard deviation	Mean	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	%	(3) µmol/l	µmol/l	(4) µmol/l	µmol/l	(3-4) µmol/l
10.00	10.00	0.00	0.00	100	340.24	0.35	346.09	0.22	-5.85
20.01	20.01	0.00	0.00	100	271.50	1.22	284.16	0.23	-12.66
20.01	20.01	0.00	0.00	50	155.42	3.39	151.59	0.20	3.83

Calculated data

CNR Results:

Seabird Sbe43 7000m s/n 430065 with Sbe39 pump s/n 1012 (CNR)

Beginning : 11/10/2012

Temperature				Oxygen					
Reference	Sensor		Correction	Reference			Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation		Nominal saturation	Mean	Standard deviation	Mean	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	%	(3) µmol/l	µmol/l	(4) µmol/l	µmol/l	(3-4) µmol/l
10.00	10.0003	0.0005	0.00	100	340.24	0.35	335.96	0.88	4.28
20.01	20.0016	0.0005	0.01	100	271.50	1.22	245.74	2.79	25.76
20.01	20.0016	0.0006	0.01	50	155.42	3.39	156.22	0.57	-0.80

Calculated data

Trueness comparison:

HCMR Results:

The regular calibration was carried out by the manufacturer Aanderaa in July 2011. However the calibration certificate of the manufacturer only displays phase readings and coefficients. As the concentrations of dissolved oxygen are not indicated, it is not possible to proceed to the comparison (no post processing function is indicated in the certificate and, due to the high risk of error, no post processing of the data can be done by the coordinating laboratory with the information given in the certificate).

NIVA Results:

The NIVA did not produce the results of the regular calibration of their sensor.

CNR Results:

The CNR did not produce the results of the regular calibration of their sensor.

7. Conclusions

This experiment took place in a friendly atmosphere: it gave all participants the opportunity to exchange on the way sensors are calibrated in the institutes. All participants promoted transparency on their knowledge, their experience and their know how.

The experiment enabled the participants to calibrate their sensors at several temperatures, salinities and dissolved oxygen concentrations. The analysis of the results showed the sensors that were exempt of trueness errors. But for the sensors with errors, it was difficult to propose any hypothesis because of the lack of information on the sensor.

Finally, this first experiment did not fulfill the final objective which was to compare different methods of calibration. It underlined the obligation to have beforehand all the information needed to achieve the goal fixed. However, it has to be kept in mind that inter-laboratory comparisons must be performed several times to be fully efficient.

Annexes and References

Annex A: Conductivity/Temperature Operating procedure

Testing Facilities

Temperature regulated bath

Temperature regulated water bath (id. yellow bath) with mixed water to reduce temperature differences:
Effective capacity: 1500 × 650 × 600 mm.
Regulation range: - 1.5°C to + 40°C.
Salinity can be changed from fresh water to seawater.

Reference temperature measurement

- Platinum resistance thermometer ROSEMOUNT 162 CE s/n 5011 (id. R8).
- DC resistance bridge GUILDLINE 9975 s/n 39067 (id. Ifremer).
- Standard resistor 10 Ω GUILDLINE 9330 s/n 38541.
- Liquid thermometer ASTM 90C s/n 2826.

The platinum resistance thermometer is regularly calibrated by the L.N.E (Laboratoire National de métrologie et d'Essais) at three fixed points of the ITS 90: the triple point of mercury, the triple point of water and the freezing point of indium.

The estimated expanded uncertainty of the reference temperature is U = ± 0.04°C.

The expanded uncertainties indicated are equal to twice the combined standard uncertainty.

Reference salinity calculation

GUILDLINE Autosal 8400 laboratory salinometer (Set temperature: 21°C).

The salinometer is calibrated with:

- standard seawater bottle IAPSO P148 – 10 October 2006 - K15 = 0,99982 - S = 34,993;
- standard seawater bottle IAPSO 10L9 - 22 July 2004 - S = 10,025.

Salinity is calculated using the conductivity ratio measured by the salinometer and the equations recommended by UNESCO in "The Practical Salinity Scale 1978".

The estimated expanded uncertainty of the reference salinity is U = ± 1.10-2.

Reference conductivity calculation

Conductivity is calculated using the reference salinity calculation, the sensor immersion, the reference temperature measurement of the bath and the iterative equation recommended by UNESCO in 1980 with C35, 15, 0 = 42,914 mS/cm.

The estimated expanded uncertainty of the reference conductivity is U = ± 0,01 mS/cm.

Calibrated sensor interface

- PC + "Seasave" software.
- Measurement frequency: 1 measure / 15 seconds.
- Measurement period: 20 minutes.

Measurement Procedure

The instrument is completely immersed in the temperature regulated bath. It is distant from the sides of the bath to prevent any effects on measurements. The protection grid of the instrument is in place.

The immersions of the sensors are indicated with the calibration results.
The sensors of the instrument are near the reference platinum resistance thermometer. The immersion of the platinum resistance thermometer is indicated with the calibration results.

During calibration, we carry out measurements before and after removing bubbles from the sensors (shaking them) to check the potential influence of bubbles on sensors.

The laboratory staff carry out the configuration of the instrument, the recovery and the post processing of the measurement.

The instrument is always powered on.

For each temperature, we sample 3 bottles of water. Their salinity is measured by the salinometer when their temperature is around the laboratory temperature.

During measurements, the stability of the bath is better than ± 0.001°C and its drift does not exceed ± 0.002°C.

The laboratory temperature during experiment is 20.0°C ± 2.0°C.

Annex B: Dissolved oxygen Operating procedure

Testing Facilities

Temperature regulated bath

Temperature regulated water bath HART 7015 no. A8C100 with mixed water to reduce temperature differences:
Effective capacity: 700 × 280 × 300 mm.
Regulation range: - 1.5°C to + 40°C.
Salinity can be changed from fresh water to seawater.

Reference temperature measurement

- Thermometer AOIP PN5207P s/n 59069 1 D5 (id 1) and its probe AOIP AN5847 s/n A42 (id $S_{1.1}$).

The platinum resistance thermometer is regularly calibrated by Ifremer.

The estimated expanded uncertainty of the reference temperature is U = ± 0.04°C.

The expanded uncertainties indicated are equal to twice the combined standard uncertainty.

Reference dissolved oxygen measurement

- Sampling bottles which volume has been measured in April 2012.
- METROHM Titrino Plus 848 automatic titrator filled with a 0.02N thiosulfate solution.
- Winkler Reagents as described in the book « Hydrologie des écosystèmes marins, paramètres et analyses » from Alain Aminot and Roger Kérouel.

Calibrated sensor interface

- PC + "Hyper Terminal" software.
- Measurement frequency: 1 measure / 15 seconds.
- Measurement period: 20 minutes.

Measurement Procedure

The instrument is completely immersed in the temperature regulated bath.

The sensor of the instrument is near the reference platinum resistance thermometer.

Bath water is sampled in three bottles and then analysed following the Winkler method described in the book « Hydrologie des écosystèmes marins, paramètres et analyses » by Alain Aminot and Roger Kérouel.

An estimation of the concentration of the sodium thiosulfate is performed before the analysis of the samples.

The laboratory staff carry out the configuration of the instrument, the recovery and the post processing of the measurement.

The instrument is constantly powered on.

During measurements, the stability and the drift of the bath are better than ± 0.001°C.

The laboratory temperature during experiment is 20.0°C ± 2.0°C.

Annex C: Temperature and conductivity/salinity calibration results

AZTI Results:

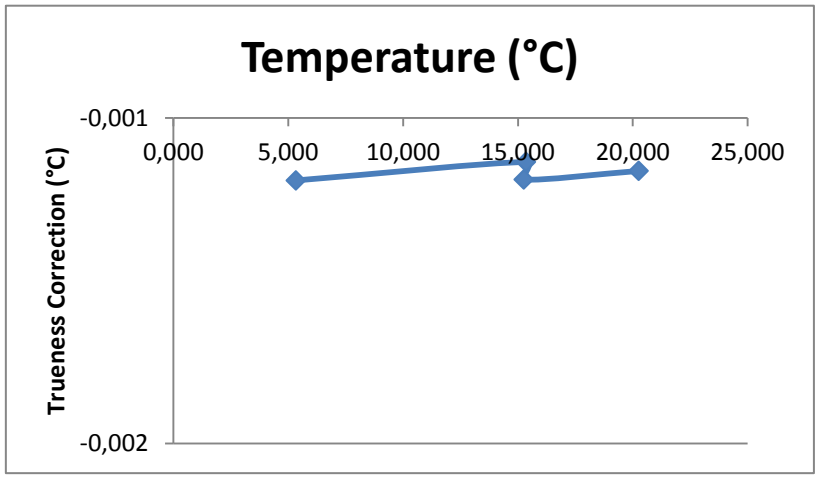
Seabird SBE37SMP s/n 37SMP62077-8279 (AZTI)

Beginning :	09/10/2012
Temperature / conductivity sensor depth (cm):	29
Reference platinum resistance thermometer depth (cm):	35

Temperature				**Salinity**				**Conductivity**			
Reference	Sensor		Correction	Reference	Sensor		Correction	Reference	Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation			$Salinity_{read}$	Standard deviation		Mean	Mean $Cond_{read}$	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	(5)	(6)		(5-6)	(3) mS/cm	(4) mS/cm	mS/cm	(3-4) mS/cm
5.343	5.344	0.001	-0.001	35.262	35.253	0.001	0.009	33.995	33.987	0.000	0.007
15.367	15.368	0.001	-0.001	35.262	35.251	0.000	0.011	43.569	43.557	0.002	0.011
15.261	15.262	0.001	-0.001	17.177	17.170	0.000	0.007	22.668	22.660	0.001	0.008
20.270	20.271	0.000	-0.001	10.479	10.475	0.000	0.004	16.108	16.102	0.000	0.006

Calculated data

Comments: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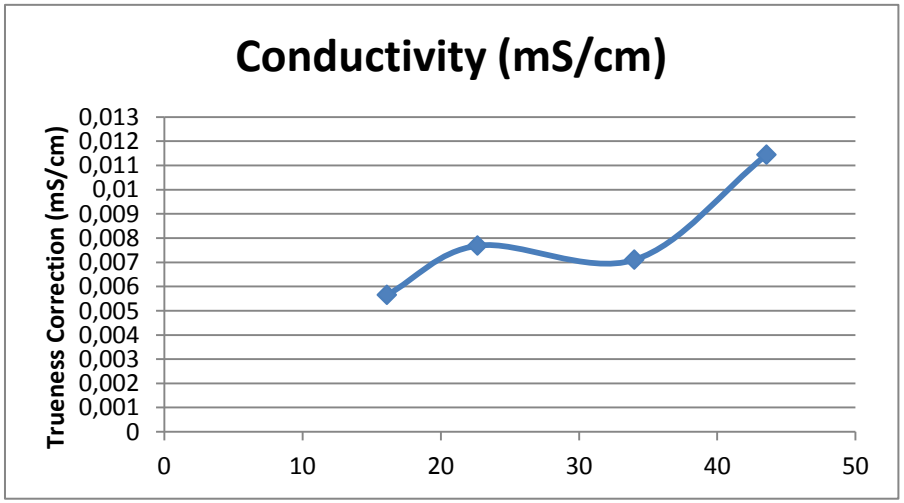
10,000
15,000
20,000
25,000


Conductivity (mS/cm)
Trueness Correction (mS/cm)
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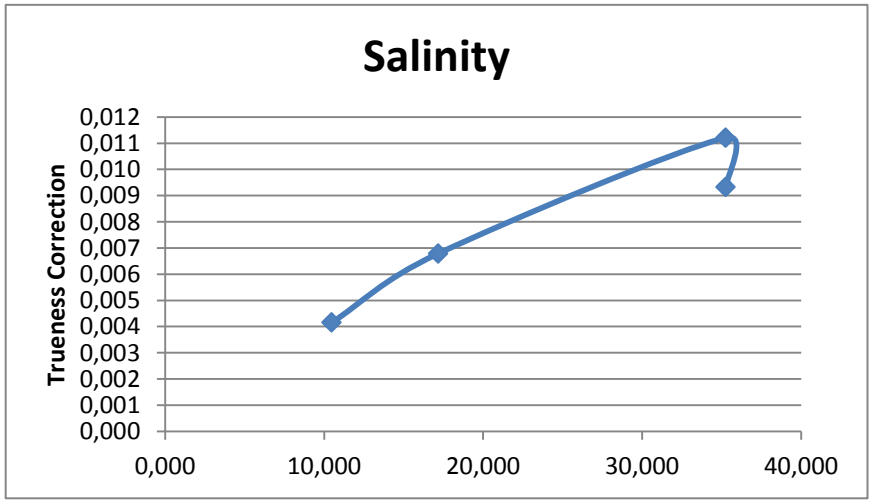
0,012
0,011
0,01
0,009
0,008
0,007
0,006
0,005
0,004
0,003
0,002
0,001
0
0
10
20
30
40
50


Salinity
Trueness Correction
0,012
0,011
0,010
0,009
0,008
0,007
0,006
0,005
0,004
0,003
0,002
0,001
0,000
0,000
10,000
20,000
30,000
40,000

HCMR Results:

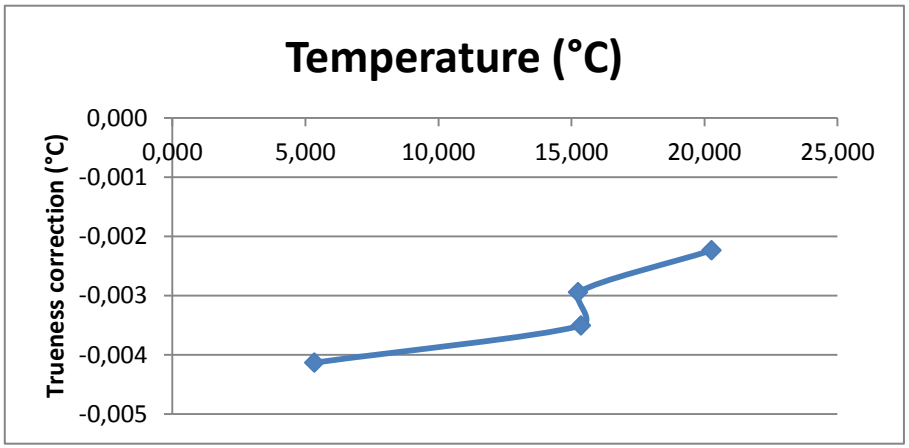
Seabird SBE37SIP s/n 37SIP63955-8310 (HCMR)

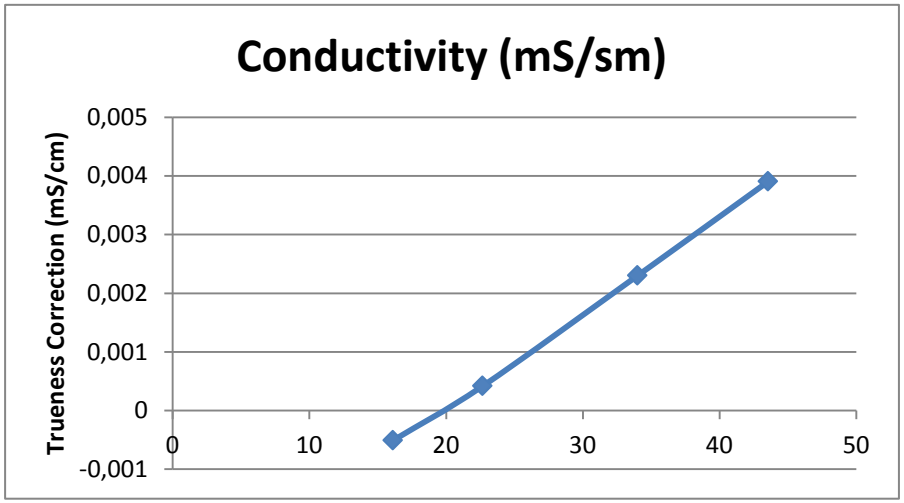
Beginning :	09/10/2012
Temperature / conductivity sensor depth (cm):	16
Reference platinum resistance thermometer depth (cm):	35

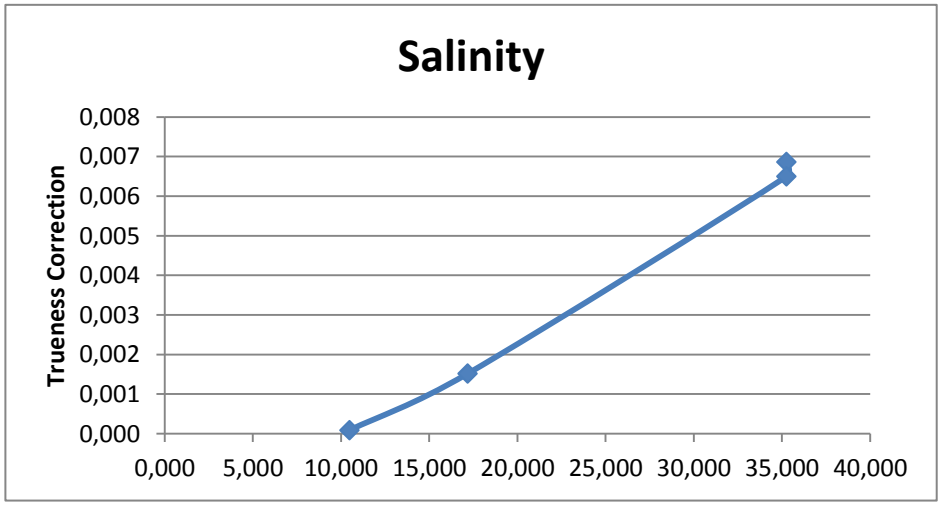
Temperature				**Salinity**				**Conductivity**			
Reference	Sensor		Correction	Reference	Sensor		Correction	Reference	Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation			$Salinity_{read}$	Standard deviation		Mean	Mean $Cond_{read}$	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	(5)	(6)		(5-6)	(3) mS/cm	(4) mS/cm	mS/cm	(3-4) mS/cm
5.343	5.347	0.001	-0.004	35.262	35.255	0.001	0.007	33.995	33.992	0.000	0.002
15.367	15.371	0.001	-0.004	35.262	35.256	0.001	0.006	43.569	43.565	0.001	0.004
15.261	15.264	0.001	-0.003	17.177	17.175	0.000	0.002	22.668	22.667	0.000	0.000
20.270	20.272	0.000	-0.002	10.479	10.479	0.000	0.000	16.108	16.108	0.000	-0.001

Calculated data

Comments:


Temperature (°C)
Trueness correction (°C)
0,000
-0,001
-0,002
-0,003
-0,004
-0,005
0,000
5,000
10,000
15,000
20,000
25,000


Conductivity (mS/sm)
Trueness Correction (mS/cm)
0,005
0,004
0,003
0,002
0,001
0
-0,001
0
10
20
30
40
50


Salinity
Trueness Correction
0,008
0,007
0,006
0,005
0,004
0,003
0,002
0,001
0,000
0,000
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000

CNR Results:

Seabird SBE19plus 600m s/n 19P26248-4068 with Sbe39 s/n 1012 (CNR)

Beginning :	09/10/2012

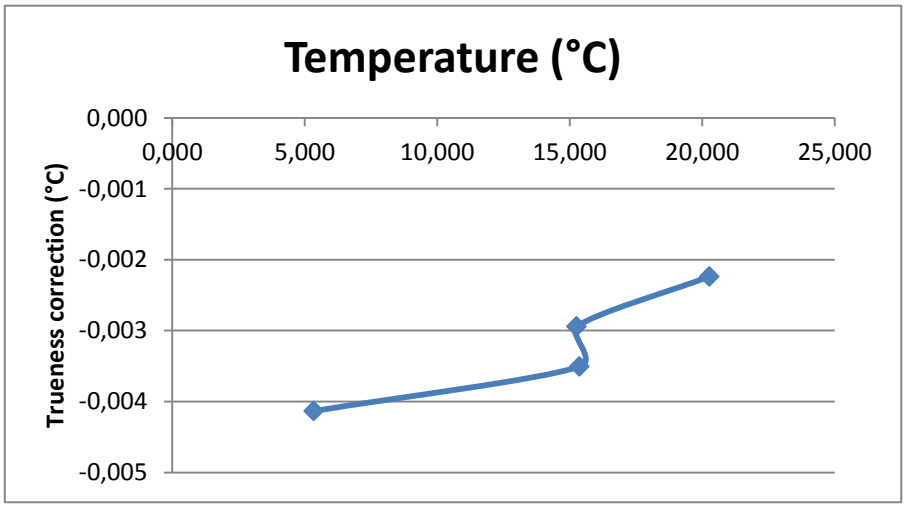
Temperature / conductivity sensor depth (cm):	23

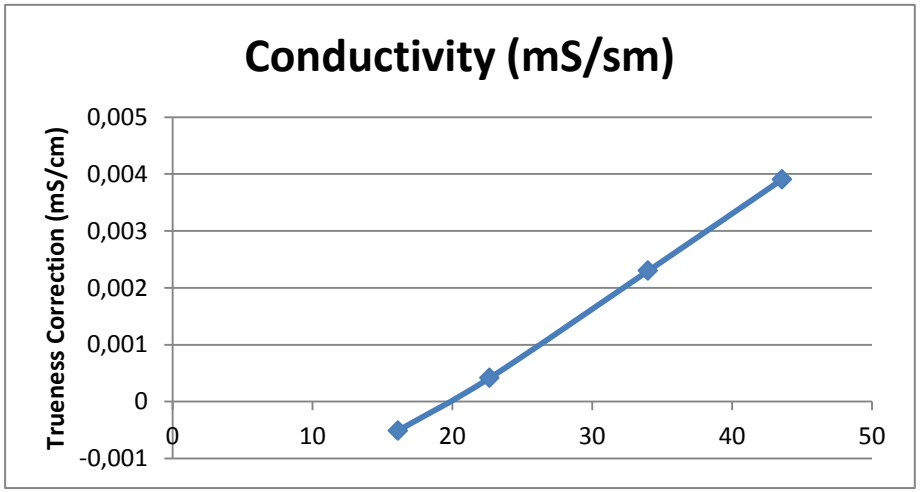
Reference platinum resistance thermometer depth (cm):	35

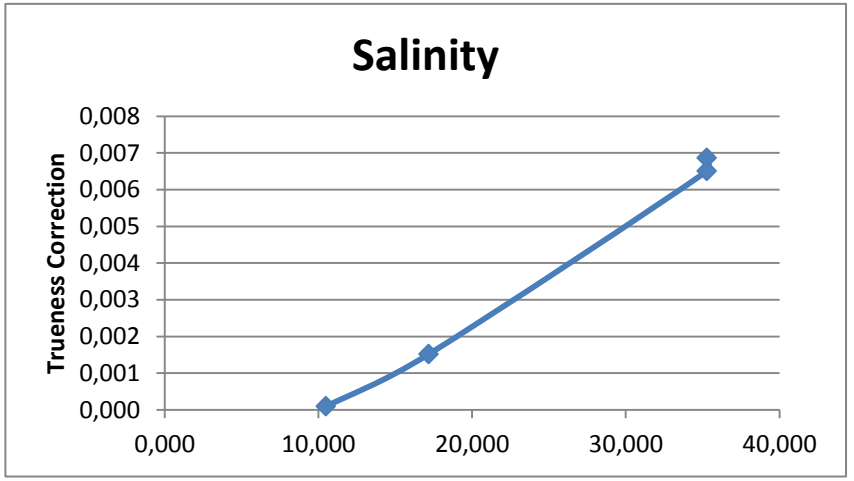
Temperature				**Salinity**				**Conductivity**			
Reference	Sensor		Correction	Reference	Sensor		Correction	Reference	Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation			$Salinity_{read}$	Standard deviation		Mean	Mean $Cond_{read}$	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	(5)	(6)		(5-6)	(3) mS/cm	(4) mS/cm	mS/cm	(3-4) mS/cm
5.343	-	-	-	35.262	-	-	-	33.995	-	-	-
15.367	15.369	0.001	-0.002	35.262	35.244	0.001	0.018	43.569	43.551	0.001	0.018
15.261	15.260	0.001	0.001	17.177	17.169	0.000	0.008	22.668	22.657	0.000	0.011
20.270	20.269	0.001	0.002	10.479	10.477	0.000	0.002	16.108	16.105	0.000	0.003

Calculated data

Comments:


Temperature (°C)
Trueness correction (°C)
0,000
-0,001
-0,002
-0,003
-0,004
-0,005
0,000
5,000
10,000
15,000
20,000
25,000


Conductivity (mS/sm)
Trueness Correction (mS/cm)
0,005
0,004
0,003
0,002
0,001
0
-0,001
0
10
20
30
40
50


Salinity
Trueness Correction
0,008
0,007
0,006
0,005
0,004
0,003
0,002
0,001
0,000
0,000
10,000
20,000
30,000
40,000

Annex D: Dissolved Oxygen calibration results

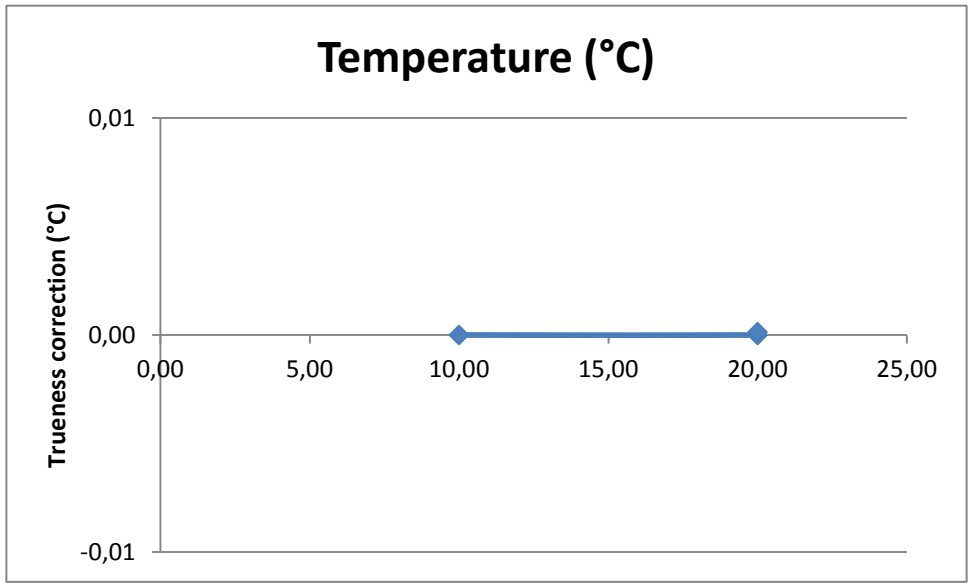
HCMR Results:

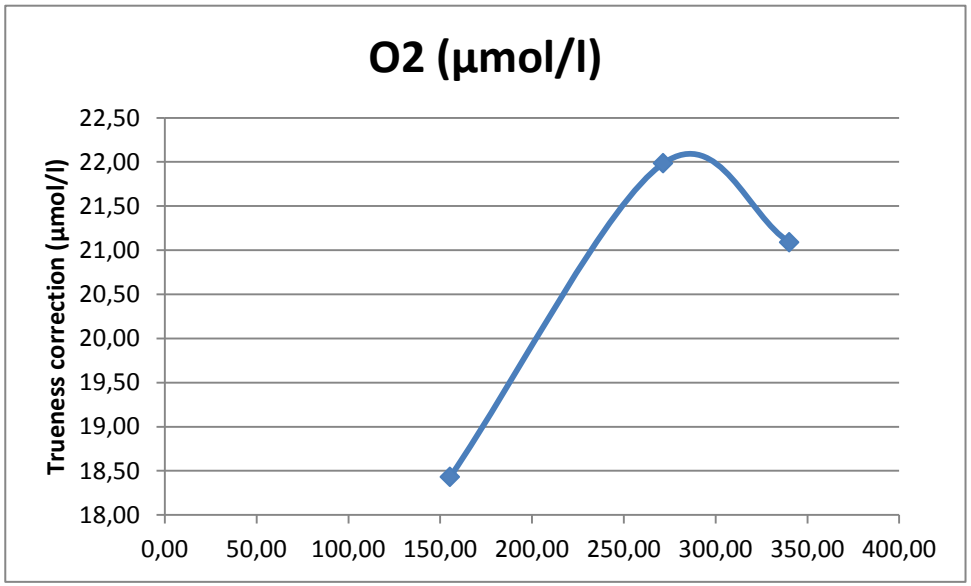
Aanderaa optode 3975A s/n 1428 (HCMR)

Beginning :	11/10/2012

Temperature				**Oxygen**					
Reference	Sensor		Correction	Reference			Sensor		Correction
Mean t_{90}	Mean t_{read}	Standard deviation		Nominal saturation	Mean	Standard deviation	Mean	Standard deviation	
(1) °C	(2) °C	°C	(1-2) °C	%	(3) µmol/l	µmol/l	(4) µmol/l	µmol/l	(3-4) µmol/l
10.00	10.00	0.00	0.00	100	340.24	0.35	319.15	0.70	21.09
20.01	20.01	0.00	0.00	100	271.50	1.22	249.52	0.42	21.98
20.01	20.01	0.00	0.00	50	155.42	3.39	136.99	0.19	18.43

Calculated data


Temperature (°C)
Trueness correction (°C)
0,01
0,00
-0,01
0,00
5,00
10,00
15,00
20,00
25,00


O2 (µmol/l)
Trueness correction (µmol/l)
22,50
22,00
21,50
21,00
20,50
20,00
19,50
19,00
18,50
18,00
0,00
50,00
100,00
150,00
200,00
250,00
300,00
350,00
400,00

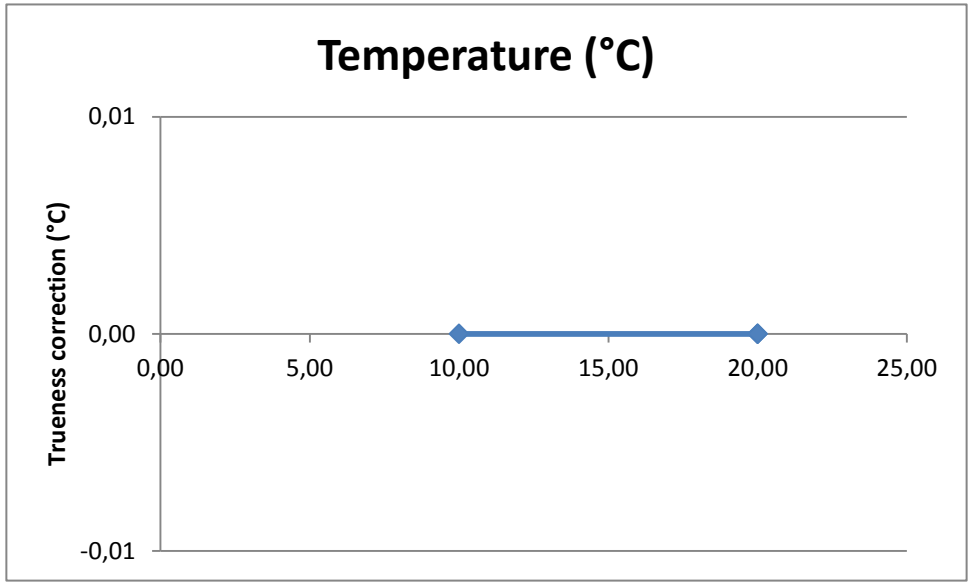
NIVA Results:

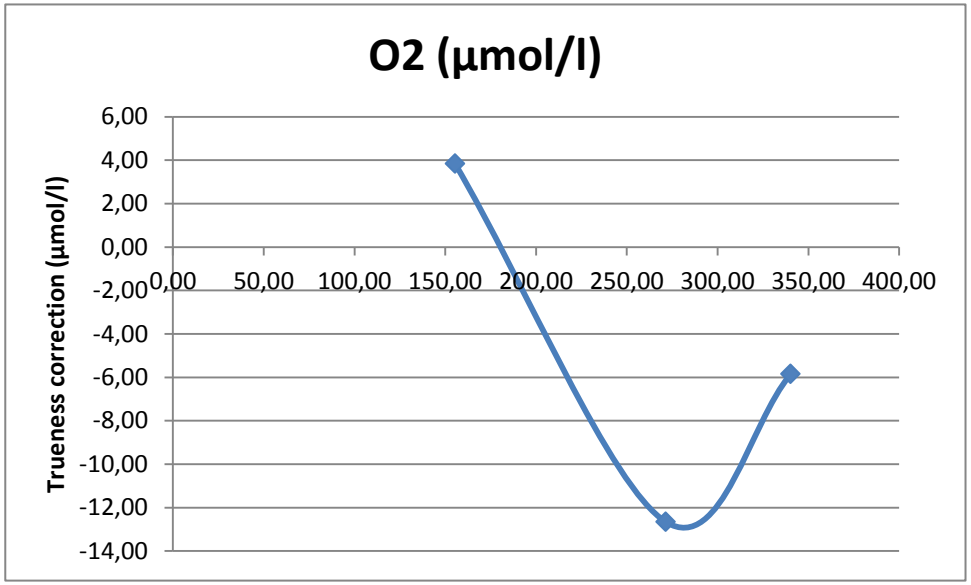
Aanderaa optode 3975A s/n 1125 (NIVA)

Beginning :	11/10/2012

Temperature				**Oxygen**					
Reference	Sensor		Correction		Reference		Sensor		Correction
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	(1-2) °C	Nominal saturation %	Mean (3) µmol/l	Standard deviation µmol/l	Mean (4) µmol/l	Standard deviation µmol/l	(3-4) µmol/l
10.00	10.00	0.00	0.00	100	340.24	0.35	346.09	0.22	-5.85
20.01	20.01	0.00	0.00	100	271.50	1.22	284.16	0.23	-12.66
20.01	20.01	0.00	0.00	50	155.42	3.39	151.59	0.20	3.83

Calculated data


Temperature (°C)
Trueness correction (°C)
0,01
0,00
-0,01
0,00
5,00
10,00
15,00
20,00
25,00


O2 (µmol/l)
Trueness correction (µmol/l)
6,00
4,00
2,00
0,00
-2,00
-4,00
-6,00
-8,00
-10,00
-12,00
-14,00
0,00
50,00
100,00
150,00
200,00
250,00
300,00
350,00
400,00

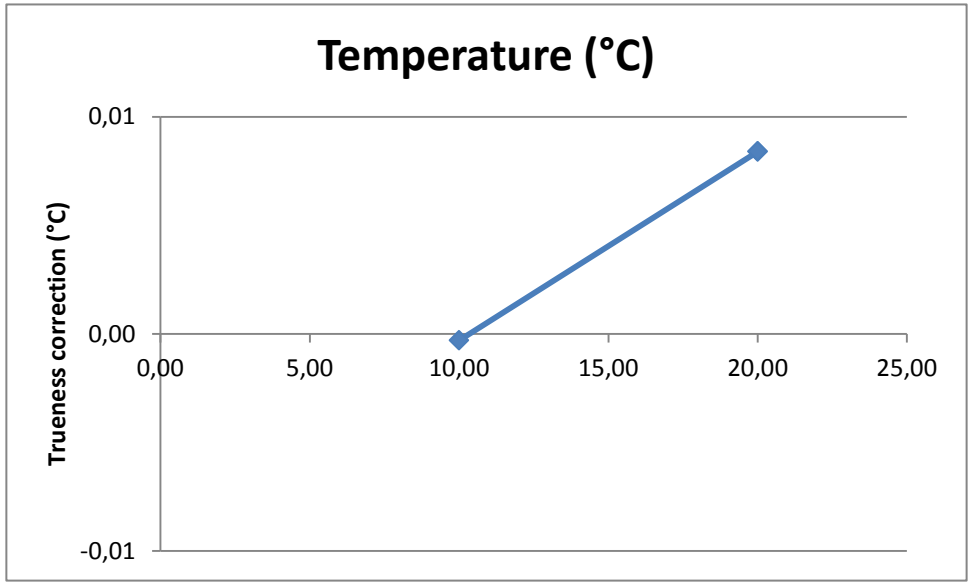
CNR Results:

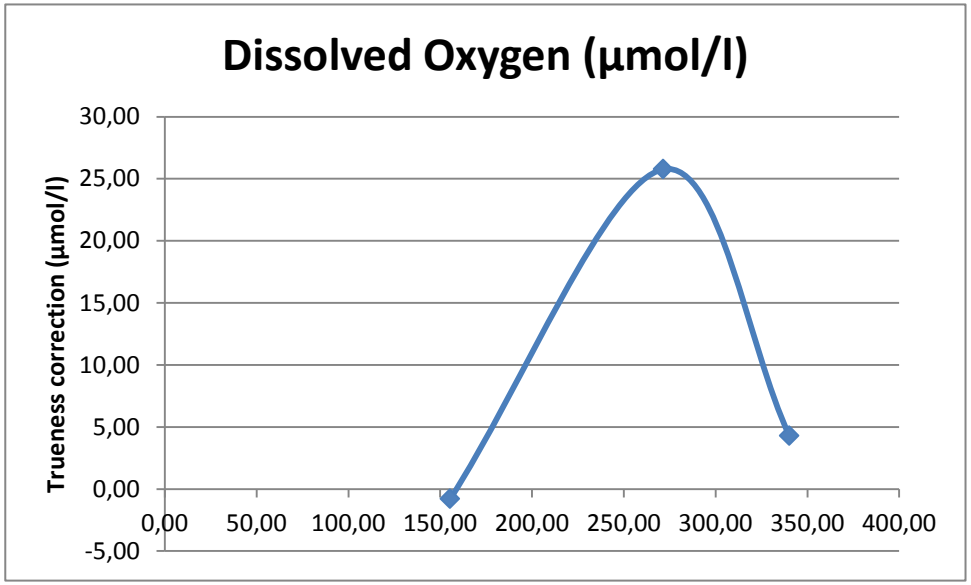
Seabird Sbe43 7000m s/n 430065 with Sbe39 pump s/n 1012 (CNR)

Beginning :	11/10/2012

Temperature				**Oxygen**					
Reference	Sensor		Correction	Reference			Sensor		Correction
Mean t_{90} (1) °C	Mean t_{read} (2) °C	Standard deviation °C	(1-2) °C	Nominal saturation %	Mean (3) µmol/l	Standard deviation µmol/l	Mean (4) µmol/l	Standard deviation µmol/l	(3-4) µmol/l
10.00	10.0003	0.0005	0.00	100	340.24	0.35	335.96	0.88	4.28
20.01	20.0016	0.0005	0.01	100	271.50	1.22	245.74	2.79	25.76
20.01	20.0016	0.0006	0.01	50	155.42	3.39	156.22	0.57	-0.80

Calculated data


Temperature (°C)
Trueness correction (°C)
0,01
0,00
-0,01
0,00
5,00
10,00
15,00
20,00
25,00


Dissolved Oxygen (µmol/l)
Trueness correction (µmol/l)
30,00
25,00
20,00
15,00
10,00
5,00
0,00
-5,00
0,00
50,00
100,00
150,00
200,00
250,00
300,00
350,00
400,00

Acknowledgements:

We thank all participants for their enthusiasm and the exchange of experience and knowledge that were possible during the experiment.