WHP Cruise Summary Information

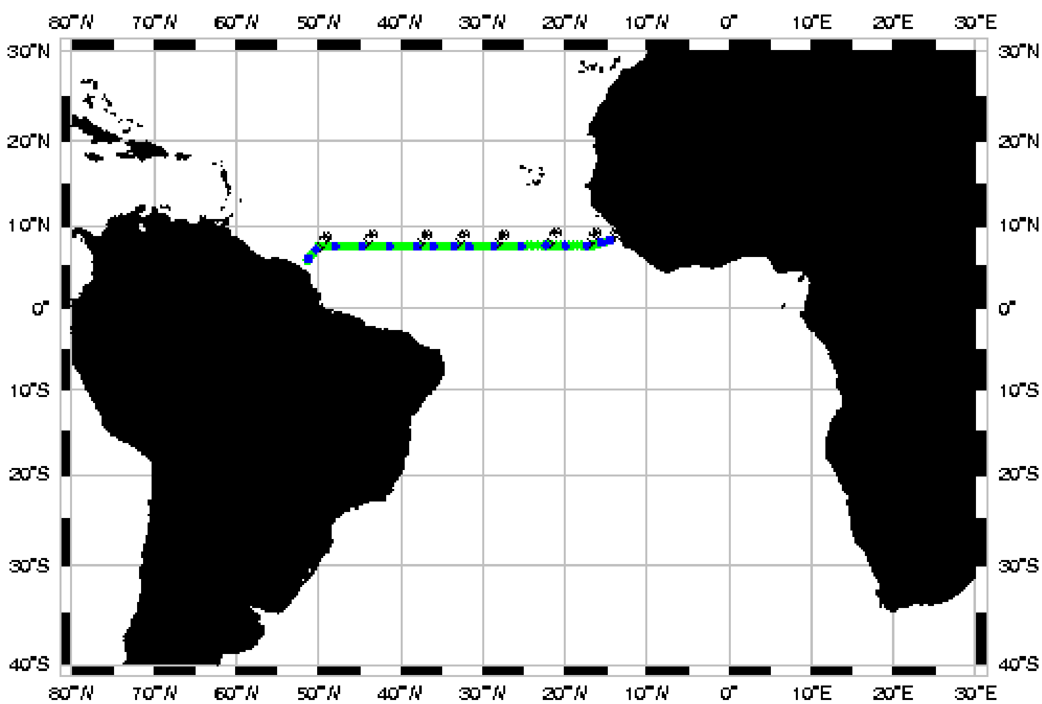
WOCE section designation	A06 & A07
Expedition designation (EXPOCODE)	35A3CITHER1_1-2
Chief Scientist(s) and their affiliation	Alain MORLIERE(ORSTOM), Christian COLIN (ORSTOM)
Dates	1993.01.02 – 1993.03.19
Ship	L'ATALANTE
Ports of call	Pointe Noire (Congo) to Natal (Brazil), Cayenne (French Guyana) to Abidjan (Ivory Coast)
Number of stations	224
Geographic boundaries of the stations	8˚20.42''N 51˚19.50''W 10˚50.39''E 5˚39.43''S
Floats and drifters deployed	none
Moorings deployed or recovered	none
Contributing Authors (In order of appearance)	T. Mueller A. Billant P. Branellec M. Arhan

WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

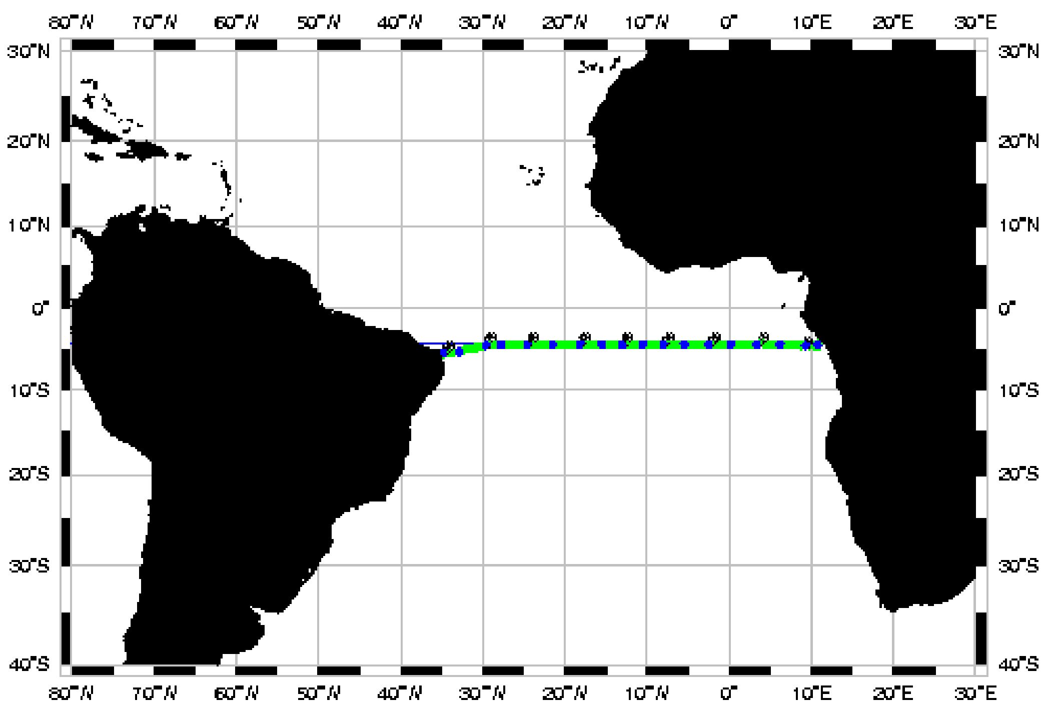
Cruise Summary Information	
Cruise track (figures A06/A07)	
Description of stations	
Description of parameters sampled	
Principal Investigators for all measurements	
Cruise Participants	
Problems and goals not achieved	
	DQE Reports
	CTD

Station locations for a06



(Produced from .SUM files by WHPO)

Station locations for a07



(Produced from .SUM files by WHPO)

CITHER 1 CRUISE

HIGHLIGHTS

Expedition Designation:

The CITHER 1 cruise is a french contribution to WOCE Programme. This cruise describes WHP Lines A6 and A7

Scientist in charge of the cruise:

Claude OUDOT, Institut Français de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM)

Chief Scientists:

Leg 1: Alain MORLIERE, Institut Français de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM)
Leg 2: Christian COLIN, Institut Français de Recherche Scientifique pour le Developpement en Cooperation (ORSTOM)

Ship: R/V L'ATALANTE

Ports of call:

Leg 1: Part 1: Pointe Noire (Congo) to Natal (Brazil): WHP Section A7
Part 2: Natal (Brazil) to Cayenne (French Guyana)
Leg 2: Part 1: Cayenne (French Guyana) to Abidjan (Ivory Coast): WHP Section A6
Part 2: Abidjan (Ivory Coast) to Pointe Noire (Congo)

Cruise Dates:

Leg 1: Part 1: January 2 (Pointe Noire) to January 23 (Natal), 1993
Part 2: January 26 (Natal) to February 10 (Cayenne), 1993
Leg 2: Part 1: February 13 (Cayenne) to March 8 (Abidjan), 1993
Part 2: March 10 (Abidjan) to March 19 (Pointe Noire), 1993

Cruise Summary

Cruise Track

The cruise track and station locations are shown above.

Sampling accomplished

Water sampling on the cruise included measurements of salinity both by CTD and water bottle samples, CTD and bottle sample oxygen determinations, CTD temperature, and nutrients (silicate, phosphate, nitrate, nitrite). Tracer analyses were made for CFC-11 and CFC-12 as well as sampling for tritium/helium.

Besides water sampling was made for measurements of CO_2 system parameters (TCO_2, pH, fugacity of CO_2), dissolved gases (nitrogen, argon, methane and nitrous oxide).

Type and number of stations

During the two legs of the cruise a total of 224 CTDO/Rosette stations were occupied using a 32-bottle IFREMER rosette equipped with 8 liters PVC water sampling bottles.

The usual spacing of stations was 30 nm, except over the continental slope (4 to 5 nm) and the abyssal plains (40 nm).

List of Principal Investigators

The parameters with the principal investigators and their affiliation are listed in Table 1.

Table 1: List of measured parameters and the Principal Investigators for each.

Parameter	Sampling Group	Principal Investigator
$CTDO_2$ / Rosette	LPO/IFREMER-Brest	M. Arhan / H. Mercier
S, O_2	LPO/IFREMER-Brest	M. Arhan / H. Mercier
NO_3, NO_2, PO_4, $Si(OH)_4$	ORSTOM-Brest	C. Oudot
	LOC/UBO-Brest	P. Morin
CFC-11, CFC-12	ORSTOM/LODYC-Paris	C. Andrie
Tritium, Helium	LMCE-Saclay	P. Jean-Baptiste
CO_2 system	ORSTOM-Brest	C. Oudot
Dissolved gases (N_2, Ar)	ORSTOM-Brest	C. Oudot
Trace gases (N_2O, CH_4)	LOC/UBO-Brest	M. Guevel
ADCP	ORSTOM/LODYC-Paris	A. Morliere
	LPO/IFREMER-Brest	H. Mercier
PEGASUS	IFM-Kiel	F. Schott
	ORSTOM-Cayenne	C. Colin

Preliminary results

The R/V L'ATALANTE departed Pointe Noire, Congo for the WHP Section A7 on January 2nd, 1993. The first station near 5˚04 N, 10˚40 E (bottom depth = 2100 m) was to test one of the two CTD systems and its rosette water sampling equipment. The CTDs are EG&G Neil Brown Mark III equipped with Beckman dissolved oxygen sensor. The first CTD equipment was replaced by the second one at station 83 (January 29, 1993) owing to problems with the conductivity sensor. All the CTD temperature, pressure and conductivity sensors were calibrated at the IFREMER calibration facility both before and after the cruise. The conductivity and oxygen sensors were also calibrated at sea using data from the analyses of the salinity and oxygen samples collected at each station. Water samples were collected from 32 PVC sampler bottles (capacity 8 liters)) mounted on the two-storied IFREMER Rosette sampler. The water sample conductivity measurements and oxygen titrations were made in a constant temperature (20˚C) portable laboratory.

Additional samples were also collected from each PVC bottle for the shipboard analysis of nutrients (silicate, phosphate, nitrate, nitrite) and chlorofluorocarbons CFC-11 and CFC-12 (every other station until station number 66, every station beyond and until the last station). Helium and tritium samples were also collected at many of the stations (a total of 58): the analysis of these samples will be later carried out in a shore-based laboratory.

Other samples were also collected from PVC bottles for the shipboard analysis of dissolved gases (nitrogen - argon - total CO_2 - methane and nitrous oxide) and the determination of pH and fugacity of CO_2 (in surface water and in atmosphere). The phytoplankton biomass (chlorophyll) was also sampled for shore-based analysis.

Underway ADCP and thermosalinograph data were recorded along the track of the ship (10 154 nm). Twelve PEGASUS profilings were done near the western coast in the boundary currents.

Problems

During the first leg (station number 83) we must have to replace the CTD system: shift and noises of the conductivity sensor. The second CTD system will be used until the end of the cruise without problems.

Through the cruise we used successively three Guildline salinometers: one Autosal and two Portasal. The problems were a shift of the calibration between the stations; or drift within a series of measurements. The later acquired Portasal model has given the best results and was used to measure all the salinities during the leg 2.

With the analytical measurements of the tracers, the most serious problem was the CFC contaminations from the PVC sampling bottles, mainly due to the grease of the stopcocks. A few special stations (5) were made to test the contaminations, by closing all the bottles at the same depth where the CFC concentrations were the lowest (generally around 2500 m depth). The mean contamination is estimated to about 0.005 $\pm$ 0.002 pmol/l for F-12 and to about 0.008 $\pm$ 0.002 pmol/l for F-11.

List of the cruise participants

The list of the cruise participants is given in Table 2.

STATION SUMMARY

The station positions, time, etc are tabulated in a summary file. This file (CITHER1.SUM) is reported on attached pages (numbered 1 to 12) and on attached floppy disk in MS-DOS format (ASCII characters).

The parameter numbers are defined in Table 3.

Table 2: Cruise participants

Participants	Role	Affiliation	Leg
Chantal Andrie	CFCs	ORSTOM/LODYC-Paris	1 - 2
Michel Arhan	$CTDO_2$	LPO/IFREMER-Brest	1
Sabine Arnault	Tritium, Helium	ORSTOM/LODYC-Paris	2
François Baurand	Nutrients	ORSTOM-Brest	1 - 2
Andre Billant	S, O_2	LPO/IFREMER-Brest	2
Jean-Michel Bore	$CTDO_2$	ORSTOM-Cayenne	1 - 2
Bernard Bourles	$CTDO_2$	ORSTOM-Cayenne	1 - 2
Pierre Branellec	S, O_2	LPO/IFREMER-Brest	1
Elisabete Braga	Oxygen	IOUSP-Sao Paulo	2
Remy Chuchla	Oxygen	ORSTOM-Cayenne	1
Souleymane Cissoko	$CTDO_2$	CRO-Abidjan	2
Christian Colin	Chief Scientist, Pegasus	ORSTOM-Cayenne	2
Daniel Corre	$CTDO_2$	ORSTOM-Brest	2
François Dangu	Salinity - $CTDO_2$	ORSTOM-Cayenne	1 - 2
Nathalie Daniault	$CTDO_2$	LPO/IFREMER-Brest	1
Andre Dapoigny	Tritium, Helium	LMCE/CEN-Saclay	1
Alain Dessier	CO_2, N_2, Ar	ORSTOM-Brest	2
Jean-Pierre Girardot	$CTDO_2$	LPO/IFREMER-Brest	2
Jean-Pierre Gouillou	$CTDO_2$	LPO/IFREMER-Brest	1
Yves Gouriou	$CTDO_2$	ORSTOM-Brest	1 - 2
Stephanie Gueneley	Nutrients	ORSTOM-Brest	1
Mickael Guevel	Trace gases	LOC/UBO-Brest	1 - 2
Catherine Hemon	$CTDO_2$	LPO/IFREMER-Brest	2
Philippe Hisard	Salinity	ORSTOM-Brest	2
Philippe Jean-Baptiste	Tritium, Helium	LMCE/CEN-Saclay	2
Milton Kampel	$CTDO_2$	INPE-Brazil	1
Lamine Keita	$CTDO_2$	CERESCOR-Conakry	2
Jean-Jacques Lechauve	$CTDO_2$	ORSTOM-Brest	1
Jerome Lecomte	CO_2, N_2, Ar	ORSTOM-Cayenne	1 - 2
Nathalie Lefevre	CO_2 Fugacity	LODYC-Paris	2
Jean-François Maguer	Nutrients	LOC/UBO-Brest	1
Jean-François Makaya	$CTDO_2$	ORSTOM-Pte Noire	1
Laurent Memery	CFCs	LODYC-Paris	1
Herle Mercier	$CTDO_2$, ADCP	LPO/IFREMER-Brest	2

Participants	Role	Affiliation	Leg
Marie-Jose Messias	CFCs	LODYC-Paris	2
Pascal Morin	Nutrients	LOC/UBO-Brest	2
Alain Morliere	Chief scientist, ADCP	ORSTOM/LODYC-Paris	1
Claude Oudot	CO_2, N_2, Ar	ORSTOM-Brest	1 - 2
Christophe Peignon	CO_2, N_2, Ar	ORSTOM-Lome	1
Jean-Paul Rebert	Tritium, Helium	ORSTOM-Brest	1
Joerg Reppin	Pegasus	IFM-Kiel	1
Birane Samb	$CTDO_2$	CRO-Dakar	2
Jean-François Ternon	CFCs	ORSTOM-Brest	1 - 2
Mohideen Wafar	Nutrients	LOC/UBO-Brest	1

Table 3: Parameter numbers in the CITHER1.SUM file

Parameter Number	Parameter	Unit
1	Salinity	PSS-78
2	Oxygen	µmol/kg
3	Silicate	µmol/kg
4	Nitrate	µmol/kg
5	Nitrite	µmol/kg
6	Phosphate	µmol/kg
7	Freon 11 (CFC-11)	pmol/kg
8	Freon 12 (CFC-12)	pmol/kg
9	Tritium	TU
10	Helium	nmol/kg
11	Delta Helium-3	%
12		
13		
14		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23	Total Carbon	µmol/kg
24	Total Alkalinity	µmol/kg
25	Fugacity fCO_2	Pa - µatm
26	pH	None
33	Nitrogen	µmol/kg
15	Argon	nmol/kg

Parameter Number	Parameter	Unit
33	Nitrous oxide	nmol/kg
31	Methane	nmol/kg
34	Chlorophyll a	μg/l
35	Phaeophytin	μg/l

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02 Oct, 1996

WOCE Hydrographic Programme
Data Quality Expert (DQE) Report on CTD data

One Time Sections A6, A7
N/O L'Atalante
Jan - Mar 1993
CTD-O_2 data

Introduction

The French written cruise report consists of four volumes:

- Volume 1 with general cruise information. Also, procedures of calibration and processing of 'En Route' data, ship borne ADCP, and some PEGASUS stations are described.
- Volume 2 (Le Groupe CITHER-1, 1994) with a description of CTD-O_2 data calibration, processing and extensive hard copy displays.
- Volumes 3 and 4 with geochemical measurements.

Also, an English written cruise report is available at the WHPO (6 pages plus -.SUM file).

The present DQE report deals with the CTD-O_2 data from A6 and A7. It consists of three parts:

(A) A brief summary of the French written A6/A7 CTD-O_2 data report (Le Groupe CITHER-1, 1994; GC1 henceforth) which describes the procedures of laboratory calibrations, data acquisition and processing, in-situ calibrations and verifications. Along with this summary, I have included (and flagged as such) some comments at the end of sections where appropriate. No figures and tables are available in electronic form from the above report, and therefore reference is made to figures and tables as they appear in the report.

(B) A report of evaluation of the A6 and A7 CTD-O_2 data as they were available at the WHP-O in September 1996.

(C) Recommendations

Part A.

Campagne CITHER-1 of R/V L'ATALANTE (2 janvier-19 mars 1993). Recueil de donnees, Volume 2: CTD-O_2

(English summary by DQE with comments added at ends of sections; sections, figures and tables are numbered as in the French report)

I The CITHER-1 Group

To obtain WOCE one time zonal sections A6 (along 07N30') and A7 (04S30') is one among other French contributions to WOCE. The cruise in 1993 was divided into two legs. In addition to stations along A6 and A7, two meridional sections were obtained between A6 and A7, along 035˚W and 004˚W.

PI's for CTD-O_2/rosette were Michel Arhan (leg 1) and Herle Mercier (leg 2); see Table 1 in the report for other PI's.

II Cruise participants with respect to CTD-O_2 work

see Table 2

III Calibration of CTD-O_2 measurements

(A. Billant and P. Branellec, LPO)

1. Acqusition of CTD-O_2 data

A total of 223 stations with two Mark III CTD-O_2 systems were obtained along with a 36x8 l bottle rosette PASH 6000 developed by LPO. For locations of stations see Figure 1.

Major events

(i) Section A7 was interrupted westbound after Stat. 77 before the vessel entered the 200 nm EEZ of Brazil. Prior to continuate A7, L'ATALANTE had to call port of Natal, Brazil, to pick up a Brazilian observer. Five days later, A7 was continued with Stat. 78 as repeat station on the position of Sta. 77.

(ii) The first CTD-O_2, S/N 2521, was replaced due to problems with the conductivity sensor after Stat. 82 by the second CTD-O_2, S/N 2782.

(iii) Stations 27, 75, 118 and 190 were taken in between WHP stations, with bottle being closed at special depths for calibration and test purposes.

Data acquisition and processing

The CTD's data cycles were transferred to the computer at a 32 Hz rate and on-line processed. Processed data then were stored on magnetic tape. Two steps of processing were applied. First, each data value was compared with the one in the preceding cycle. If the absolute difference of a value to the preceding one exceeded a certain amount (see table below), the complete cycle was omitted. The parameters for this comparison were:

Pressure	0.5 dbar
Temperature	0.032 K for pressure < 1500 dbar
	0.005 K for pressure > 1500 dbar
Conductivity	0.032 mS/cm for pressure < 1500 dbar
	0.005 mS/cm for pressure > 1500 dbar
Oxygen curr.	0.010 UA
Oxygen temp.	0.3 K

Next, cycles were averaged in pressure intervals. The intervals were chosen such that of all data cycles at least 25% were kept as 'good' and contribute to the average. For a lowering speed of 1 m/s, this means that at least 8 cycles contribute to an average over 1 dbar.

Only, lowering profiles are considered.

DQE's comments on section 1:

From the French report, I understand that the original data set is not stored but only the (single value) de-spiked and averaged cycles with no other processing steps being applied before or afterwards. If this is true, I see some principal problems with this procedure. Although such a procedure may not affect very much CTDs that behave well, and although the non-averaged data may not be available any longer (as I understand the report), let me describe some steps necessary in processing open sensor CTD data.

(i) the de-spiking method as described above can only recognize single spikes. It also is problematic in that it compares only with preceding values. If two or more spikes occur in turn (which to my experience may happen) these are smeared into the average during the averaging process; they can never be re-identified, and it is hard to detect and remove such 'bad' averages.

(ii) Before averaging or low pass filtering, other important processing steps are performed for 'open sensor' CTD's by other institutes like WHOI (see Yang and Millard, 199xx) and IFM Kiel. They are not described for A6 and A7. The steps are:

- create (if not already available) a cycle number or time and keep it throughout the processing.
- check the (single value) despiked series for further spikes.
- apply a low pass filter to the pressure series; this matches the pressure sensor resolution (0.1 dbar) to the lowering speed which at 1 m/s requires a resolution of 0.03 dbar.
- monotonize the profile with respect to pressure; conductivity and oxygen sensor respond quite differently under different lowering speeds. Even better would be to first apply a 'minimum lowering speed' criterion to the profile and then monotonizing.

- match the time constants of the (combined) temperature signal and the conductivity sensor. This can be done either 'by eye' looking at salinity spikes in sharp gradient regions, or more objectively by looking at the coherence and phase spectra.
- apply a low pass filter to 0.5 dbar response and average on 0.5 dbar intervals.
- apply the (static) calibrations for pressure, temperature and conductivity.
- apply a low pass filter to 2 dbar response.
- apply the correction for the dynamic response of the pressure sensor to temperature changes
- average on 2 dbar intervals
- calculate follow up quantities (salinty, pot. temperatur, pot. density)
- apply the calibration of the oxygen sensor.

2. Sampling

Sampling was done with a 36 x 8 l bottle rosette PASH 6000 developed by LPO. Bottles were closed on the way up (see Fig. 2, 3). A total of 6269 samples for salinity and 6460 samples of analysis of dissolved oxygen were taken. 12 bottles carried reversing temperature and pressure sensors made by SIS. Samples from bottles were drawn according to the instructions in the WOCE operation manual.

DQE's comment on section 2

ok

3. Sample analysis for salinity and dissolved oxygen

3.1 Salinity

Samples for salinity were drawn to 125 ml flasks, stored in a constant temperature (20˚C ± 1 K) laboratory and analyzed within 20 h to 30 h.

Standard seawater, batch P120 (K15=0.99985) from Wormley by 06 April 1992, was used to standardize the salinometers. Standardizations were performed before analysis started each day. After 36 bottles, standardization was verified and the result noted in a log. Each sample was rinsed three times before measuring and read three times.

Due to stability problems of order 0.003 psu within a series of 36 bottles, salinometers were changed:

Stat		ID	Stability 36 samples
001 to 010	PORTASAL	A	0.001 psu
011 to 018	AUTOSAL 8400	B	<0.003 psu
019 to 119	PORTASAL	A	0.001 psu
120 to 223	PORTASAL	B	<0.001 psu

Whenever unstable conditions were observed, standard seawater was used and salinity linearly corrected for drift.

At four (non-WHP) stations, bottles were closed at same depths to get multiple samples for comparison. The maximum deviations from the means were less 0.003 psu. From the following statistics it follows that the precision is better 0.002 psu.

Test stations: Salinity

Stat	depth	Bottles close	Stand. dev
27	2000	32	0.0009
75	4400	26	0.0018
118	2500	27	0.0011
190	1000	24	0.0016

Figures 4 and 5 show the results from 275 double samples from pairs of bottles taken throughout the cruise from the whole water column. Of these, 51% differ by less than 0.001 psu, and 85% by less than 0.003 psu. This result is not significantly improved when only samples from deeper than 980 dbar are considered.

DQE's comment on section 3.1

All salinity measurements were done and reported thoroughly. As the comparisons of oxygen measurements (see 3.2 below) from the same test stations with significantly improved results from deeper levels show, the relative high value in salinity precision seems not to be due to mistakes in sampling but to the trouble with drifts in all 3 salinometers, rather. Nevertheless, from the high number of samples one may expect a good calibration the CTD's salinities.

3.2 Dissolved Oxygen

Samples for oxygen were drawn after those for CFC's and helium into flasks of 120 ml. Temperature of the sample was measured before rinsing the flask three times. Samples were measured along the guidelines of the WOCE Operations Manual in constant temperature (20˚C ± 1 K) laboratory. The method included to automatically detect the inflection.

Multiple samples from same depths at three test stations show that a precision of 0.01 ml/l is expected.

Test stations: Oxygen

Stat	depth	Bottles close	Stand. dev
27	2000	32	0.003
75	4400	26	0.007
190	1000	24	0.009

In figures 6 and 7 the results from 297 double samples from pair of bottles throughout the cruise and the water column are displayed. Of all double samples, 39% agree to within 0.005 ml/l, and 70% to within 0.015 ml/l. This result is much improved if one restricts to the 213 samples from depths larger than 980 m: then, even 45% agree to within 0.005 ml/l. For depths larger 2480 m, the standard deviation is 0.013 ml/l.

DQE's comment on section 3.2

As the multiple and the double samples show, oxygen measurements meet the requirements of the WHP.

4. CTD pressure sensor calibration

Both CTD's carried a Paine strain gauge sensor. These sensors routinely are calibrated at IFREMER's calibration center which is certified by the 'Bureau National de Metrologie' (BNM). A dead weight tester made by 'Desgranges et Huot' with an accuracy of ± 0.75 dbar at 6000 dbar is used.

4.1 Calibration under laboratory conditions (20˚C)

Pre- and post cruise calibrations were made for both CTD's with repeated loading (upper panels in fig. 8, 9) and unloading (lower panels) cycles. Third order polynomials have residuals less 2 dbar.

4.2 Static temperature effects

Pressure sensor temperature was measured during the profiles. Laboratory calibrations at 7 different temperatures that cover the range are available. The effect is less 5 dbar. The additional corrections are necessary after having applied the 20˚C basic calibration less than 3 dbar. The inner sensor temperature is modeled for a typical decent and hatched in figure 10.

4.3 Dynamic effects of temperature changes

The dynamic responses to about 20 K temperature shocks were measured in the laboratory for both CTD's (fig. 11). The corrections applied for CTD profiles assume a single shock of this order within the thermocline, a lowering speed of 1m/s, 13 minutes at maximum pressure before the up-profile starts, and a 1 minute stop to close a bottle.

4.4 Corrections of pressure measurements

Taking the 20 C basic 3rd order regressions at the 400 dbar interval calibration points, the corrections for the effects of both, static and dynamic temperature corrections are added. For the combined effects, a 5^{th} order polynomial regression is applied to all pressure measurements (fig. 12, 13: loading mode in upper panels, unloading mode in lower panels).

4.5 Verifications after corrections

For both CTDs, the differences at the surface before and after the profile corresponded well to the overall laboratory calibrations displayed in figures 12 and 13.

Reversing electronic pressure sensors of SIS were used on the up profile. Pre- and post cruise calibrations were performed at 2.5˚C at 7 points between 0 dbar and 6000 dbar. The corrected values of CTD and SIS sensors compare well within 2 dbar which may be assumed to be the overall accuracy of pressure measurements for WHP cruises A6 and A7.

DQE's comment on section 4

Both sensors show a major change in their response characteristics at pressures larger than 4500 dbar in the post cruise calibration (fig. 8, 9) which appears strange to me. While the pre cruise calibration has the 3^{rd} order polynomial response as it is typical for the Paine sensor, the post cruise calibrations for both sensors are more or less parabolic. The effect results in an order 3.5 dbar change for CTD2521 at 5400 dbar, which is the maximum pressure during the cruise; the effect is less for CTD2782. I wonder if such a change in the response characteristics found in other sensor calibrations from this period of time in which case they might indicate a shift in reference rather than CTD sensors.

Hysteresis may depend on the maximum pressure to which the sensor was exposed before unloading, with maximum hysteresis being expected at the high end of the range at 6000 dbar. During these calibrations, the maximum pressure was kept to 6000 dbar. This excludes check of hysteresis effects at lower maximum pressures. However, since hysteresis was less than about 1.5 dbar at all pressures this will have a minor effect on the final calibration.

The corrections for static temperature responses could better have been applied directly by linear interpolation since the inner temperature was measured, as I understand. However, the effect will be small, anyway. The same holds for the dynamic response.

All corrections are modeled empirically into one 5^{th} order polynomial for each, loading and unloading mode. As the comparison of corrected CTD pressures with corrected SIS pressures shows this method was able to meet the WHP requirements for CTD pressure measurements.

5. CTD temperature sensor calibration

The measurements of a high precision Rosemount and that of a fast response NTC resistance are combined to standard MKIIIB temperature output at a resolution of 5 mK.

5.1 Operational mode

CTD temperature sensors are routinely calibrated at IFREMER before and after a cruise. During calibration, the CTD is completely immersed into the temperature stabilized calibration bath. Temperature readings are compared to a reference Rosemount sensor which ITS90 calibration is traced back on a regular basis to the BNM.

Both CTDs were in use since 1982 with changes in calibration not exceeding 10 mK. While CTD2521 stayed stable during the cruise (fig. 16a), CTD2782 showed a clear offset of 2 mK at 0˚C and 8 mK at 25˚C (fig. 16b). The uncertainty of CTD2782 is 2 mK up to 5˚C, and 4 mK for larger temperatures.

5.2 Verification after correction

Seven reversing electronic thermometers made by SIS and calibrated, both before and after the cruise, were used throughout the cruise. After the change of CTDs between stations 82 and 83, a 'jump' in the difference to all SIS sensors is observed (15 mK $\pm$ 1 mK) that corresponds well to the difference in the CTD laboratory calibration at 2˚C (16 mK; see fig. 17 for temperature range 2.5 to 5˚C and fig 18 for the 1˚C to 2.5˚C range). Final offsets between SIS and CTD are probably due to a pressure effect on the SIS sensors.

For stations 1 to 82, accuracy as derived from figures 17 and 18 is of order 1 mK, over the whole cruise 2 mK.

DQE's comment on section 5

From the calibration curve of CTD2521, its uncertainty seems to be of the order of 1 mK. As for CTD2782, it might be interesting to search for similiar 'jumps' in earlier calibrations.

Accuracy of CTD temperatures as estimated from pre- and post cruise calibrations, and from comparisons with the seven SIS thermometers seems better than 2 mK, thus meeting WHP requirements.

6. CTD conductivity sensor in-situ calibration

6.1 Operational mode

The conductivity sensor output is averaged while bottles are closed. This average is subject to the cell's pressure and temperature correction. The result is compared to in-situ conductivity values as derived from bottle salinities. A first order linear polynomial regression is calculated for stations or groups of stations:

$$COR=C0 + C1*COS$$

Outliers are removed until all differences are within 2.8*STDEV, STDEV being the standard deviation.

6.2 Station grouping

CTD2782 stayed rather stable for large groups of stations. CTD2521, however, needed a station by station calibration from station 57 on until its exchange after station 82. Since the linear coefficient C1 did not change when calculated for stations 1 to 56 or station 1 to 77, the change in calibration was totally due to the offset C0. Thus, taking C1 as fixed, C0 was adjusted for station 57 to 77. For stations 78 (after the call of port) to 82, both coefficients were calculated station by station. See table III-1 for a complete listing of coefficients.

6.3 Overview profile calibration

With the 5580 samples (89%) used for the calibration (see fig. 19, 20 for conductivity; fig. 21 for salinity), the overall standard deviation of the residuals is 0.0023 mS/cm. Only station group 204 to 219 is slightly worse (0.0029 mS/cm). Overall the cells' in-situ calibrations are close to WHP standards.

6.4 Verification

Stations 31 and 119 were repeated with a different CTD at stations 223 and 156, respectively. Also, positions of stations 211 and 145 are close to SAVE station 45 and TTO station 63, respectively. All 4 theta-S diagrams coincide well in the deep sea with salinity deviations of just 0.001 psu.

DQE's comment on section 6

The method applied to determine the calibration coefficients is well established. Comparison in theta-S space of two 'cross stations' of this cruise and two 'cross stations' with stations from SAVE and TTO establish an accuracy in salinity close to 0.001 psu meeting WHP standards.

7. CTD dissolved oxygen sensor in-situ calibration

7.1 Operational modes

The calibration of the oxygen sensor followed the method described first by Millard (1982, see GC1 for the complete reference). The formula models the effects of temperature, inner and outer temperature difference and pressure, and salinity through the saturation formula by Krause (1984, see CG1 for the complete reference) on the electrical current (OC) that is measured in the cell. Compared are averages of OC over a 15 dbar interval from those depths of the lowering profile where sample oxygen were measured. The calibration coefficients are determined for groups of stations.

7.2 Units of dissolved oxygen

The calibration is performed and reported in units of ml/l. All units are converted then to Umol/Kg keeping those values in ml/l.

7.3 Station grouping

Three sensors were used:

Stat.	CTD	Oxygen sensor
001-069	2521	A
070-082	2521	B
083-223	2782	C

Sensor A, in addition to Millard's regression needed a 5^{th} order polynomial regression in pressure. Sensor B needed a calibration by stations. Only sensor C was stable over large parts. See Tables III-2 and III-3 for coefficients and details.

7.4 Overview of profile calibration

The results are presented in figures 24 and 25. A total of 6052 samples (93.7%) were used in the calibration procedure. Of these 42.4% have residuals less 0.025 ml/l, and 83.9% less 0.075 ml/l with a standard deviation of 0.066 ml/l. Disregarding samples from depths less 980 dbar, this result improves to 49.8% and 92.2%, respectively and a standard deviation of 0.041. The subset of stations 70 to 223 has an overall (all depths) standard deviation of 0.046 ml/l.

7.5 Verification

One station pair (Stat. 119, 156) from this cruise with different sensors, and two SAVE stations can be compared (fig. 26, 27). The obvious differences between stations 119 and 156 also show up in other chemical parameters, and thus probably are due to a change in deep water masses at that position during the cruise.

Stations 218 and 130 compare well with SAVE station 158 and TTO station 25.

DQE's comment on section 7

The formula used to model the oxygen sensor response did not account for the sensor's speed through the water as requested in a later version in the WHP Operations and Methods Handbook. Nevertheless, the standard deviations reported for the residuals of the sensor calibration meet well the WHP requirements.

Part B.
CTD data evaluation

8. Basics

A6 and A7 data available at the WHP-O were:

- .SUM file
- .WCT CTD data
- .HY2 bottle data

and additional two meridional sections linking A6 and A7.

CTD data were on 1 dbar intervals. WHP requirements are 2 dbar intervals; the higher vertical resolution has led to problems with computer (PC) storage and computing time using the programs kindly provided by R. Millard, WHOI.

CTDTMP and CTDSAL in the CTD files are reported with 4 decimal places, however with tailoring zeros. This is not WHP standard. Also, the quality byte for oxygen was set to zero throughout the CTD-files.

Although the overall quality of the data set is expected to meet WHP standards, the remarks above and the quick evaluation below will show that some revision of the data needs to be made. I therefore restrict to the (more problematic section A7 plus some meridional stations (Stat. 1 - 99); nevertheless, all recommendations made below also hold for A6.

The set of DQE programs allows to compare the CTD files with the CTD values in the bottle file. Only data flagged as 'good' were used. The following checks including some blow-up figures (not always shown) were made:

- theta-CTDSAL, overall in the east and in the west
- theta-CTDOXY, overall in the east and in the west
- deviations CTDSAL and SALNTY on pressure levels by station
- deviations CTDOXY(downcast) and OXYGEN on pressure levels by stations
- same by pressure in station groups (waterfall plots)
- noise level in the deep ocean
- static stability in profiles

9. Theta-CTDSAL, Theta-SALNTY

These plots are grouped for Stat. 1-50, and 41 -91. For stations 1 - 50 in the eastern basin, the overall plot (*Fig. 28a) shows extremely low salinities at the surface as a result of the Congo River plume. At least two non-flagged CTDSAL outliers from the upcast at the high end are detectable (and marked in *fig. 28a). Others are identified at lower temperatures (*Fig.28b). In the deep ocean (*Fig. 28c), some SALNTY values are aside the bunch. An example (*Fig 28c) shows that large deviations between samples and the CTD are observed at Stat. 9. This station needs to be compared directly with neighboring stations for the salinity calibration. A more careful check will later identify other stations with calibration offsets.

In *Fig. 29a to 29.c the same is repeated for Stat. 41 to 91. Again, some few outliers of SALNTY are identified in the deep ocean.

Overall, flags need to be checked.

10. Theta-Oxygen

Station groups 1 to 51 (*Fig. 30a-c) and 41 to 91 (*Fig. 31 a-c), both show some extreme non-flagged spikes (Stat. 7, Stat. 38) in CTDOXY and some bad non-flagged values in the samples. Also, some CTDOXY profiles look rather noisy. Overall, flags need to be set/checked.

11. Residuals in calibration

11.1 CTDSAL

In *figure 32a these differences are plotted as single dots by STNNBR for all depths (upper panel), for depths larger 1000 dbar (middle) and by pressure (lower panel). Also included are the mean differences for each station (bold line). *Fig. 32b gives a blow-up of the upper and lower panels of *Fig. 32a. Some non-flagged outliers are marked.

The marked minima and the maxima of the bold line in the *Fig. 32a (middle panel) identify those stations, where the differences between CTDSAL and SALNTY need a check of the CTDSAL calibration by comparing neighbouring deep CTD stations: This is recommended for the following stations: 009, 010, 023, 033, 035, 048, 076, 077, 078.

A more severe problem is obvious from *Fig. 32b: It shows a bias in CTDSAL calibration at pressures higher than 4000 dbar. Perhaps, the pressure compensation that has been applied is not sufficient. To my experience, these sensors may need additional corrections to the linear one applied to the compensated raw data.

While *Fig. 32 allows one to identify stations with suspicious overall calibration, the waterfall plots in *Fig. 33a to 33i give insight to the residuals' distribution over single profiles. Although the resolution is sparse, some stations can be identified to have a systematic bias against the samples on that station. This holds for almost all stations which have samples from depths larger than 4000 dbar (as seen already in *Fig. 32). In *Fig. 33a and 33b, the subset shallow stations may have calibration problems: stations 005, 006, 010 and 097.

11.2 CTDOXY

In *Figure 34, the residuals between the CTD downcast and the sample oxygen are shown. Some non-flagged outliers are marked (*Fig. 34a). With better resolution, *Fig. 34b (middle) shows the station mean residuals well within ± 5 Umol/Kg for pressures > 1000 dbar. Problems may occur at the beginning (Sta.6), and only a few other stations. I recommend comparison of neighboring stations in the deep ocean: 57, 58, 88, 95 and maybe 86. Station 6 is shallow and may checked against station 008.

In the waterfall plots of *Fig. 35 those stations are marked that over wider parts of a profile show a bias in the residuals. At these stations, the CTDOXY should be compared to neighboring stations to verify the calibration.

12. Noise level in CTD profiles

Since the data are provided on a 1-dbar interval rather than on 2-dbar intervals, the noise level maybe expected higher than usual for 2-dbar WOCE data. The method calculates means and rms over 2 - 12 dbar high pass filtered data.

For the deep ocean (*Fig. 36a), the rms of CTDSAL is well below 0.001 psu (upper panel), that of CTDOXY generally below 0.5 Umol/Kg (middle panel). The mean rms for salinity is 0.0004 psu is slightly higher than for other WOCE cruises with low values in the deep eastern basin (stations 10 to 50) and high values between station 55 and 86 reflecting more variability in the deep western basin.

The station averaged rms for oxygen (0.24 Umol/Kg is twice as high as the so far best WOCE cruises show probably reflecting the fact that the sensor's speed through the water column was not taken into account during the calibration. Some stations (around 20, 43, 51, and 75) peak in scatter and may be re-examined.

Part C.
Recommendations

Resubmit the data set subject to:

** check for the calibration procedure of CTDSAL for high pressures
** incorporate the oxygen sensor's speed through the water column into the calibration to improve the noise level.
** deliver downcasts at:
2dbar intervals
4digit places for CTDTMP, CTDSAL, SALNTY (no zeros tailoring)

** set flags for CTDOXY
** carefully check all flags for SALNTY, CTDSAL, CTDOXY; setting flags may make use of the known standard deviations for the calibration.

I'm prepared to inspect the complete data set when resubmitted.

Acknowledgements

The WHP-O at WHOI again has been a friendly and effective host. Software used for part B of this evaluation, was kindly made available by Bob Millard; special thanks to him for his helpful guidance. This work was supported by the Bundesminister fuer Bildung und Wissenschaft, Bonn, Germany, under grant WOCE IV.

References

Le Groupe CITHER-1: Campagne CITHER-1 N/O L'ATALANTE (2 janvier-19 mars 1993). Recueil de donnees, Vol 2: CTD-O2. Rap. Interne LPO 94-04, Laboratoire de Physique des Oceans, IFREMER, Brest, France, 1994.

Millard, R.R. and K.E. Yang. CTD calibration and processing methods used at WHOI. WHOI Techn. Rep. 93-44, 1993

For further references see Le Groupe CITHER-1 (1994), there especially Billant (1985) for CTD calibration methods as applied at IFREMER; Billant (1990) for SIS pressure meter characteristics; Millard (1982) for the calibration of the oxygen sensor.

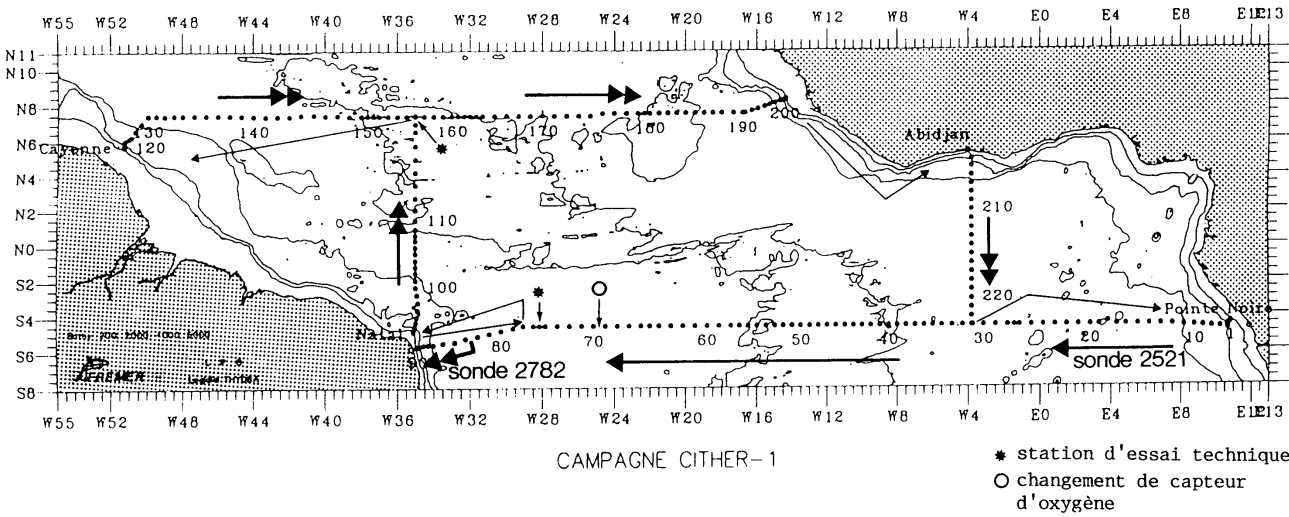


Fig. 1: Position géographique des 223 stations de la campagne CITHER 1
Les principaux 'évènements' intervenus en cours de campagne sont répertoriés.

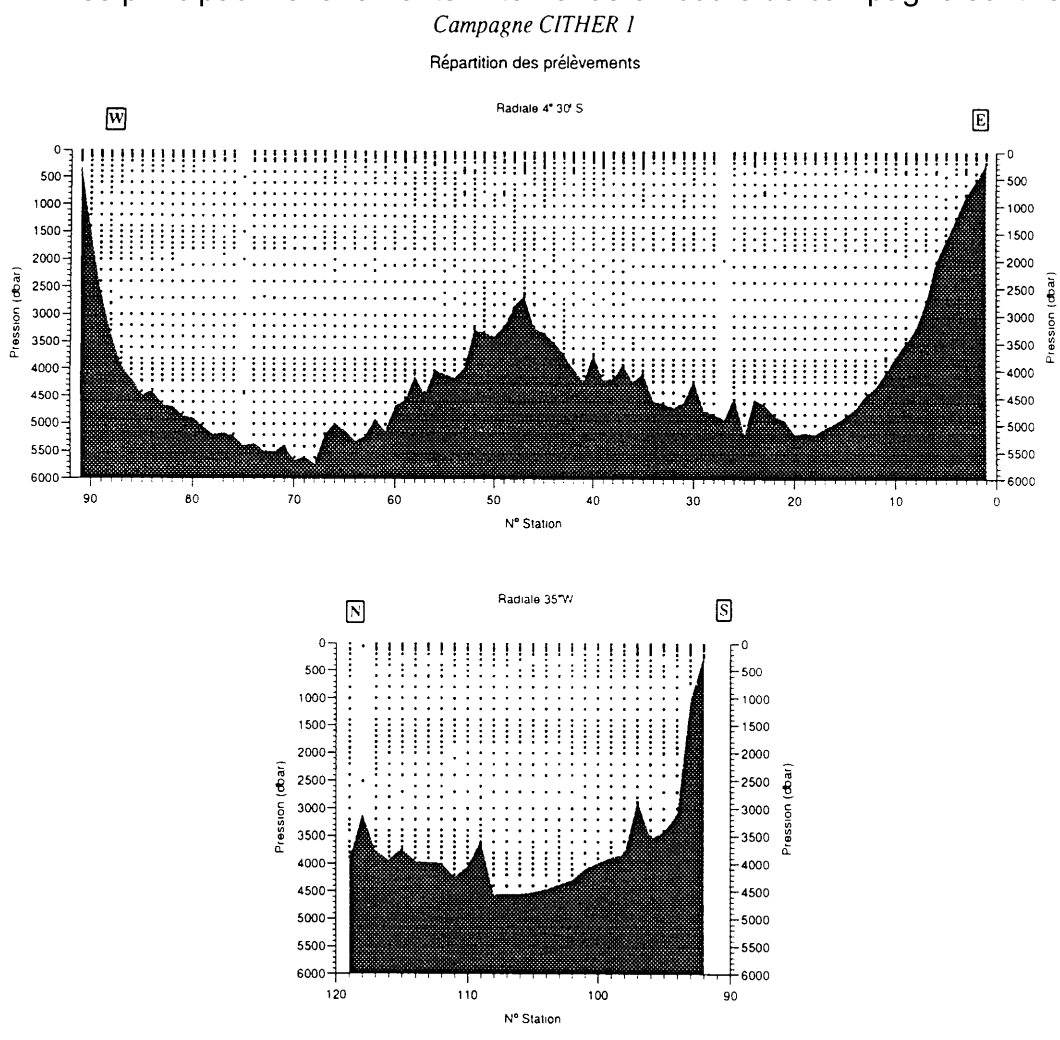


Fig. 2: Coupes synoptiques indiquant le niveau des prélèvements à chaque station sur les radiales 4°30S et 35°W.

Campagne CITHER 1

Répartition des prélèvements

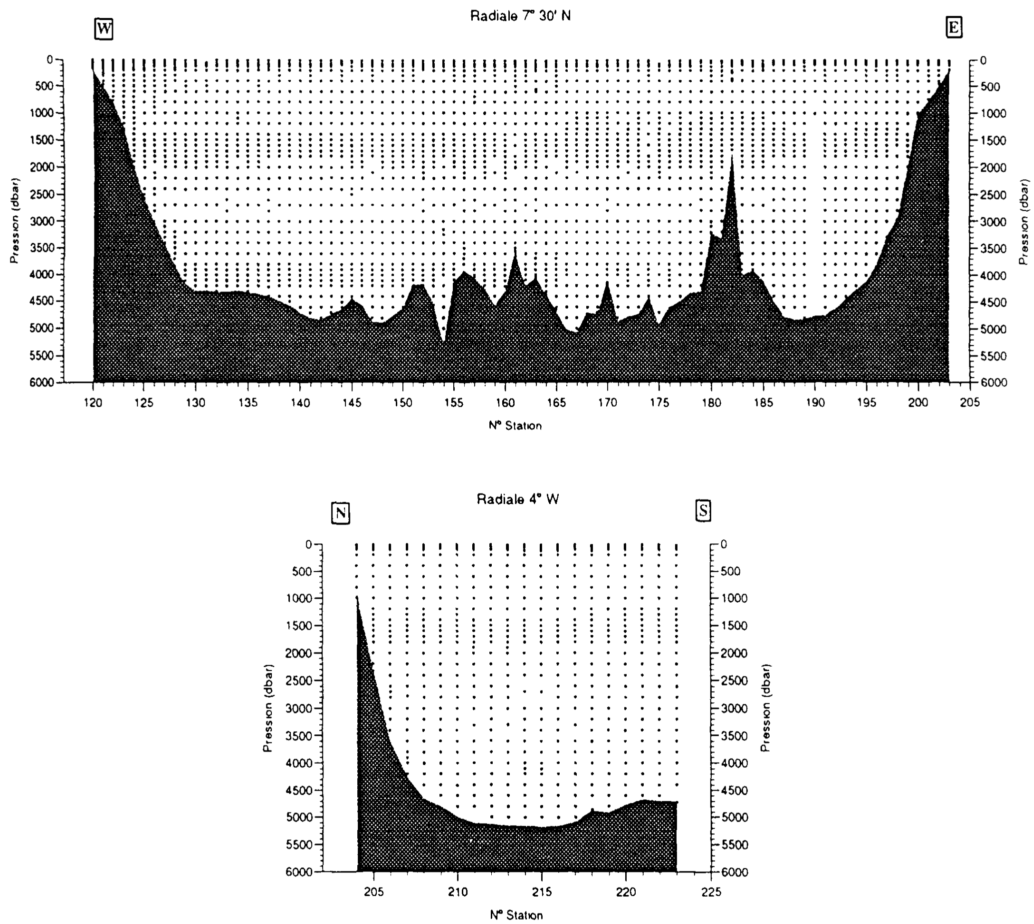
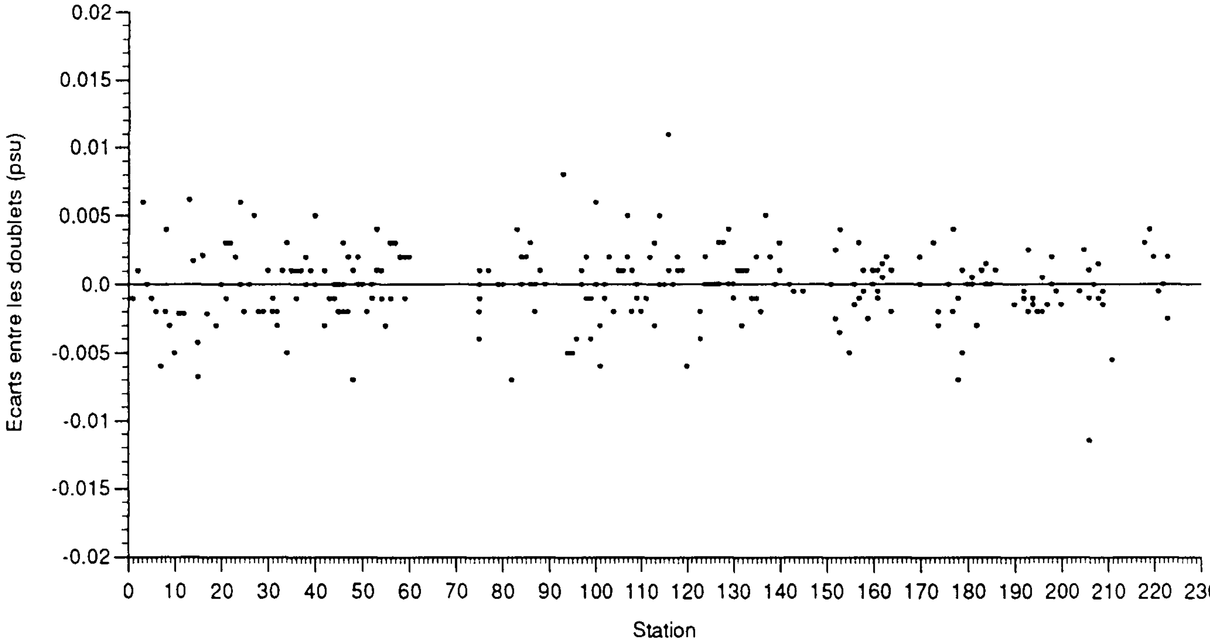


Fig. 3: Coupes synoptiques indiquant le niveau des prélèvements à chaque station sur les radiales 7°30S et 4°W.

Campagne CITHER 1

Répartition des écarts entre les doublets pour la Salinité



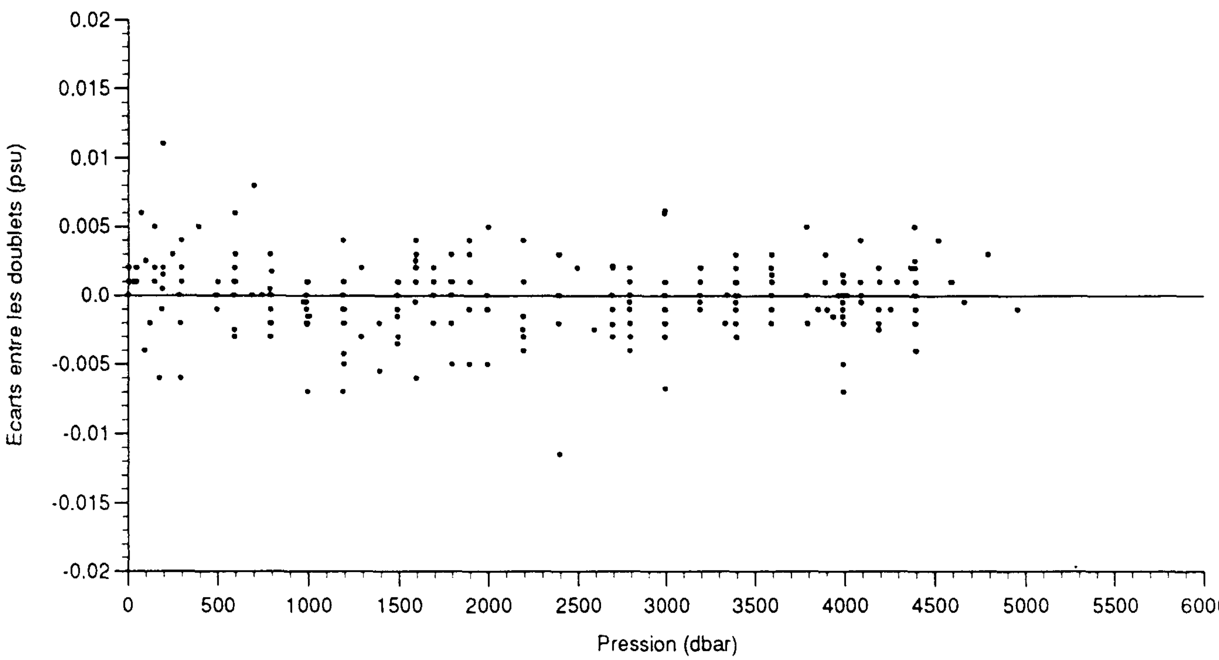


Fig. 4: Ecarts de salinité entre deux bouteilles fermées au même niveau:
a) en fonction du numéro de station à laquelle a été réalisé le doublet,
b) en fonction de la pression à laquelle a été réalisé le doublet.

Campagne CITHER 1

Répartition des doublets en Salinité

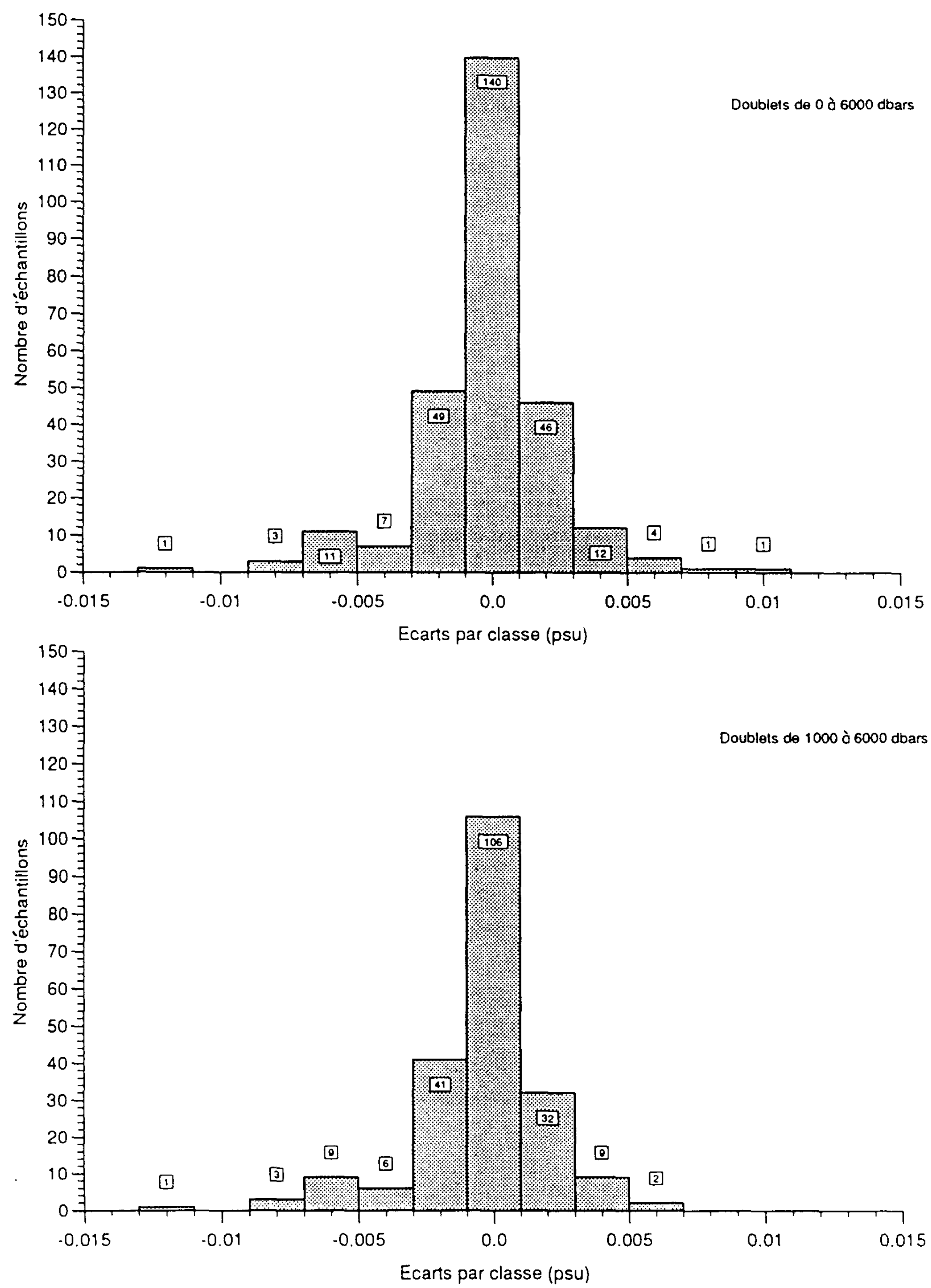


Fig. 5: Histogramme des écarts de salinité:
a) pour les 275 doublets de la campagne,
b) pour les 209 doublets réalisés à pression supérieure à 980 dbars.

Campagne CITHER 1

Répartition des écarts entre les doublets pour l'Oxygène

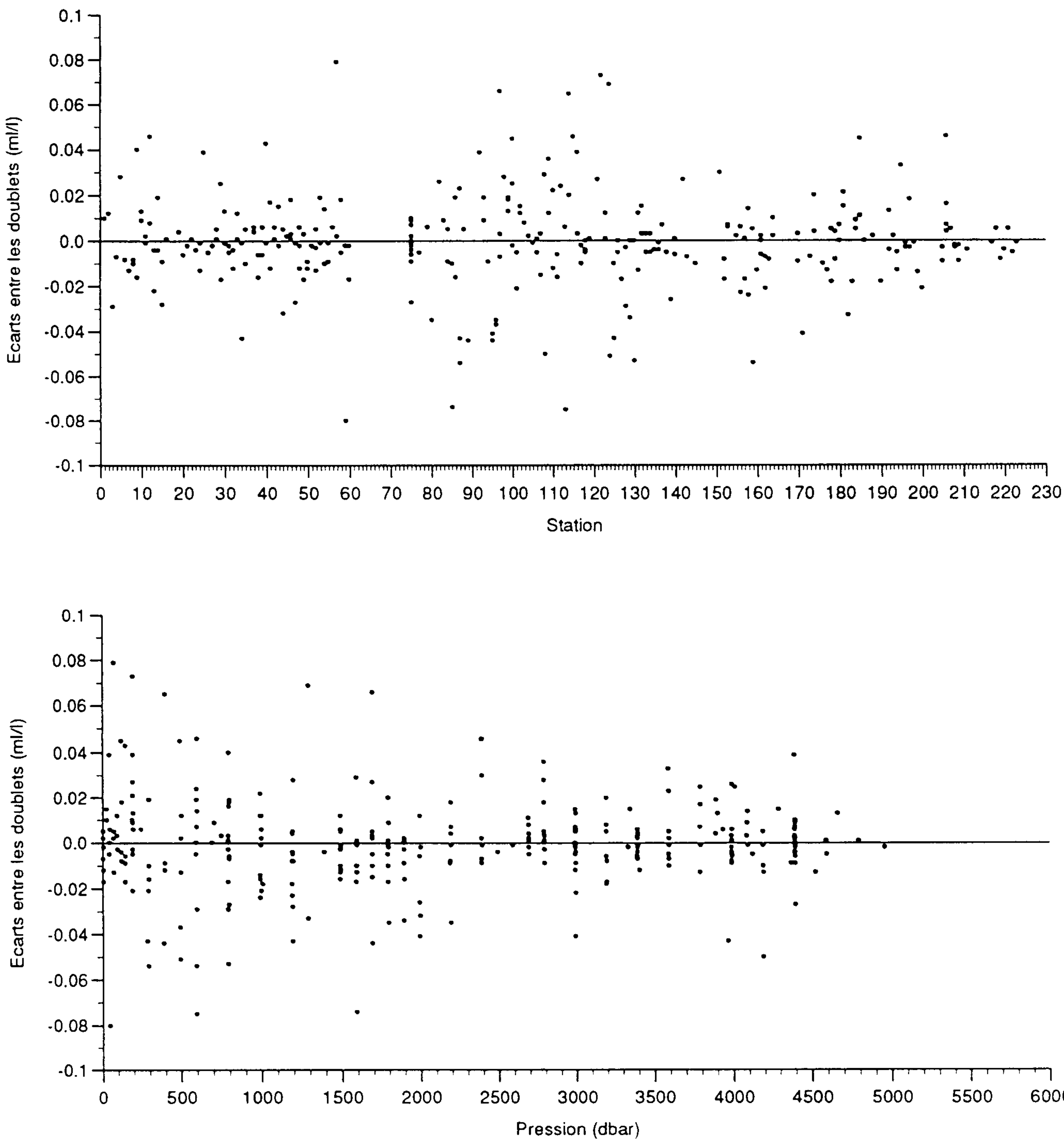


Fig. 6: Ecarts en oxygène entre deux bouteilles fermées au même niveau:
a) en fonction du numéro de station à laquelle a été réalisé le doublet,
b) en fonction de la pression à laquelle a été réalisé le doublet.

Campagne CITHER 1

Répartition des doublets en Oxygène

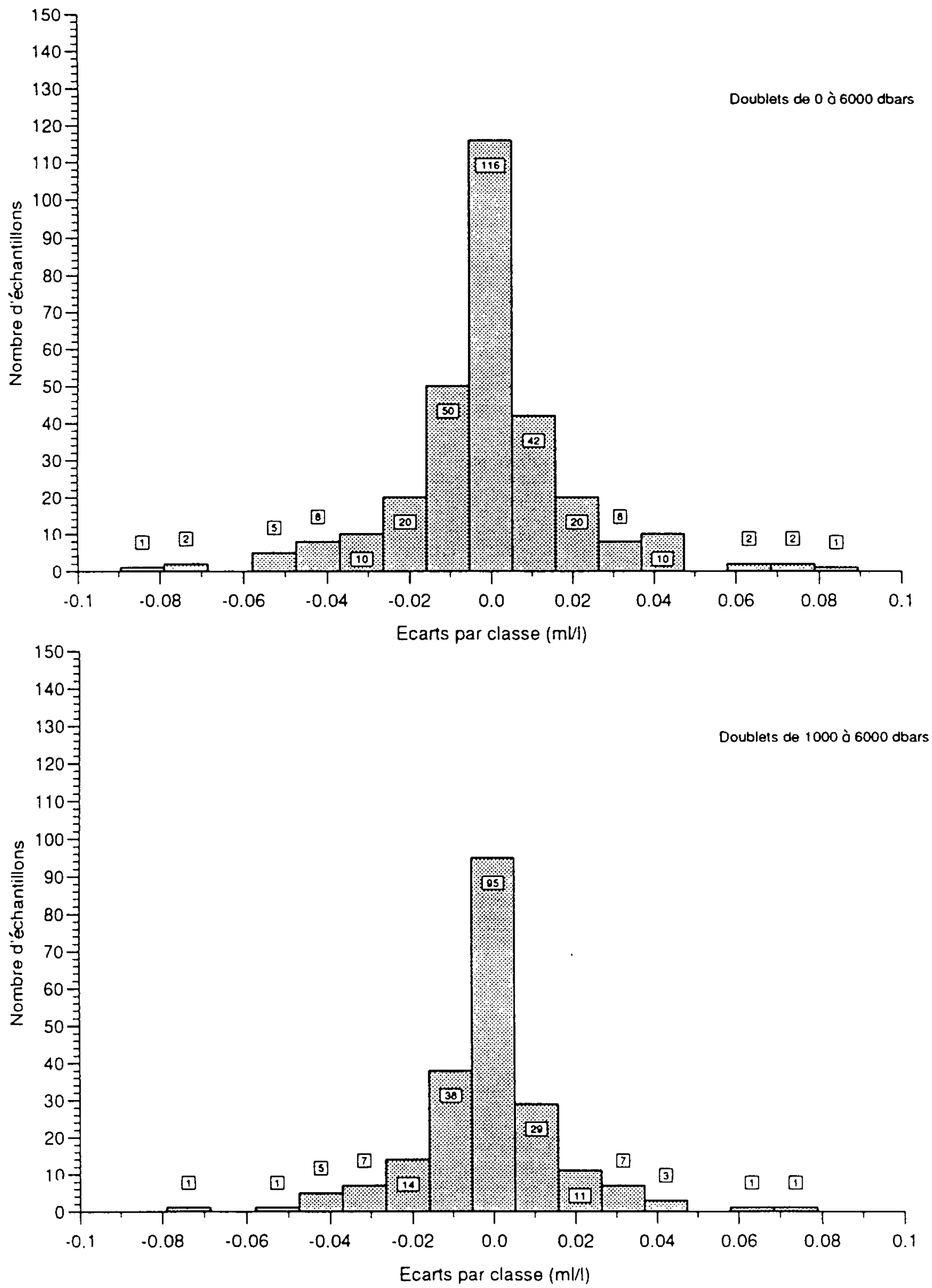


Fig. 7: Histogramme des écarts en oxygène:
a) pour les 275 doublets de la campagne,
b) pour les 209 doublets réalisés à pression supérieure à 980 dbars.

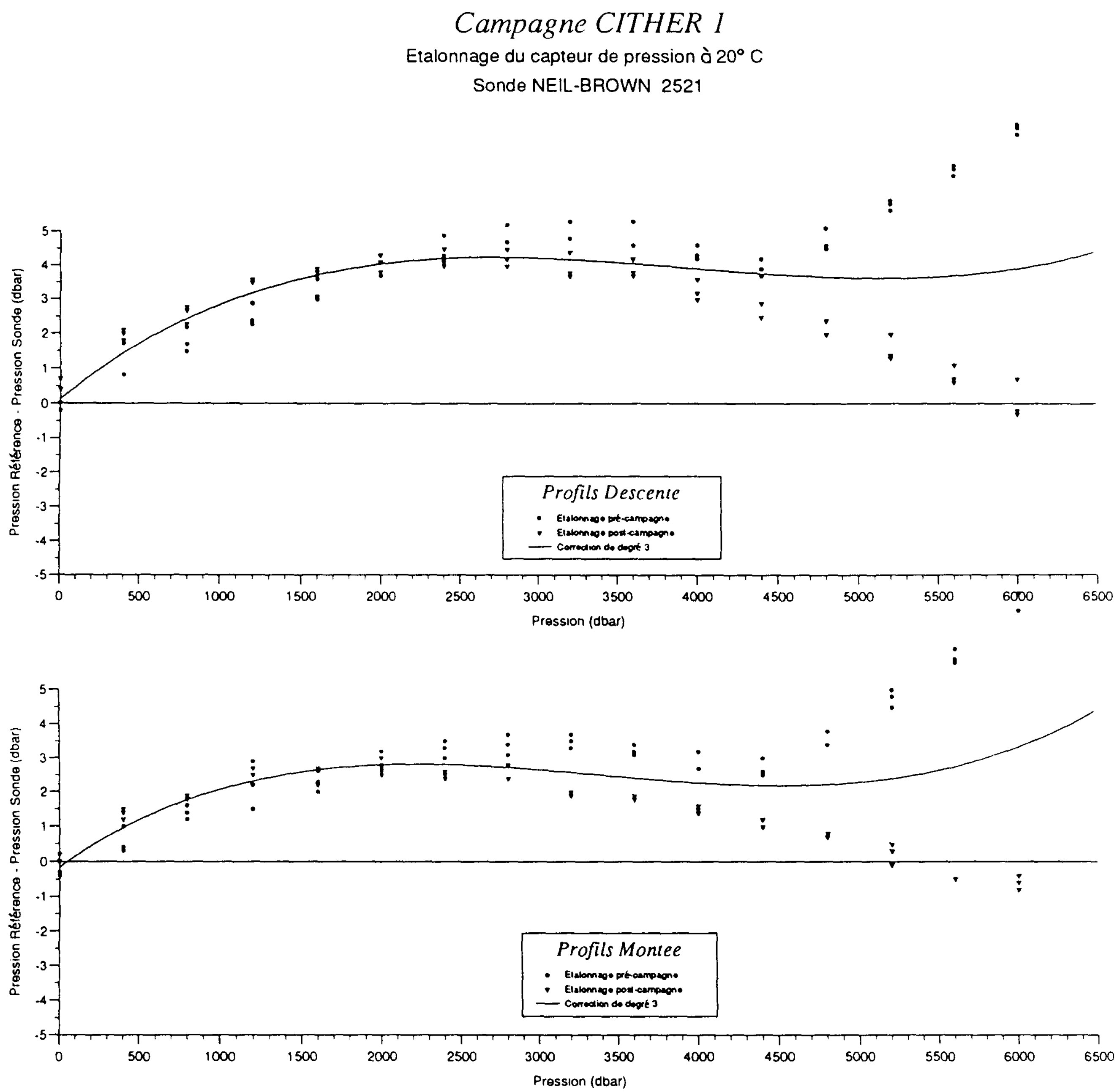


Fig. 8: Répartition des écarts, tous les 400 dbars, entre la pression de référence et la pression indiquée par le capteur Neil-Brown (sonde 2521) lors de l'étalonnage pré- et post- campagne à la température de 20°C:
a) cycles montée en pression (profil descente),
b) cycles descente en pression (profil montée).
Le courbe de degré 3 qui réduit ces écarts est représentée.

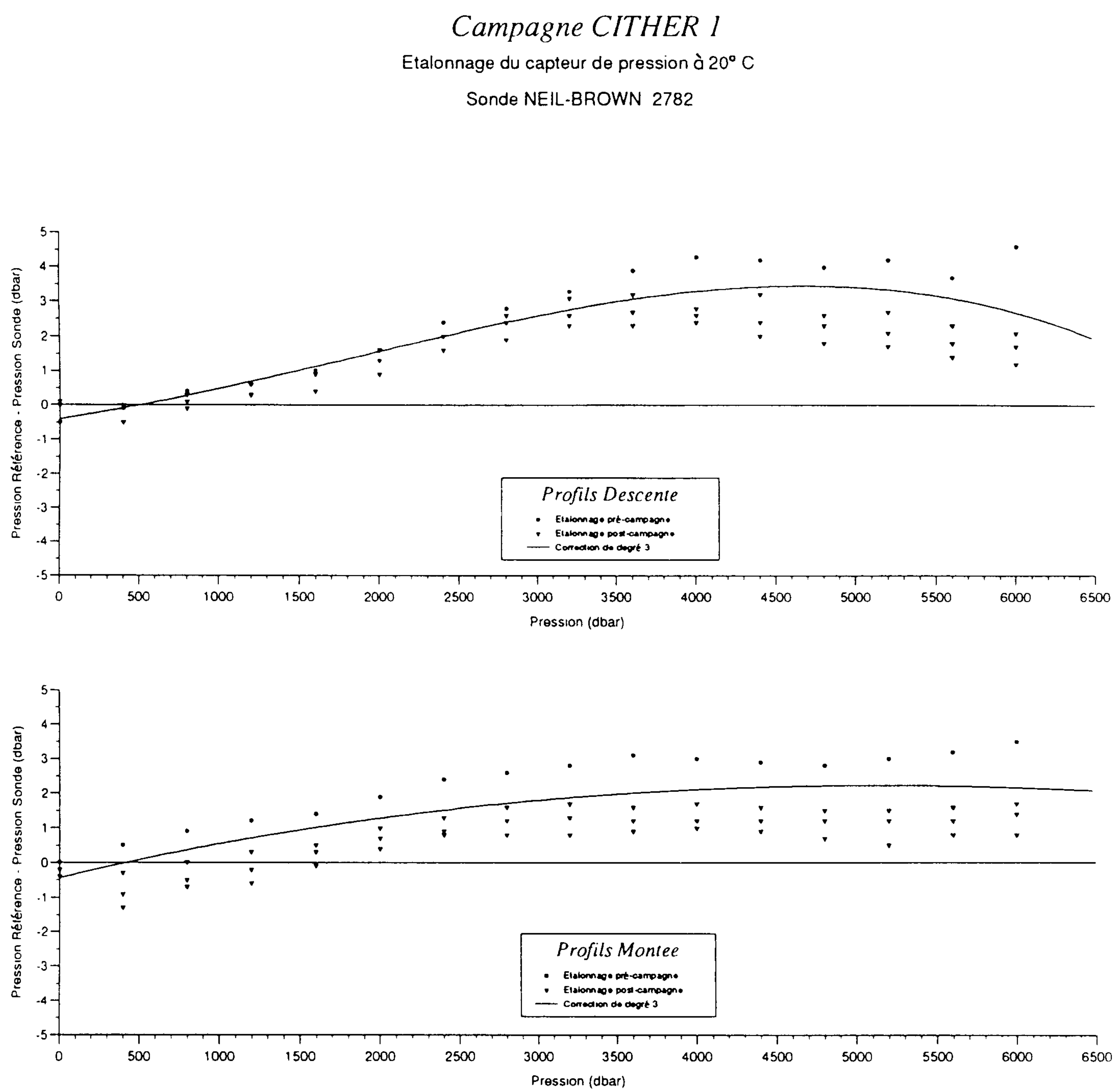


Fig. 9: Répartition des écarts, tous les 400 dbars, entre la pression de référence et la pression indiquée par le capteur Neil-Brown (sonde 2782) lors de l'étalonnage pré- et post- campagne à la température de 20°C:
a) cycles montée en pression (profil descente),
b) cycles descente en pression (profil montée).
Le courbe de degré 3 qui réduit ces écarts est représentée.

Campagne CITHER 1

Influence de la température sur le capteur de pression

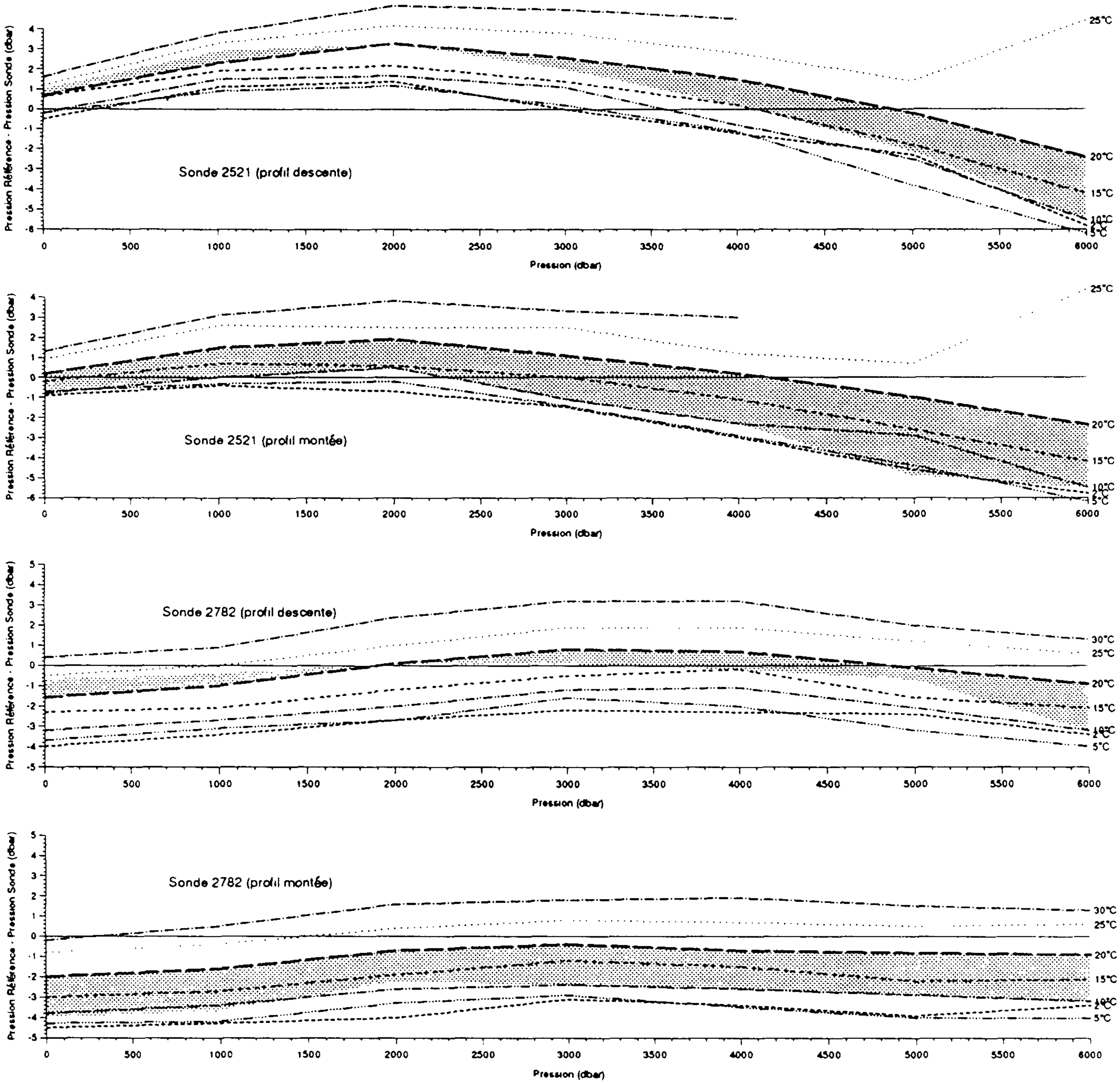


Fig. 10: Ecarts, tous les 1000 dbars, entre la pression référence et la pression indiquée par le capteur Neil-Brown à différentes températures expérimentales. Les limites de la surface pointillée sont, d'une part, la courbe obtenue à la température à 20°C et, d'autre part, celle d'une température à la température équivalente interne du capteur Neil-Brown mesurée sur les profils "bathysonde": cette surface correspond à la correction de température statique.

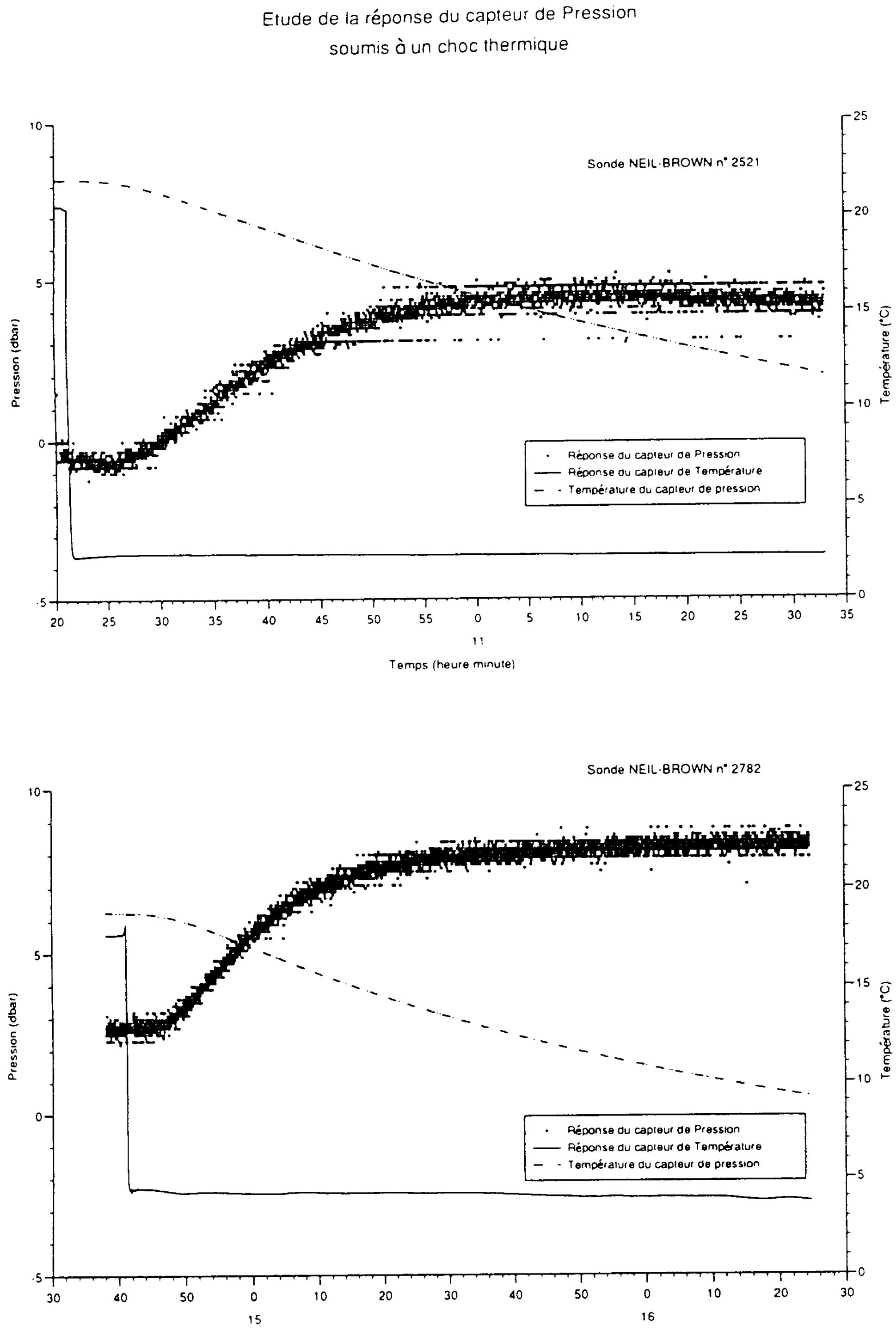


Fig. 11: Etude de l'effet dynamique de température sur les capteurs de pression Neil-Brown (2521 et 2782) en laboratoire. Après immersion de la sonde dans un bain plus froid, les paramètres pression, température et température interne du capteur de pression sont représentés en fonction du temps. Le choc thermique provoque un décalage de l'indication de pression qui atteint environ 5 dbars après 30 minutes.

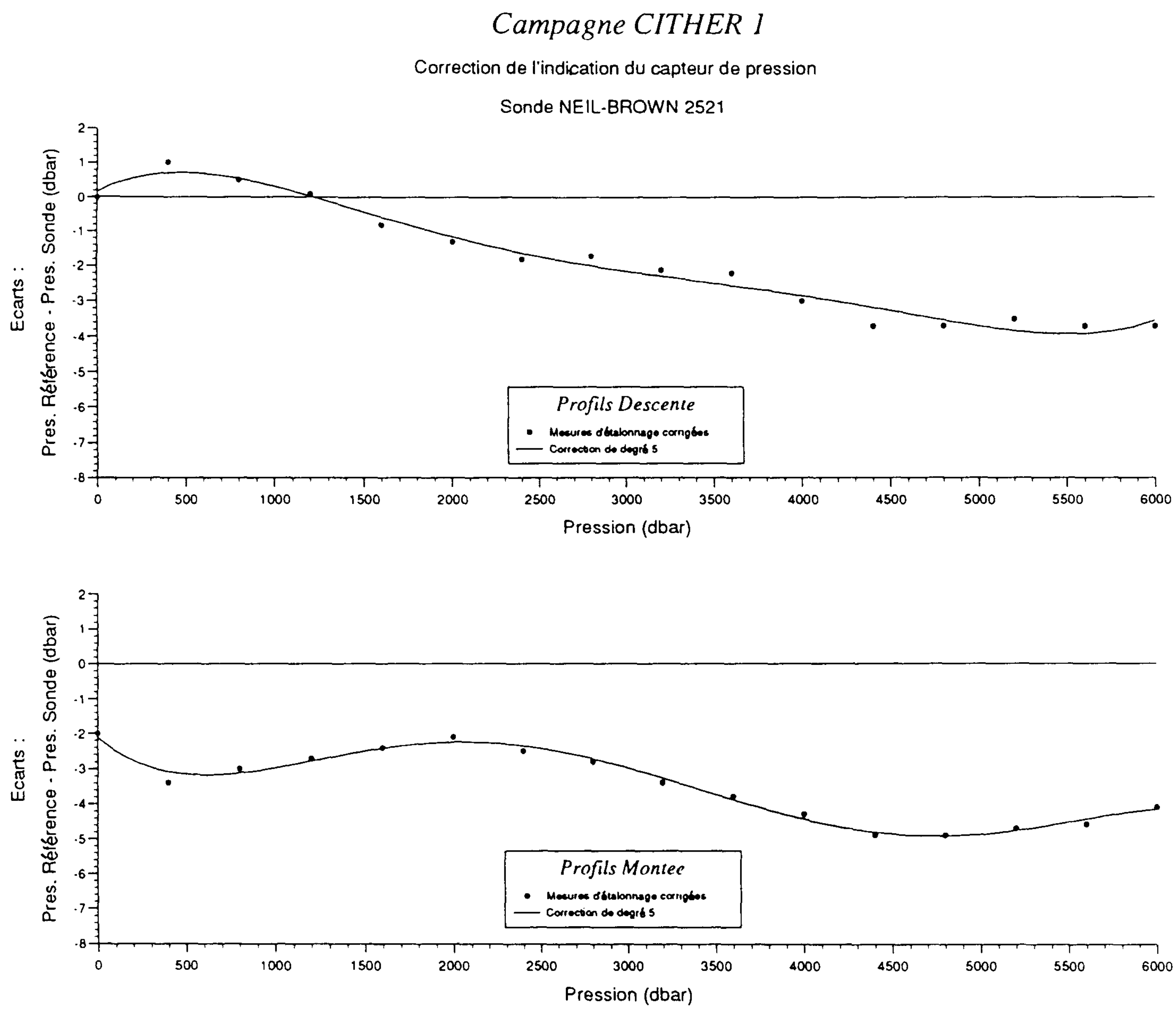


Fig. 12: Ecarts, tous les 400 dbars, entre la pression de référence et la pression indiquée par le capteur Neil-Brown (sonde 2521) après correction de la linéarité du capteur à 20° (figure 8), de l'influence de température statique (figure 10) et de l'effet dynamique de température (figure 11).
a) montée en pression (profil descente),
b) descente en pression (profil montée).
La courbe de degré 5 qui corrige la pression sur les profils est représentée.

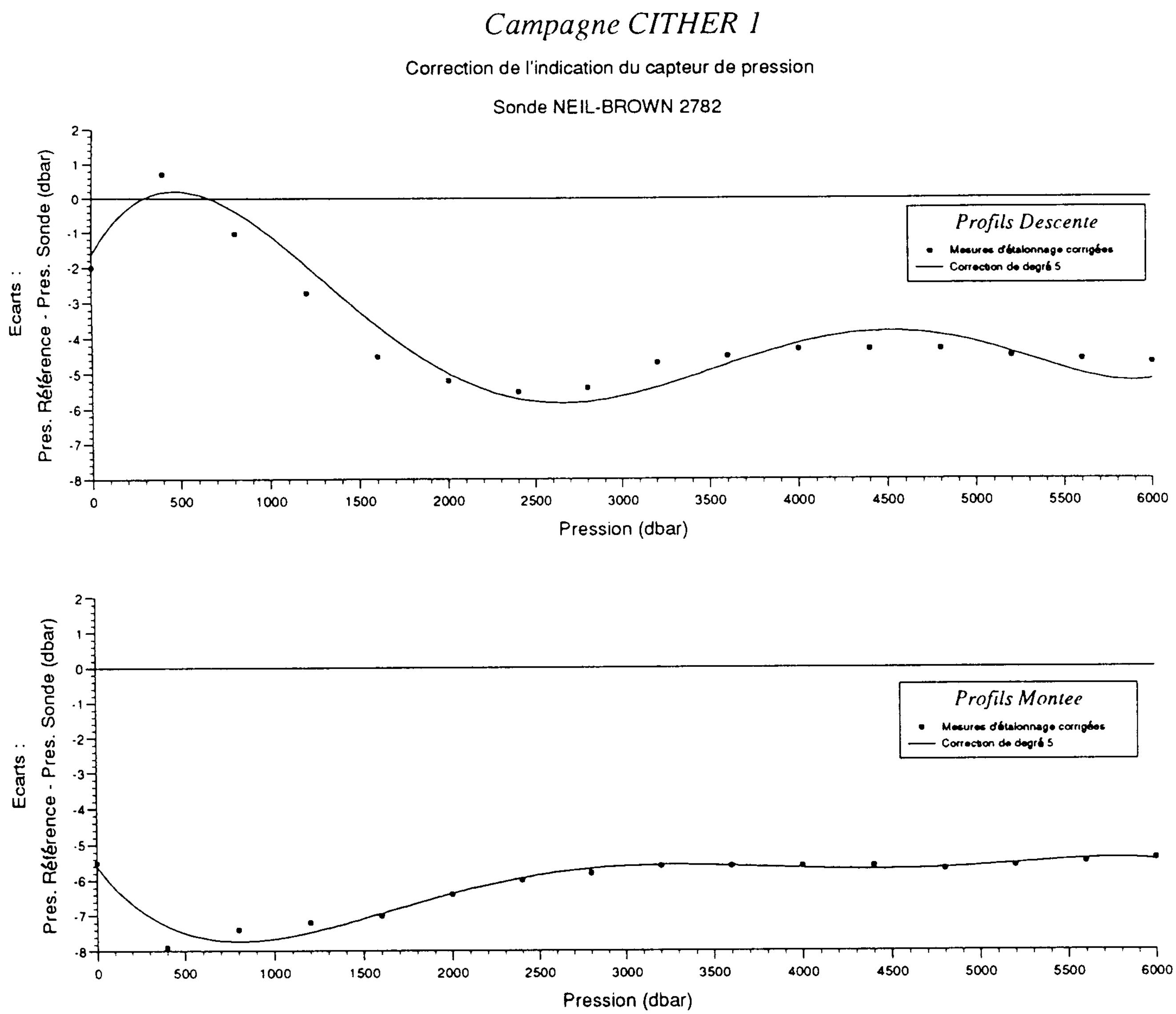


Fig. 13: Ecarts, tous les 400 dbars, entre la pression de référence et la pression indiquée par le capteur Neil-Brown (sonde 2782) après correction de la linéarité du capteur à 20° (figure 9), de l'influence de température statique (figure 10) et de l'effet dynamique de température (figure 11).
a) montée en pression (profil descente),
b) descente en pression (profil montée).
La courbe de degré 5 qui corrige la pression sur les profils est représentée.

Campagne CITHER 1

Ecarts entre les pressiomètres SIS et les sondes NEIL-BROWN

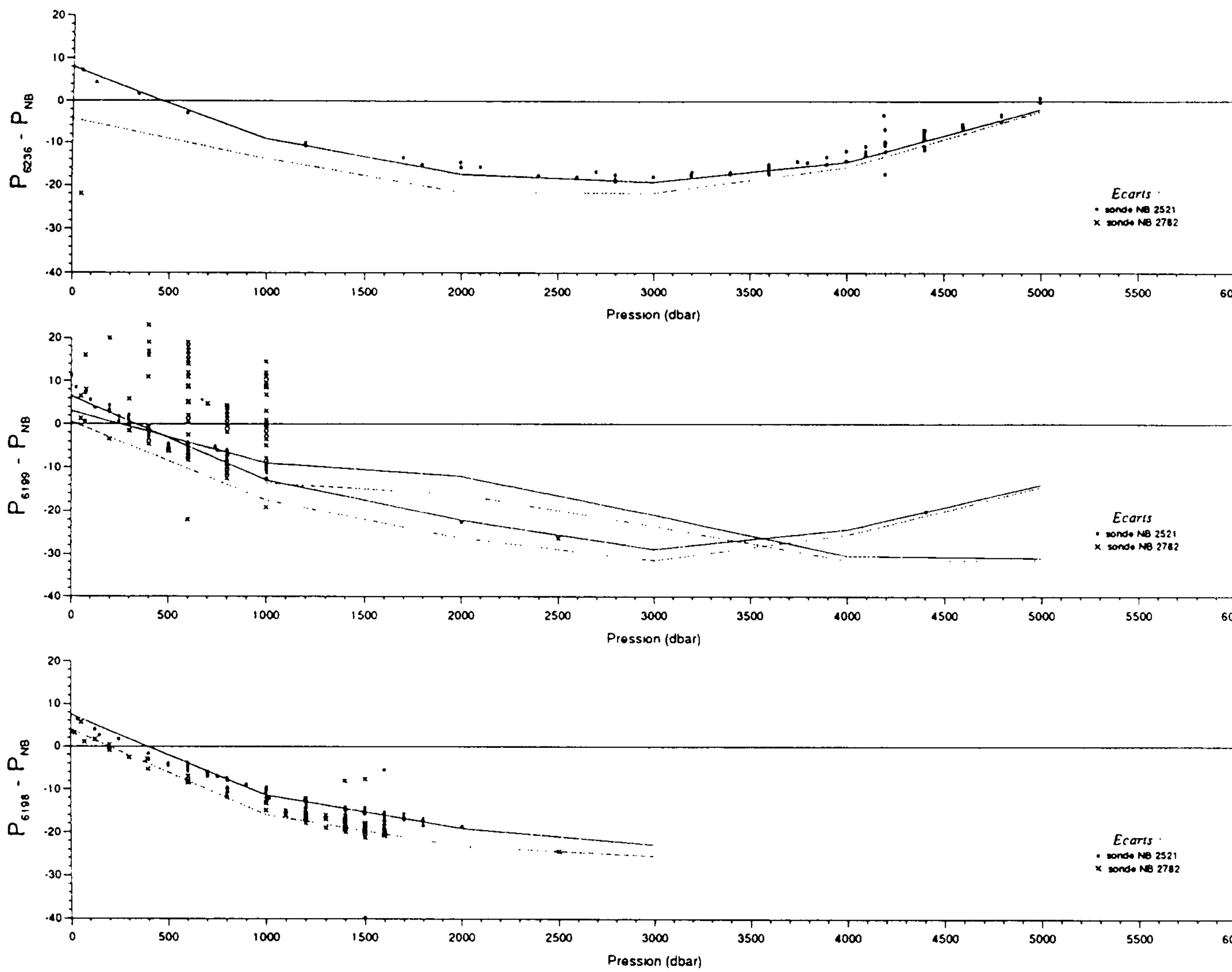


Fig. 14: Ecarts obtenus, à chaque station, entre la lecture de 3 pressiomètres SIS et la pression indiquée par le capteur Neil-Brown en fonction de la pression d'observation. Les écarts, concernant les deux sondes utilisées pendant la campagne sont différenciés. Les courbes (en trait plein pour la sonde 2521 et en pointillé pour la sonde 2782) représentent la correction d'étalonnage à apporter à la lecture des deux instruments comparés (SIS et Neil-Brown). Lorsque les étalonnages pré- et post- campagne du pressiomètre sont différents, deux courbes sont présentées.

Les points comparés à ces courbes montrent que, après correction, la pression SIS est égale à la pression CTD à 2 dbars près (le pressiomètre 6199 est devenu défectueux en cours de campagne).

Campagne CITHER 1

Ecarts entre les pressiomètres SIS et les sondes NEIL-BROWN

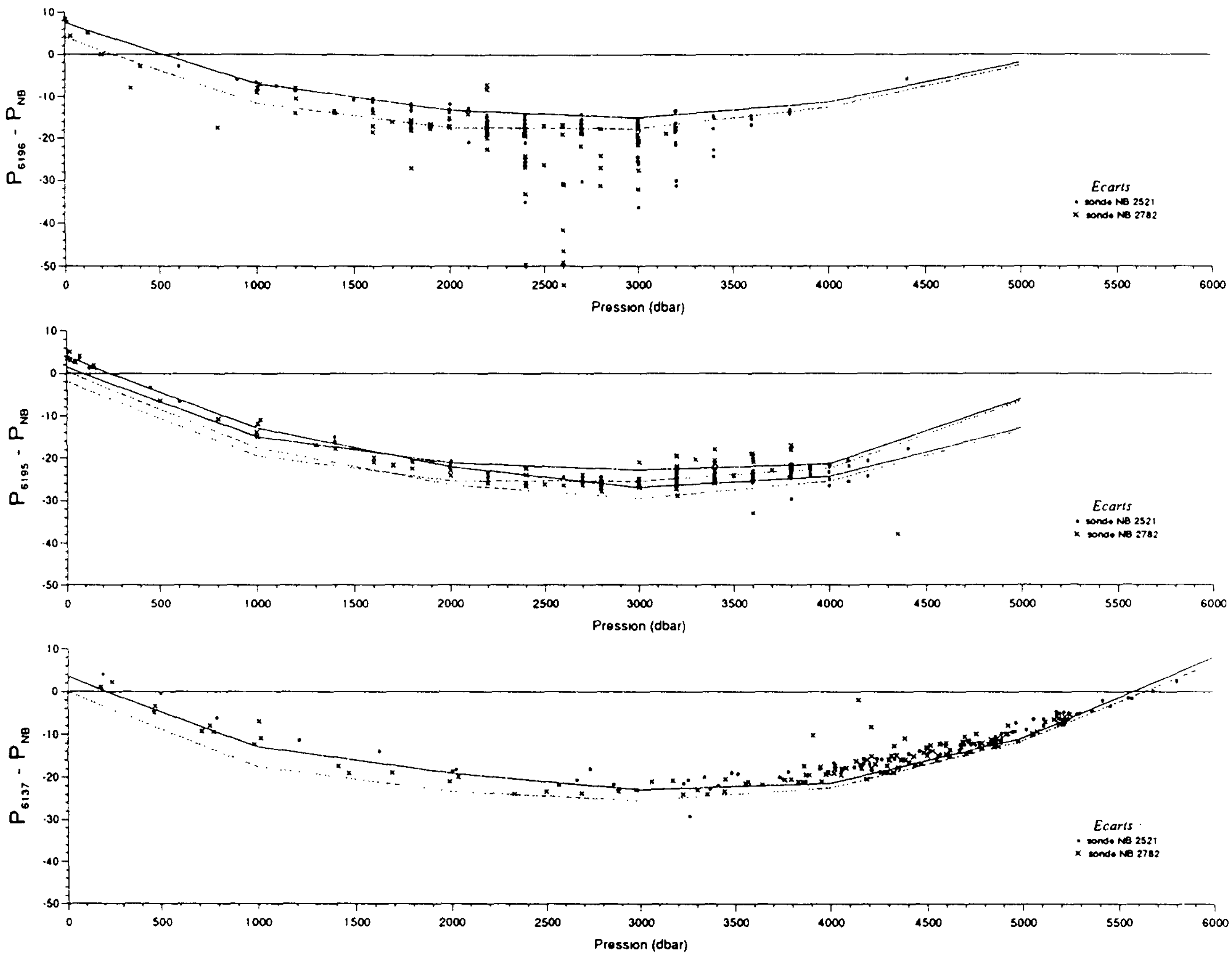


Fig. 15: même légende que la figure 14 pour une autre série de 3 pressiomètres.

- A noter le mauvais fonctionnement intermittent du pressiomètre 6196.
- Dans le cas du pressiomètre 6137, les écarts observés après correction sont de l'ordre de 4 dbars : cette différence est attribuée à un étalonnage incorrect du pressiomètre.

Campagne CITHER 1

Etalonnage du capteur de température pour les sondes NEIL-BROWN

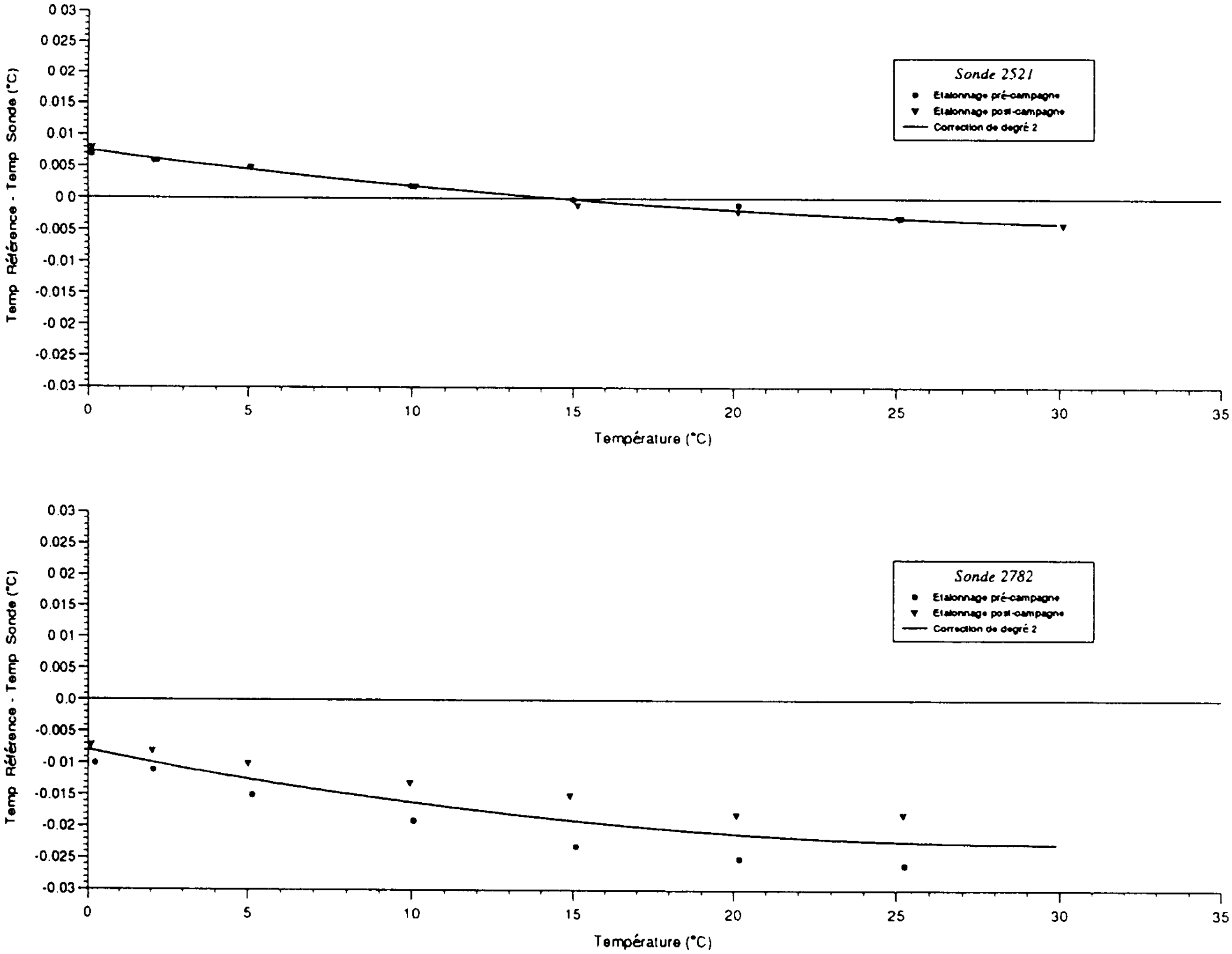


Fig. 16: Ecarts entre la température de référence et la température indiquée par le capteur Neil-Brown lors de l'étalonnage pré- et post- campagne:
a) sonde 2521,
b) sonde 2782.
La courbe de degré 2 qui corrige la température sur les profils est représentée.

Campagne CITHER 1

Ecarts entre les thermomètres SIS et les sondes NEIL-BROWN

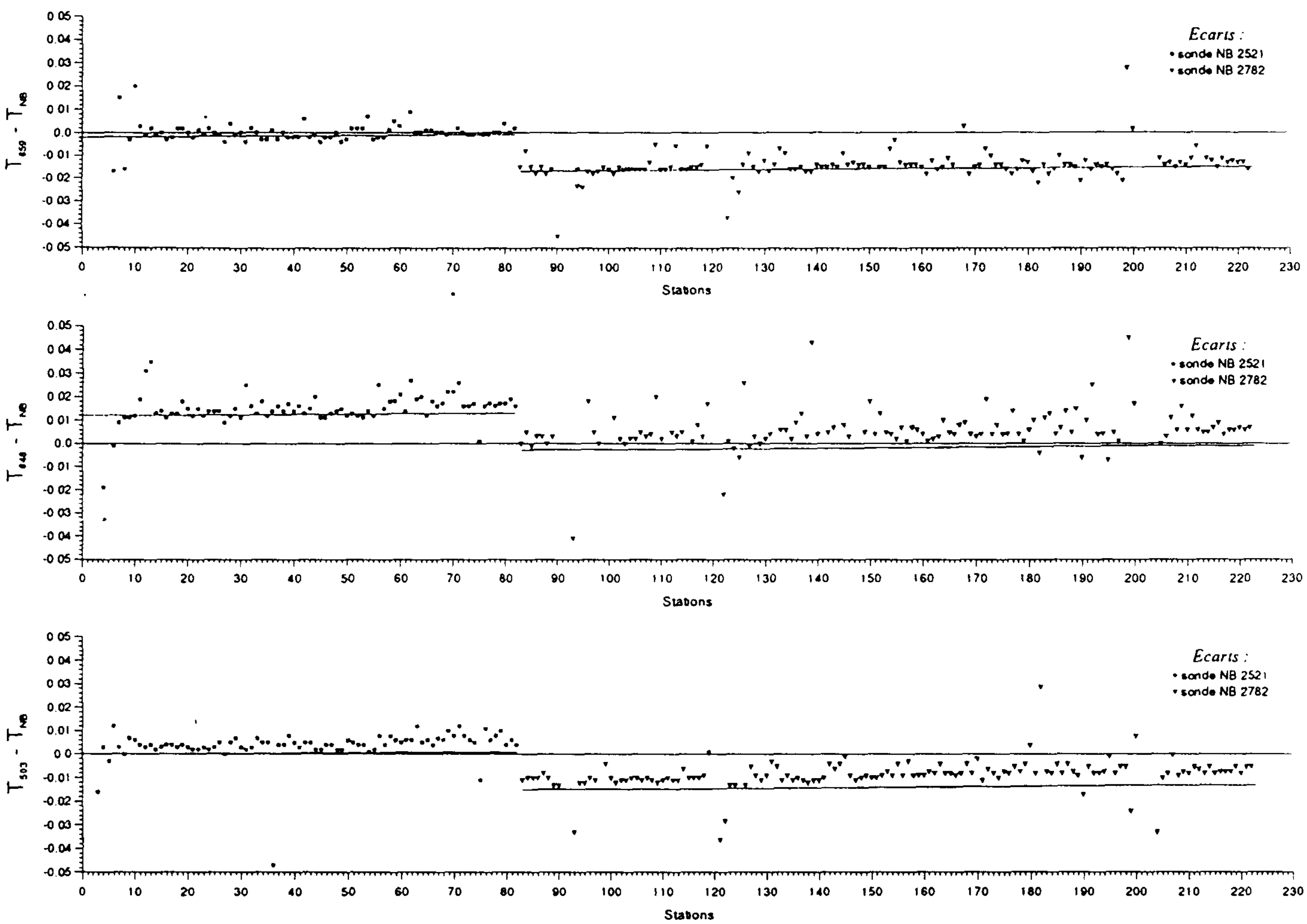


Fig. 17: Ecarts obtenus, à chaque station, entre la lecture de 3 thermomètres SIS, et la température indiquée par le sonde Neil-Brown: la température expérimentale est comprise entre 2.5 et 5.0˚C.
Les segments de droites représentent la correction d'étalonnage à apporter à l'indication du capteur Neil-Brown additionnée à celle du thermomètre SIS. La dérive des thermomètres a été compensée à raison de 0.001˚ entre les stations 1 et 82 et de 0.002˚C entre les stations 83 et 223.
Le décalage des points par rapport à ces segments de droites est attribué à un effet de pression sur le thermomètre SIS.

Campagne CITHER 1

Ecarts entre les thermomètres SIS et les sondes NEIL-BROWN

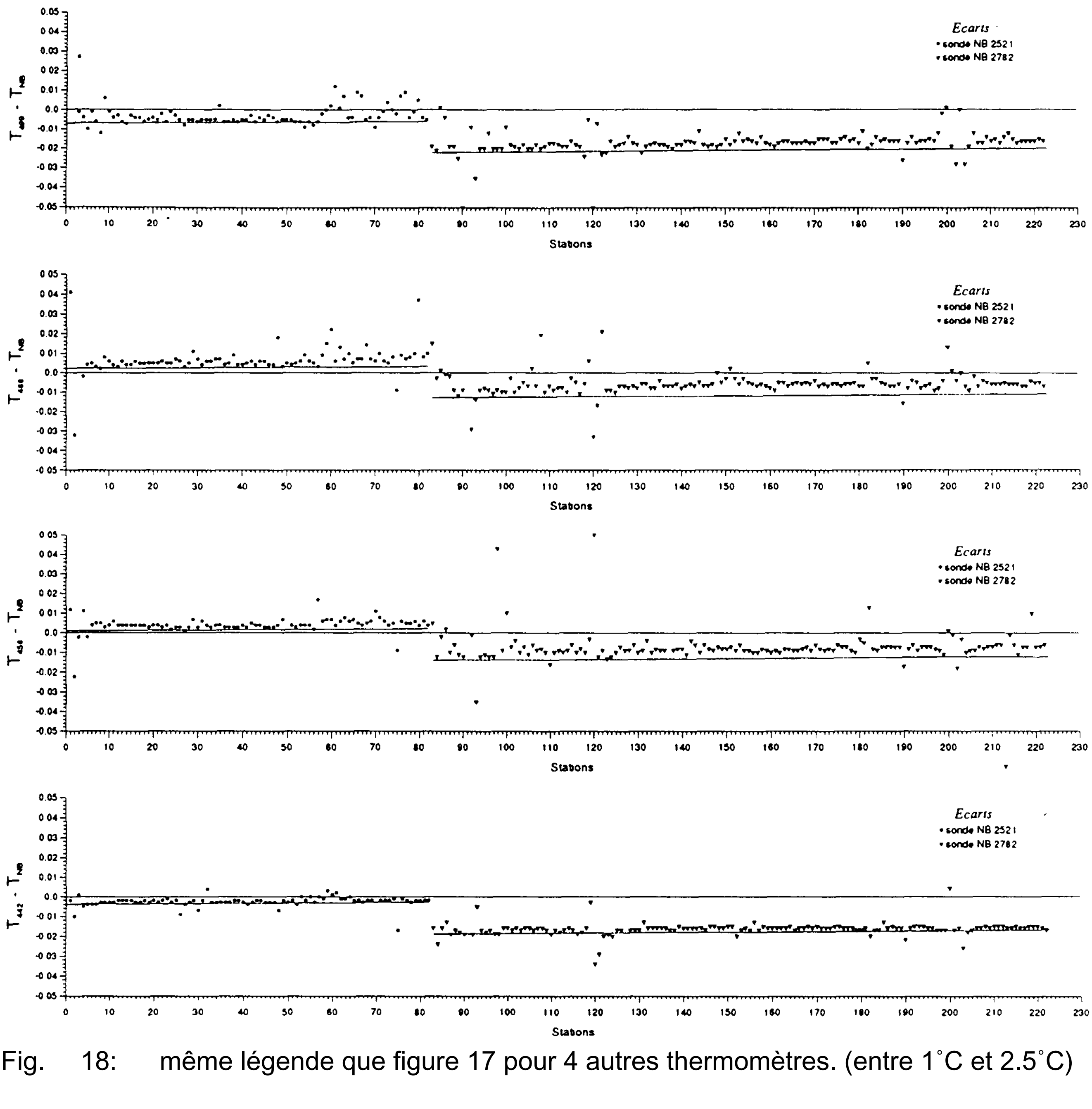


Fig. 18: même légende que figure 17 pour 4 autres thermomètres. (entre 1˚C et 2.5˚C)

Campagne CITHER 1

Répartition des écarts en conductivité
après recalage des profils CTD

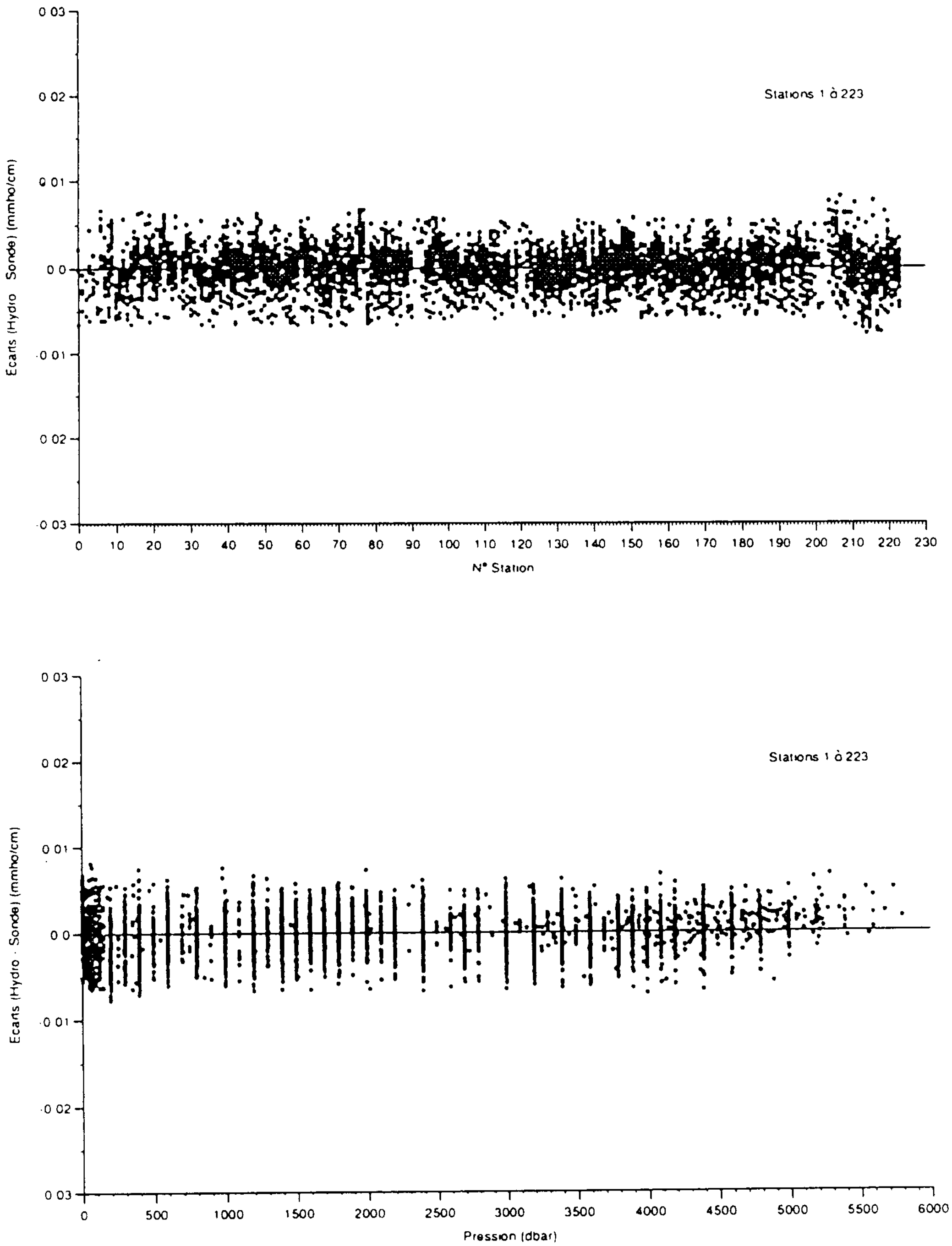


Fig. 19: Ecarts entre la conductivité des 5580 échantillons validés et la conductivité 'bathysonde', au niveau du prélèvement, après recalage:
a) en fonction du numéro de la station concernée,
b) en fonction de la pression au niveau du prélèvement.

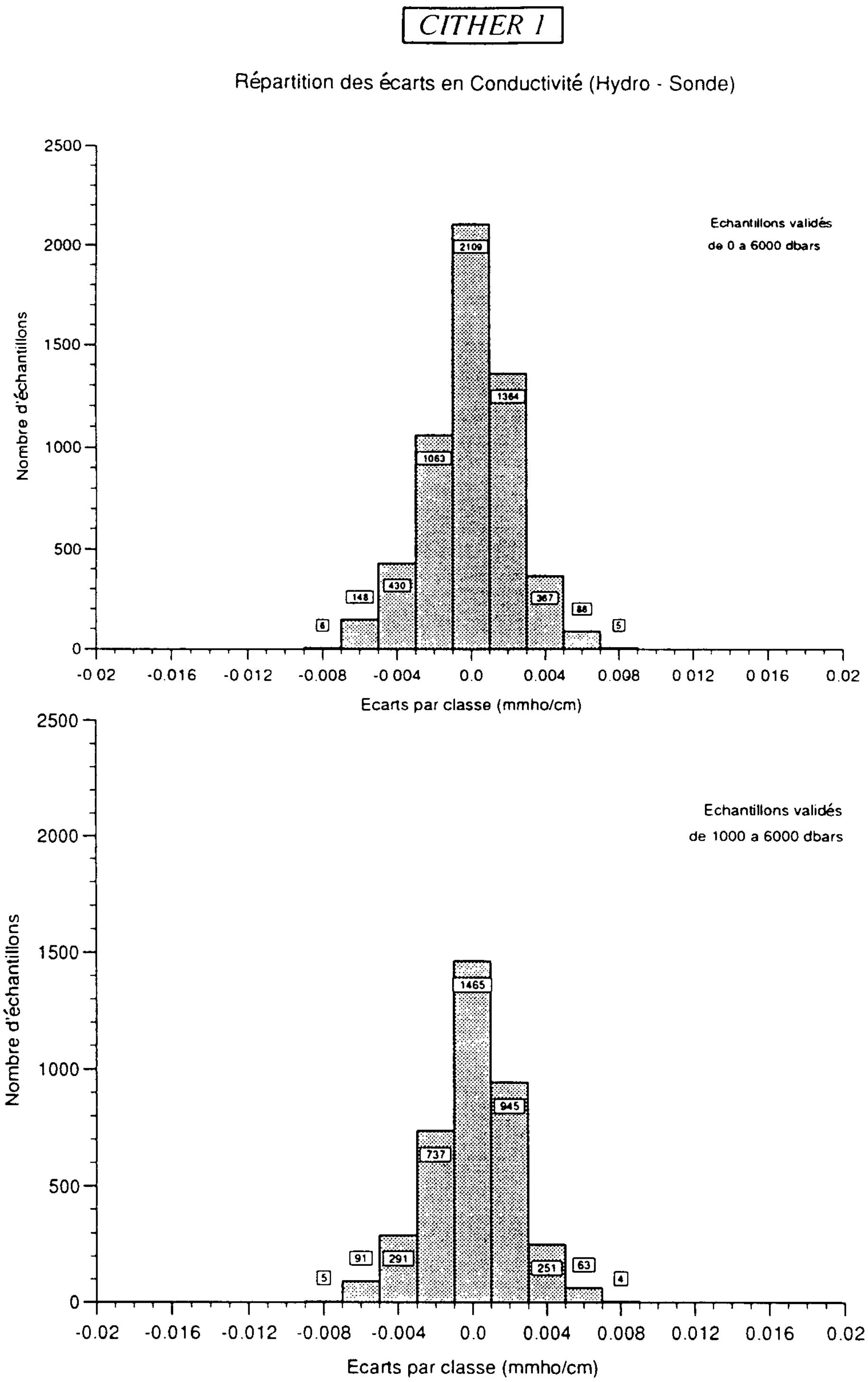


Fig. 20: Histogramme des écarts entre la conductivité des échantillons et la conductivité 'bathysonde', au niveau du prélèvement, après recalage:
a) pour la totalité des 5580 échantillons validés sur la campagne,
b) pour les 3852 échantillons validés et prélevés à pression supérieure à 980 dbars.

CITHER 1

Répartition des écarts en Salinité (Hydro - Sonde)

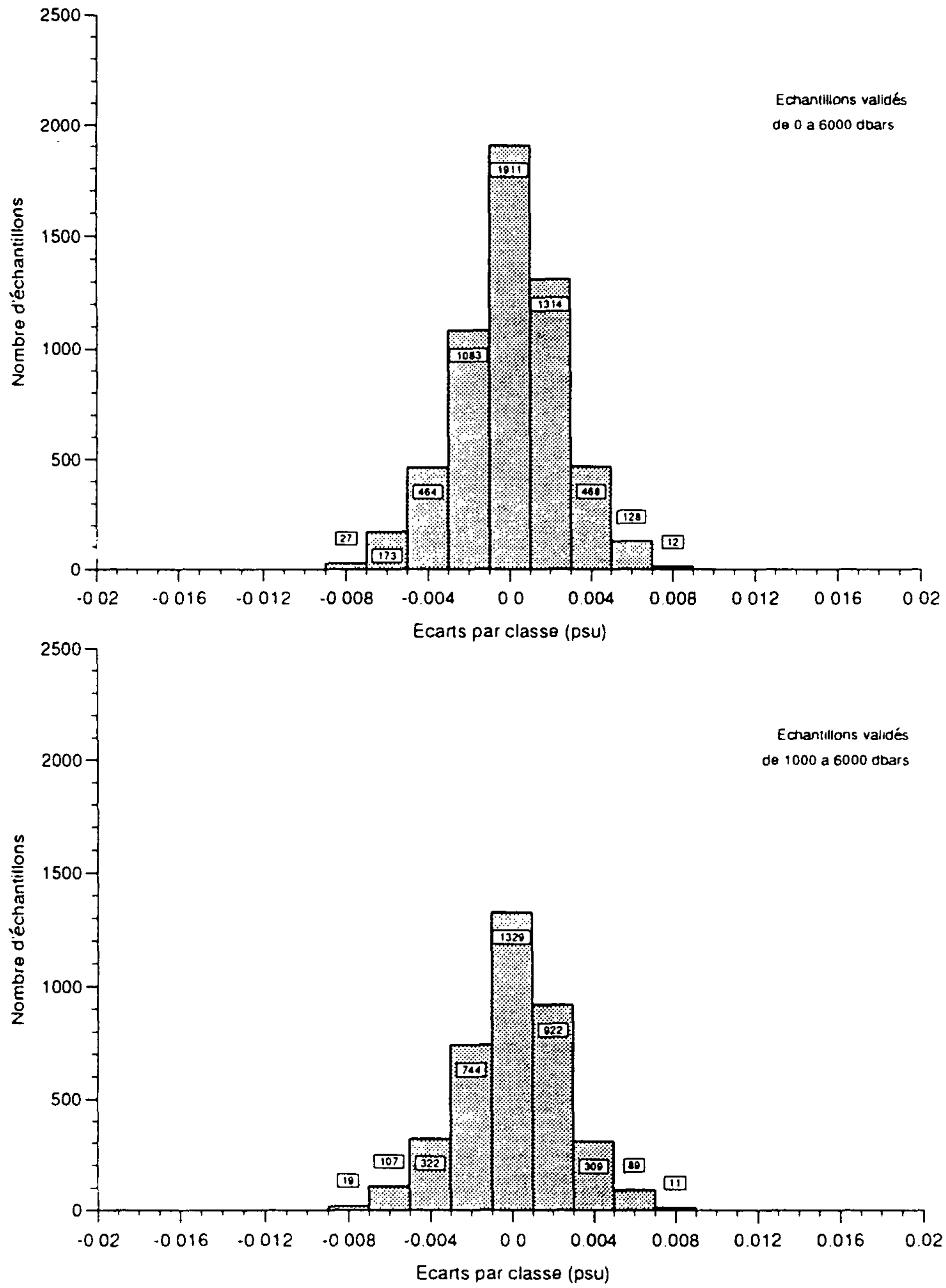


Fig. 21: même légende que figure 20 pour les écarts en salinité.

Diagrammes θ-S

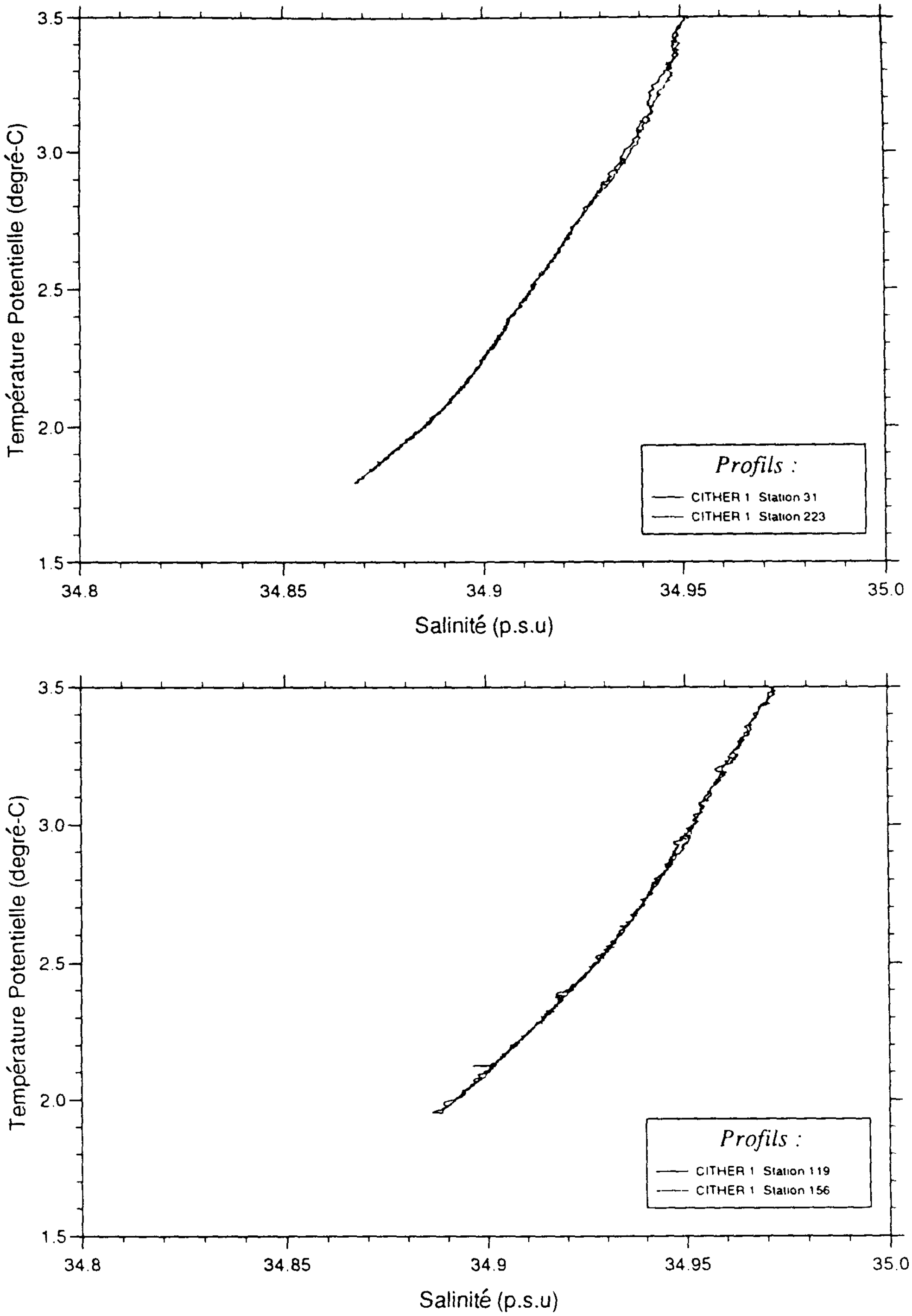


Fig. 22: Comparaison de diagrammes θ-S tracés d'après les données de la campagne CITHER 1.
Dans les deux cas, les stations ont été réalisées à la même position géographique avec unesonde différente.

Diagrammes θ-S

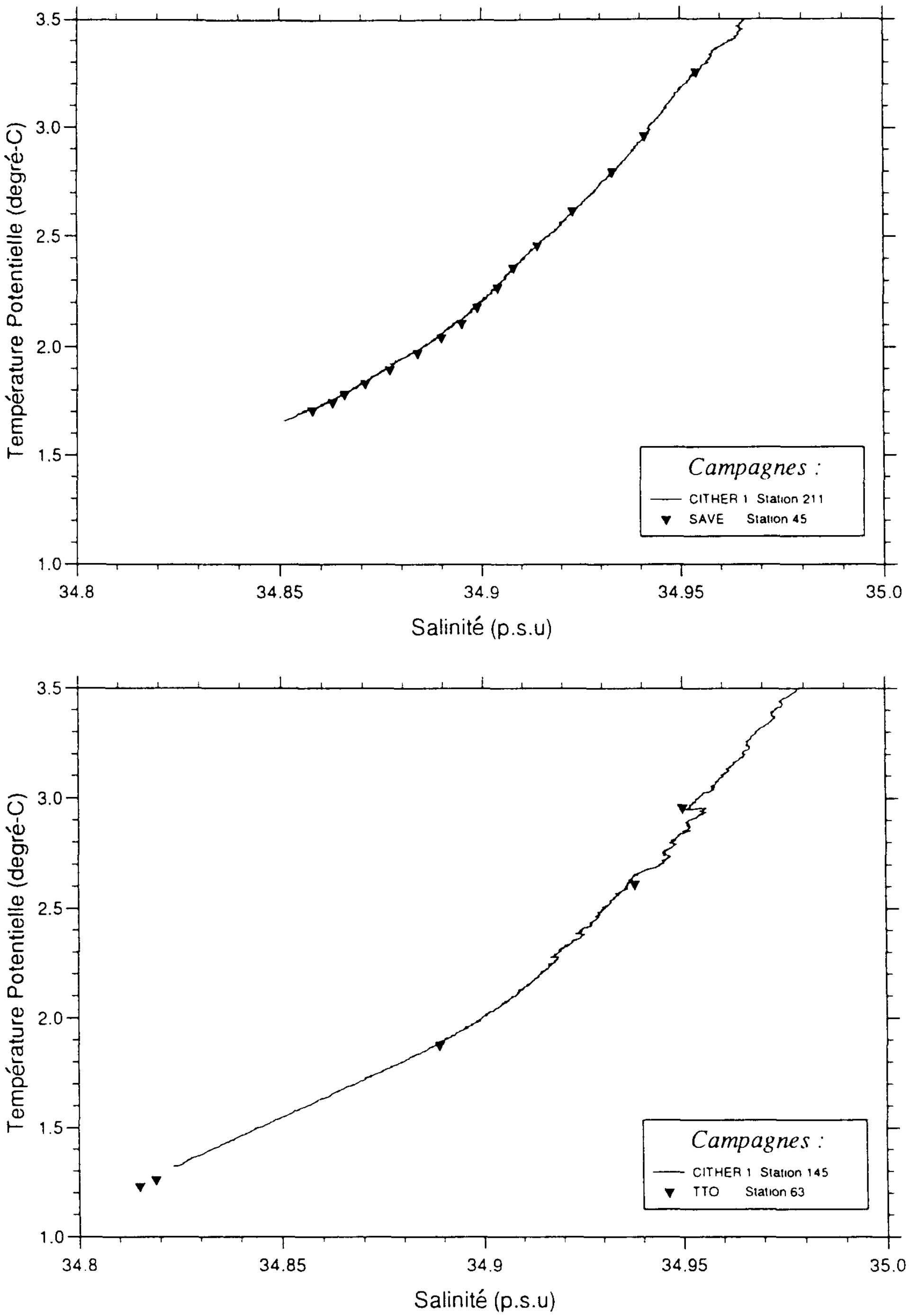


Fig. 23: Comparaison de diagrammes θ-S de la campagne CITHER 1 avec les données d'autres campagnes obtenues à une position géographique proche:
a) station 211 de CITHER 1 et station 45 de SAVE (leg 2) (données 'bathysonde'),
b) station 145 de CITHER 1 et station 63 de TTO-TAS (données 'rosette').

Campagne CITHER 1

Répartition des écarts en Oxygène
après recalage des profils CTD

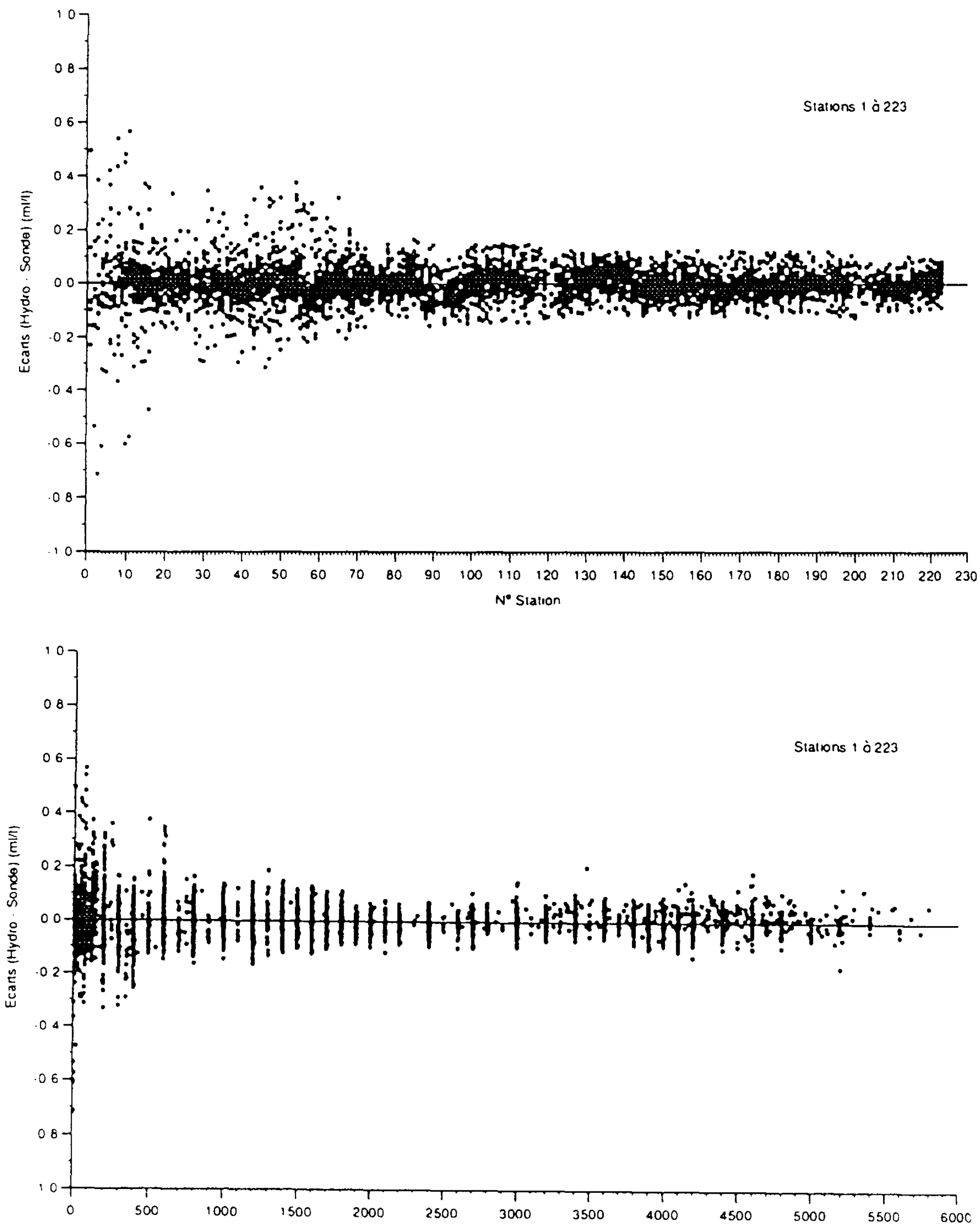


Fig. 24: Ecarts entre la valeur d'oxygène mesurée sur les 6052 échantillons validés et celle du profil descente 'bathysonde' à la pression du prélèvement, après recalage:
a) en fonction du numéro de la station concernée,
b) en fonction de la pression au niveau du prélèvement.

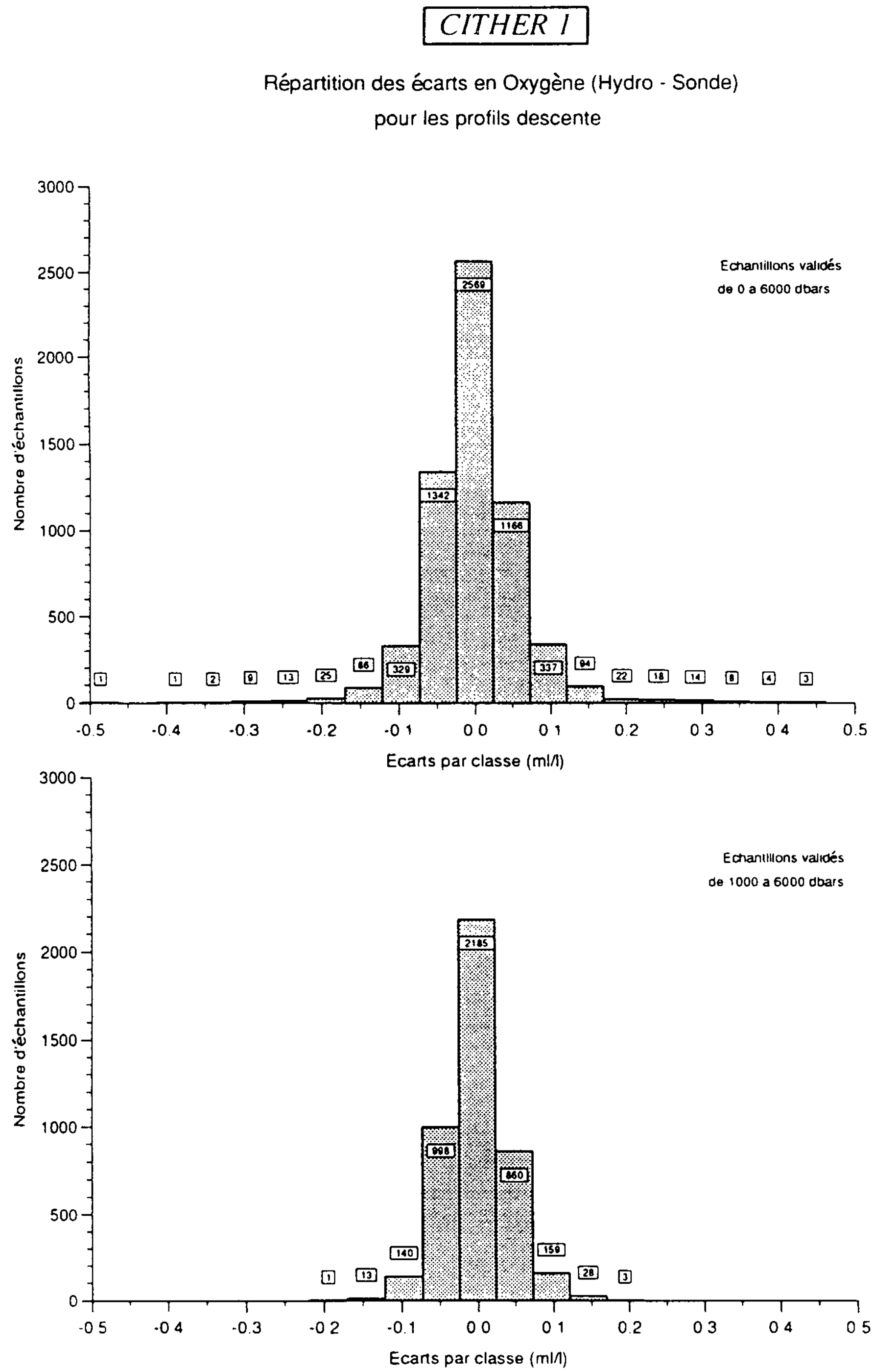


Fig. 25: Histogramme des écarts en oxygène entre la valeur mesurée sur les échantillons validés et celle du profil descente 'bathysonde' à la pression du prélèvement, après recalage:
a) pour la totalité des 6052 échantillons validés sur la campagne,
b) pour les 4387 échantillons validés et prélevés à pression supérieure à 980 dbars.

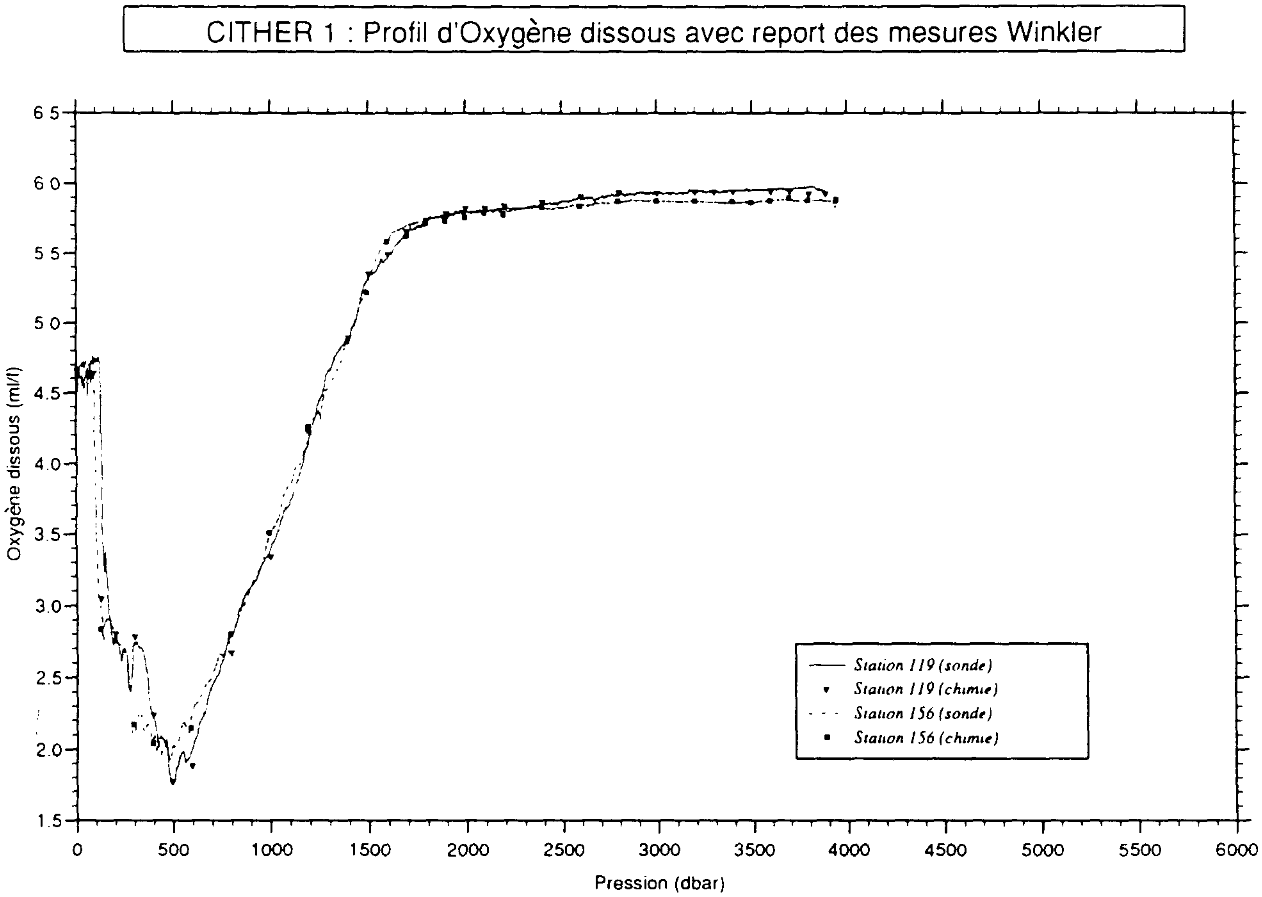


Fig. 26: Profils d'oxygène dissous obtenus à la campagne CITHER 1. Les stations 119 et 156 ont été réalisé à la même position géographique avec deux sondes différentes. L'oxygène mesuré sur les prélèvements de chaque station est reporté sur les profils avec un signe distinctif.

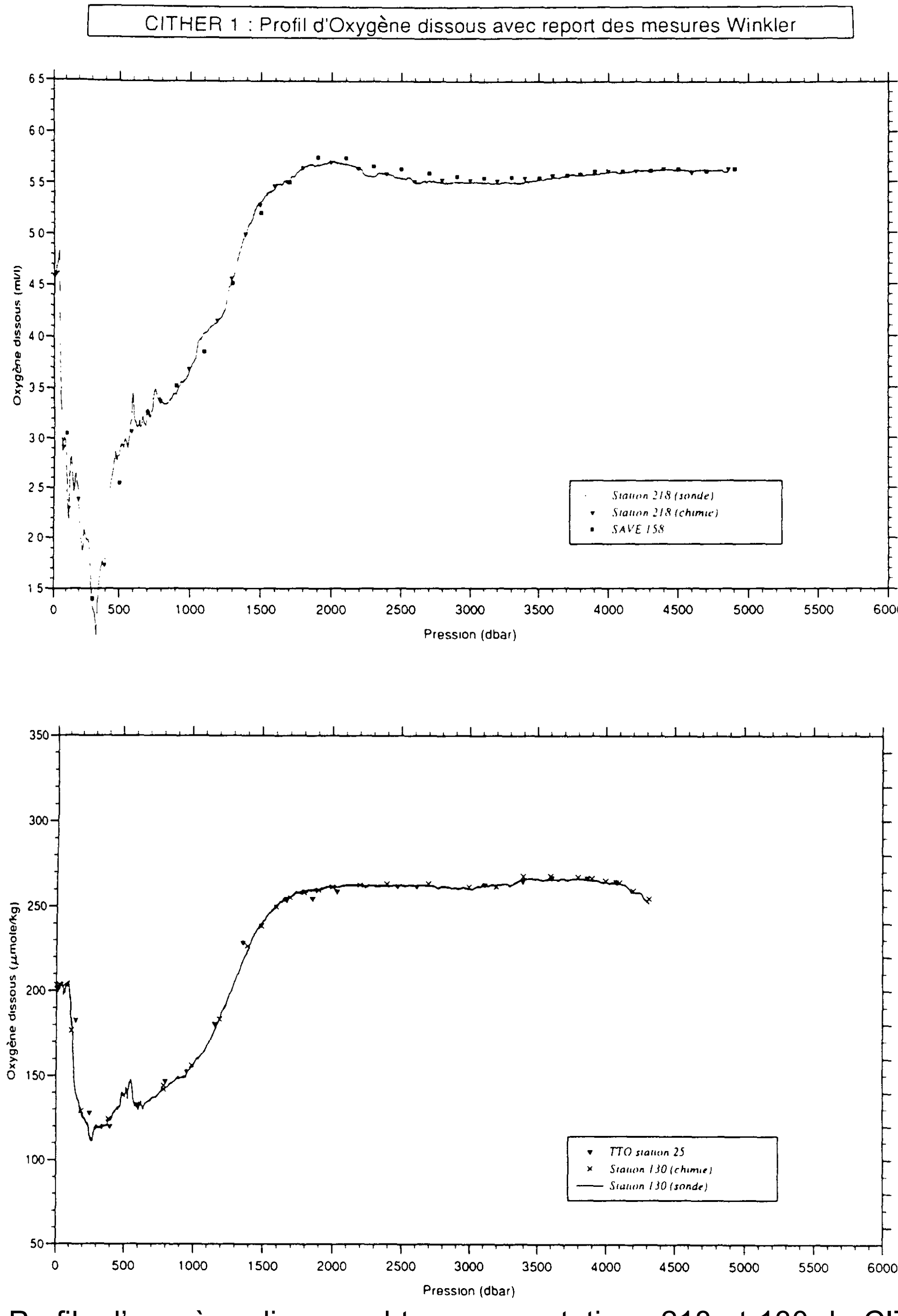


Fig. 27: Profils d'oxygène dissous obtenus aux stations 218 et 130 de CITHER 1. Les valeurs d'oxygène mesurées sur les prélèvements de ces 2 stations sont indiquées.

Pour comparaison, les mesures d'oxygène extraites de stations, réalisées à une position géographique proche, au cours d'autres campagnes sont portées sur ces figures.

a) les valeurs de la station SAVE 158 (leg 3) sont les données 'bathysonde',

b) les valeurs de la station TTO-TAS 25 sont les données 'rosette'.

Tableau III-1

Bilan de la calibration des profils de conductivité de la campagne CITHER 1

Sonde utilisée	Station ou groupe	Nombre d'échantillons considérés	Nombre d'échantillons retenus par le calcul	Déviation Standard (0-6000)	Coefficients	
					C1	C0
2521	1 => 56	1367	1187	0.0024	0.999357	0.0320
	57	32	28		"	0.0290
	58	32	29		"	0.0227
	59	32	28		"	0.0233
	60	32	27		"	0.0239
	61	32	29		"	0.0245
	62	32	31		"	0.0252
	63	32	28		"	0.0258
	64	32	29		"	0.0264
	65	32	27		"	0.0270
	66	32	29		"	0.0277
	67	32	30		"	0.0283
	68	32	30		"	0.0271
	69	32	26		"	0.0277
	70	32	28		"	0.0284
	71	32	31		"	0.0290
	72	32	28		"	0.0296
	73	32	30		"	0.0302
	74	32	30		"	0.0309
2782	75	32	32	0.0017	0.999022	0.0423
2521	76	32	30		0.999357	0.0303
	77	32	27		"	0.0310
	78	32	19		0.999492	0.0415
	79	32	29	0.0024	0.999716	0.0258
	80	32	30	0.0021	0.999520	0.0332
	81	32	29	0.0021	0.999382	0.0323
	82	32	29	0.0019	0.999096	0.0405
2782	83=>91	237	211	0.0022	0.999781	0.0063
	92=>118	769	686	0.0021	0.999695	0.0072
2521	119	32	29	0.0013	0.999862	0.0379
2782	120=>203	2425	2164	0.0021	0.999589	0.0112
	204=>219	479	442	0.0029	0.999545	0.0106
	220=>223	128	117	0.0020	0.999687	0.0106

Tableau III-2

Bilan de la calibration des profils d'oxygène dissous de la campagne CITHER 1

Capteur utilisé	**Station ou groupe**	**Nombre d'échantillons considérés**	**Nombre d'échantillons retenus par le calcul**	**Déviation Standard**			**Coefficients**				
				0-6000	**0-1000**	**1000-6000**	**SOC**	**OXPC**	**OXTC**	**OXC2**	
Capteur A	1 => 11	189	184	0.179	0.244	0.053	0.0356	0.000193	-0.0169	3.552	*Correction supplémentaire par polynome de degré 5*
	12	30	30	0.103	0.165	0.044	0.0394	0.000165	-0.0334	0.769	
	13	30	30	0.093	0.185	0.045	0.0404	0.000153	-0.0246	1.511	
	14	31	31	0.095	0.156	0.038	0.0398	0.000163	-0.0227	1.497	
	15	31	31	0.098	0.209	0.035	0.0409	0.000149	-0.0252	1677	
	16	32	32	0.131	0.240	0.029	0.0403	0.000155	-0.0260	1.553	
	17 => 21	160	143	0.061	0.120	0.045	0.0468	0.000122	-0.0348	2.678	
	22	32	32	0.076	0.135	0.027	0.0408	0.000154	-0.0239	1.791	
	23	29	29	0.059	0.103	0.032	0.0425	0.000147	-0.0261	1.311	
	24	32	31	0.054	0.088	0.023	0.0404	0.000162	-0.0237	1.420	
	25	31	31	0.037	0.070	0.025	0.0444	0.000141	-0.0285	1.341	
	26 et 27	35	34	0.063	0.111	0.030	0.0422	0.000155	-0.0256	1.347	
	28 => 67	1251	1216	0.082	0.127	0.046	0.0430	0.000149	-0.0267	1.402	
	68 *	32	27	0.102	0.148	0.118	0.0430	0.000128	-0.0270	1.210	
	69 *	32	31	0.049	0.064	0.046	0.0440	0.000137	-0.0272	0.972	
Capteur B	70	32	32	0.062	0.111	0.043	0.0658	0.000138	-0.0348	0.596	
	71	32	31	0.051	0.087	0.041	0.0712	0.000131	-0.0335	0.933	
	72	32	30	0.065	0.113	0.053	0.0750	0.000125	-0.0349	1.111	
	73	32	31	0.047	0.047	0.047	0.0732	0.000131	-0.0343	0.820	
	74	32	32	0.036	0.042	0.035	0.0712	0.000139	-0.0328	1.102	
	75•	32	29								

* Les profils 68 et 69 sont partiellement inexploitables.
• Le profil 75 est totalement inexploitable

Tableau III - 3

Bilan de la calibration des profils d'oxyène dissous de la campagne CITHER I

Capteur utilisé	Station ou groupe	Nombre d'échantillons considérés	Nombre d'échantillons retenus par le calcul	Déviation Standard			Coefficients			
				0-6000	0-1000	1000-6000	SOC	OXPC	OXTC	OXC2
Capteur B	76	32	31	0.037	0.043	0.037	0.0683	0.000143	-0.0326	0.799
	77	32	31	0.031	0.033	0.031	0.0698	0.000142	-0.0341	0.657
	78	32	32	0.066	0.077	0.063	0.0698	0.000140	-0.0331	0.938
	79	32	32	0.044	0.080	0.029	0.0689	0.000144	-0.0328	0.687
	80	32	29	0.016	0.008	0.018	0.0694	0.000144	-0.0331	0.521
	81	32	29	0.048	0.043	0.050	0.0703	0.000142	-0.0333	0.817
	82	32	32	0.052	0.082	0.042	0.0707	0.000143	-0.0345	0.753
Capteur C	83=>91	236	221	0.059	0.086	0.043	0.0566	0.000148	-0.0307	0.563
	92=>118	769	717	0.054	0.074	0.044	0.0559	0.000149	-0.0295	0.658
Capteur B	119	32	31	0.046	0.083	0.027	0.0679	0.000157	-0.0316	0.698
Capteur C	120=>203	2423	2213	0.045	0.058	0.040	0.0562	0.000147	-0.0304	0.609
	204=>223	607	557	0.037	0.048	0.033	0.0551	0.000149	-0.0294	0.642

Comments on the DQE recommendations for the CTD-O_2 data of WHP lines A6 and A7
(M. Arhan, A. Billant)

The DQE considered the data as meeting the WHP standard, yet made several recommendations (Part C of the report).

** *Check for the calibration procedure of CTDSAL for high pressures.* We have checked the calibration procedure: It is the one recommended in the WHP operations manual, and described in the Unesco Technical Paper in Marine Science nb 54 (1988). When using this procedure, some depth-dependency of the residuals at high pressures (> 5000 dbar) cannot be avoided (as an example, see figure 3.8 of the UNESCO report) at least in certain oceanic area.

** *Oxygen sensor speed:* No accurate measurement of the time was available on that cruise, for which the in situ reference parameter was pressure. We usually remove the heave effect from the oxygen profiles by a ~10dbar running mean.

** *Four digit places for CTDTMP, CTDSAL, SALNTY:* As said in the cover letter, we can create new exchange files at this format if you judge it necessary.

** *Set flags for CTDOXY:* These are oxygen values from the down-profiles, averaged over a 15 dbar pressure range centered at the pressures of bottle triggering. These values are compared with the water sample data and, in case of a discrepancy exceeding 2.8 standard deviation, we choose to flag the bottle value, not the CTD one. This is a matter of convention, and the DQE is right in pointing out that, in some cases, the high difference is caused by inaccurate CTD values. As these CTDOXY values are only used for the calibration, we did not judge it necessary to examine the problematic cases to decide which parameter should be flagged. Had we done it, the choice could only have been subjective in most cases.

** *Carefully check all flags for SALNTY, CTDSAL, CTDOXY.* (See the set of figures with the problematic points marked). In several property-property plots (e.g. 28b, c, d), some points are found slightly aside of the main << cloud of points >>, although the difference << CTD minus water sample >> was less than 2.8 standard deviations, and the values were therefore not flagged. Again, this is a matter of convention.

In several other plots (e.g. 30a, 31a, 32a, 33, 34a), differences CTD-water sample were reported, although the water sample data were flagged to either 5 or 3. This leads to apparent problems (only apparent, because the data were flagged). For instance, the value -9 was set when there was no data, with a flag of 5 (absence of data) in the WS files. Taking into account the value –9 leads to several differences at ~44 (~35 –(-9)) in figure 32a, or ~209 (= 200 -(-9)) on figure 34a. The same cause leads to horizontal lines on the <<waterfall plots>>, and to points aside of the <<main cloud>> in the property-property plots. In particular, although CTDOXY was not measured at station 75 (all flags at 5) and was only partially present at stations 68, 69 (sensor problems), erroneous points for these stations are reported on figure 34a.