

# CORRECTION OF SALINITY MEASURED DURING THE FOCAL EXPERIMENT

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## ABSTRACT

From July 1982 to August 1984 nine cruises were performed in the intertropical Atlantic ocean as a component of the FOCAL program (programme Français Océan et Climat Atlantique équatorial). Profiles of temperature and salinity and oxygen were done with a CTDO probe at the longitudes 35°W, 23°W and 4°W, by the R.V. Capricorne and hydrocast measurements were collected at 1°E and 6°E by the R.V. A.Nizery.

Systematic differences in salinity measurements taken by the R.V. Capricorne are apparent when comparing them with other cruises which took place in 1983 or 1984: salinities are underestimated by the FOCAL cruises at 35°W, 23°W and 4°W.

This note draws up the balance-sheet of these differences, and the following corrections are proposed to apply to the west of 0°, for each cruise :

F0 : .000, F1 : .000, F2 : -.004, F3 : .032, F4 : .030,  
F5 : .042, F6 : .034, F7 : .048, F8 : .048.

## DATA

During FOCAL at 35°W, 23°W and 4°W, the hydrological stations from 0 to 500m deep were made with a CTDO probe (Neil Brown MarkIII). Salinity is measured with a precision of .01.

The probe was calibrated at the IFREMER center in Brest before the first cruise in July 1982 and was used without further calibration during the rest of the program, i.e. two years.

A 12 sampling bottle "rosette" from General Oceanics was used to calibrate the salinity probe measurements, but from the third cruise the salinometer was not running properly and no systematic calibrations of the probe measurements could be done.

Other cruises : TTO, AJAX, FLOT, Perkins which took place in the equatorial Atlantic ocean during FOCAL were obtained from NODC. Other data from the U.S. (Bay St Louis), East Germany and Soviet hydrocasts were also obtained. Salinity measurements, neither from FLOT nor from East Germany cruises, are considered here because they also had to be corrected. Also no Soviet Hydrocasts were available for comparison with FOCAL measurements, but this set includes up to now only 1982 hydrocasts.

Salinity profiles of TTO, AJAX and Perkins were made with a probe. The other US data are only available for fixed isotherms (25°, 22°, 20°, 17°, 15°, 14°, 13°, 12°, 11°, 10°).

The dates of different cruises can be found in table 1.

## COMPARISONS



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The water masses between 100-200m to 600-700m deep originate mainly from the South Atlantic (Sverdrup et al., 1942). The southeast boundary of the Central North Atlantic Water is near 10°N.

In the equatorial area, the South Atlantic Waters have a well defined T-S curve which is almost linear and we do not expect large variations within the two years of the program. We will limit our comparisons between the 14°C and 7°C isotherms, for the domain 5°N to 5°S.

## 1 - Comparisons between FOCAL and the other cruises

Comparisons of FOCAL salinity measurements are carried out with four campaigns: TTO, Perkins, Ajax and other US data.

The points included for the comparisons are :

- with the closest FOCAL cruise, in time. Difference can be up to 40 days as in the comparison AJAX-FOCAL.
- for stations at the same position (latitude and longitude). For TTO and Perkins comparisons are made at 28°W, FOCAL data are then linearly interpolated between 23°W and 35°W. For AJAX and the other US data, comparisons are carried out at 4°W.
- between the isotherms 14°C and 7°C every 1°C. So there are 8 points of comparison at most, but could be less, if the temperature profile does not reach 7°C. For the other US data, comparisons are made between 14°C and 10°C, i.e. 5 points for each station.

Comparisons are shown on table 2. It is clear that after FOCAL 2, the probe underestimates the salinity by about .030 to .060 with a standart deviation between .011 and .020. The probe calibrated at the beginning of the FOCAL program, seems to have been steady until FOCAL 2. We notice that the standart deviation of salinity measurements at a given longitude, for an isotherm, is very close for the compared stations (FOCAL2-TTO, FOCAL4-Perkins, FOCAL5-AJAX, FOCAL7-US data).

Unfortunately, the small number of available cruises (especially none for the FOCAL 0, 1, 3, 6) do not suffice to calibrate the FOCAL salinities.

If we suppose that FOCAL 0 data are well calibrated, comparisons of the FOCAL cruises with that one, should allow us to estimate the shift of the salinity captor from 1982 to 1984.

## 2 - Comparisons between FOCAL cruises

Clearly, the salinity data of the FOCAL probe are very stable during an individual cruise. T-S curves, for each meridian and for 2°5 latitude band, do not show a large dispersion at the level of the South Atlantic Central Water (between 14°C and 7°C). For instance figure 1 shows the T-S diagrams between 2°N and 5°N at 4°W and 23°W for FOCAL 4. As the profiles are .5° of latitude apart, 6 stations are represented on each diagram.

To estimate the shift of the probe, we compared salinity profiles of each FOCAL cruise with the closest profiles made during FOCAL 0. This comparison is carried out between 14°C and 7°C at 23°W

and 4°W. The results are outlined in table 3.

The points of comparison are not very numerous, as FOCAL 0 was a probing campaign for the instruments, and therefore the profiles are not as regularly spaced as they were in the following campaigns. Nevertheless we find that :

- the shift of the probe is not linear with time. The maximum difference is found at FOCAL 7, and there is a relative minimum for FOCAL 6.
- for a same cruise, the differences are usually very close along 23°W and along 4°W, except for FOCAL 6 and especially FOCAL 1 when it seems that a shift occurred between 23°W and 4°W.
- differences are less important for FOCAL 5 and FOCAL 7 than those found for the comparison with AJAX and U.S. data. Furthermore the mean difference between AJAX in October 1983 and FOCAL 0 (not shown) is about +.016, but only 3 stations have been compared (i.e. 23 points). Comparisons between FOCAL 0 and the other U.S. data in June 1984 show a positive difference of .010 (6 stations, 30 points).

To supplement the small number of comparison points with FOCAL 0, the analysis has also been made by using FOCAL 1 as a reference (table 4):

- at 23°W differences are similar to those found before (table 3). Maximum difference is found for FOCAL 7.
- the non-stationarity of the probe during FOCAL 1 is clearly seen, as the difference with FOCAL 2 at 4°W is positive (.012) and as the other values are lower than those found at 23°W. We must note that a more careful look at each station of that cruise (FOCAL 1) does not allow to determine when the shift begins. Furthermore we do not know what correction on the probe was done with the salinometer measurements during the cruise.

Then a third comparison was made by using T-S slopes between 14°C and 11°C.

The slopes between 14°C and 11°C have been adjusted by a least square method,  $S=a*T+b$ . Then the differences between the adjustments of each FOCAL cruise and FOCAL 0 have been computed, between the 14°C and 11°C isotherms.

Conclusions are similar to those found before, i.e. :

- differences are negligible during FOCAL 1 and 2, maximum at FOCAL 7 and there is a relative minimum at FOCAL 6.
- the magnitude of the differences are lower than those found for the comparisons with AJAX and other U.S. cruises.

It is also interesting to note that the time variations of those differences are similar for each band of latitude. This confirms that those differences come from instrumental errors rather than from characteristic variability of Central Water.

### 3 - Stability during a cruise

A latter computation can give us an idea of the probe stability during a FOCAL cruise. We computed the salinity differences for a given latitude between 23°W and 4°W. If there is no zonal salinity variability of the south Atlantic Water, it would indicate how stable the probe is.

Results are shown on table 6.

If we keep apart the station at 5°N (which is near the

coast), the mean of the difference for each campaign is inferior or equal to .01, except for FOCAL 6 and particularly FOCAL 1.

This confirms that the probe was stable during each campaign except FOCAL 1.

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## CONCLUSIONS

The whole comparisons are summarized in table 7. We simply add  $-.015$  (FOCAL 1 - FOCAL 0) to each difference at  $4^{\circ}W$  to account for the shift of the probe during FOCAL 1 (cf table 4).

The differences (in comparison with FOCAL 0) are coherent whatever their position. They are also consistent with the differences found between the FOCAL cruises and the other cruises.

The strong value of FOCAL 5 - AJAX difference is hardly explainable with the set of data we have.

Salinity measurements are very stable during a single cruise (except for FOCAL 1), we then suggest to correct every cruise, west of  $0^{\circ}$ , globally as followed :

F0 : .000, F1 : .000, F2 :  $-.004$ , F3 : .032, F4 : .030,  
F5 : .042, F6 : .034, F7 : .048, F8 : .048.

There is even some residual differences with the AJAX and U.S. campaign, but they are lower than .020. So we can think that the salinity measurement precision, after correction, can be estimated to .01 or .02.

## BIBLIOGRAPHY

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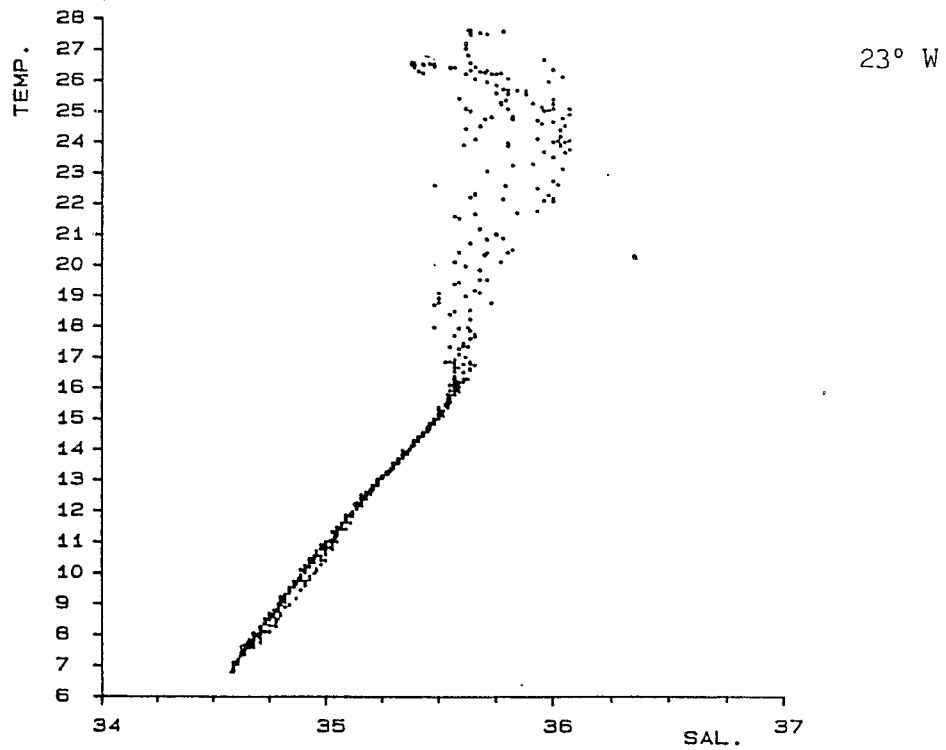
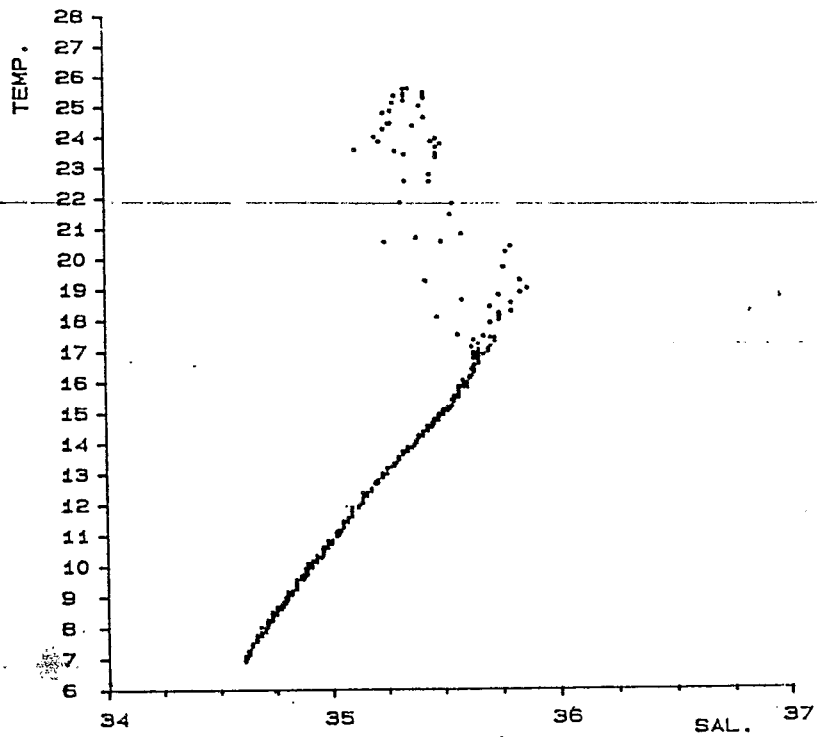


Figure 1 : T-S Diagram at 4° W and 23° W, between 2° N and 5° N, for FOCAL 4.

TABLE 1 : Dates of the cruises

CAMPAIGNS	DATE	
	FOCAL	OTHERS
FOCAL 0	7/06/82 au 07/23/82	
FOCAL 1	10/14/82 au 11/20/82	
TTO		2/07/83 au 02/20/83
FOCAL 2	01/12/83 au 02/18/83	
FOCAL 3	03/26/83 au 04/29/83	
PERKINS		7/09/83 au 07/20/83
FOCAL 4	7/02/83 au 08/06/83	
AJAX		10/07/83 au 10/14/83
FOCAL 5	10/09/83 au 12/02/83	
FOCAL 6	01/11/84 au 02/19/84	
FOCAL 7	4/03/84 au 05/14/84	
US DATA		06/17/84 au 06/20/84
FOCAL 8	7/03/84 au 08/07/84	

TABLE 2 : MEAN SALINITY DIFFERENCE BETWEEN FOCAL AND OTHER CRUISES

DIFFERENCE BETWEEN	Number of stations	Number of points	Mean shift in day	Mean Difference	Standart deviation
28 W FOCAL 2 - TIO	7	48	20 days	- . 002	. 020
28 W FOCAL 4 - PERKINS	6	39	< 5 days	- . 030	. 016
4° W FOCAL 5 - AJAX	9	69	40 days	- . 060	. 016
4° W FOCAL 7 - US DATA	8	40	40 days	- . 056	. 011

TABLE 3 : SALINITY DIFFERENCES, FOR INDIVIDUAL STATION, BETWEEN FOCAL CRUISES AND FOCAL O.

THE DIFFERENCE HAS BEEN DONE BETWEEN 14° C AND 7° C.

	F1	F2	F3	F4	F5	F6	F7	F8
23W - 6N								
23W - 5N	.014	.004	-.028	-.028	-.029	-.022	-.054	-.032
23W - 4N								
23W - 3N	.011		-.020	-.030	-.32	-.013	-.045	-.042
23W - 2N								
23W - 1N	-.003		-.030	-.047	-.042	-.022	-.053	-.045
23W - 1S	.003		-.027	-.037	-.031	-.015	-.045	-.038
23W - 2S								
23W - 3S	.008		-.025	-.028	-.029	-.012	-.045	-.025
23W - 4S								
23W - 5S								
MEAN	.007		-.026	-.034	-.033	-.011	-.048	-.036
STANDART DEVIATION	.014		.017	.013	.016	.013	.015	.017
4W - 5N								
4W - 4N	-.020	-.004	-.028		-.046	-.038	-.048	-.059
4W - 3N	-.007	-.007	-.026	-.022	-.038	-.032	-.049	-.033
4W - 2N	-.013	-.005	-.022	-.029	-.030	-.030	-.046	-.042
4W - 1N								
4W - 1S	-.017		-.044	-.041	-.043	-.039	-.060	-.061
4W - 2S								
4W - 3S								
4W - 4S								
4W - 5S	-.018	-.012	-.046	-.030	-.042	-.034		
MEAN	-.015	-.005	-.030	-.027	-.039	-.034	-.048	-.045
STANDART DEVIATION	.007	.010	.010	.007	.011	.008	.008	.018



TABLE 4 : SALINITY DIFFERENCES, FOR INDIVIDUAL STATION, BETWEEN FOCAL CRUISES AND FOCAL 1.

THE DIFFERENCE HAS BEEN DONE BETWEEN 14° C AND 7° C.

	F0	F2	F3	F4	F5	F6	F7	F8
23W - 6N		.004	-.018	-.020	-.030	-.016	-.041	
23W - 5N	-.014	-.010	-.042	-.040	-.043	-.036	-.068	-.046
23W - 4N		-.020	-.045	-.049	-.033	-.046	-.074	-.047
23W - 3N	-.011		-.029	-.041	-.041	-.024	-.056	-.051
23W - 2N		-.014	-.040	-.041	-.043	-.038	-.068	-.058
23W - 1N	+.003		-.027	-.045	-.040	-.019	-.050	-.042
23W - 1S	-.003		-.030	-.038	-.036	-.019	-.050	-.042
23W - 2S		-.001	-.025	-.028	-.034	-.014	-.044	-.044
23W - 3S	-.008		-.033	-.036	-.037	-.020	-.053	-.033
23W - 4S		.007	-.016	-.019	-.021	-.017	-.037	-.031
23W - 5S		-.004	-.042	-.040	-.034	-.021		-.032
MEAN	-.007	-.005	-.032	-.036	-.036	-.025	-.054	-.043
STANDART DEVIATION	.014	.017	.015	.015	.012	.014	.017	.013
4W - 5N		.013	-.015	-.017	-.033	-.026	-.030	-.028
4W - 4N	.020	.016	-.008		-.026	-.017	-.028	-.039
4W - 3N	.007	.0	-.020	-.015	-.031	-.026	-.043	-.027
4W - 2N	.013	.018	-.009	-.014	-.017	-.017	-.033	-.031
4W - 1N			-.014	-.020	-.026	-.022	-.037	-.045
4W - 1S	.017		-.027	-.024	-.027	-.022	-.043	-.044
4W - 2S		.021	-.010	-.009		-.013	-.023	-.028
4W - 3S			-.022	-.009	-.032			-.031
4W - 4S		.006	-.017	-.016	-.031	-.013	-.029	-.026
4W - 5S	.018	.006	-.027	-.012	-.024	-.015		
MEAN	.015	.012	-.017	-.015	-.028	-.019	-.033	-.033
STANDART DEVIATION	.007	.011	.011	.010	.012	.009	.012	.017

TABLE 5 : COMPARISON OF T-S SLOPES. MEAN DIFFERENCE BETWEEN 11° C AND 14° C ISOTHERMS.

	23W 2S - 5S	23W 2S - 2N	23W 2N - 5N	23W 5N - 10N	4W 2S - 5S	4W 2N - 2S	4W 2N - 5N	MEAN
F1	.000	- .003	.010	- .003	- .016	- .011	- .015	- .005
F2	.007	.000	.004	.000	- .006	- .001	- .003	0
F3	- .022	- .032	- .024	- .025	- .036	- .036	- .030	- .029
F4	- .027	- .038	- .033	- .034	- .029	- .032	- .028	- .032
F5	- .028	- .038	- .032	- .033	- .044	- .038	- .043	- .037
F6	- .017	- .031	- .024	- .017	- .033	- .037	- .036	- .028
F7	- .041	- .052	- .052	- .042	- .049	- .051	- .051	- .048
F8	- .034	- .040	- .043	- .031	- .047	- .049	- .047	- .042

TABLE 6 : MEAN SALINITY DIFFERENCE

- FOR INDIVIDUAL STATION
- BETWEEN 23° W AND 4° W
- BETWEEN 14° C AND 7° C

	F1	F2	F3	F4	F5	F6	F7	F8	MEAN
5N	.053	.030	.027	.026	.043	.043	.016	.035	.034
4N	.046	.009	.009	.000	.038	.017	.000	.038	.020
3N	.023		.013	-.002	.014	.025	.010	-.003	.011
2N	.024	-.006	-.006	-.003	-.004	.005	-.013	-.003	-.001
1N	.008		-.006	-.017	-.006	.011	-.006	.011	-.001
1S	.018		.015	-.001	.009	.022	.012	.017	.013
2S	.015	-.004	-.001	-.004		.016	-.006	.002	.003
3S	.012		.001	-.014	.011			.009	.004
4S	.002	.004	.003	-.002	.012	.000	-.004	-.002	.002
5S	.014	.002	-.002	-.013	.003	.009			.002
MEAN	.022	.006	.006	-.003	.013	.016	.001	.012	
MEAN WITHOUT SN	.018	.001	.003	-.006	.010	.013	-.001	.009	

TABLE 7 : SUMMARY OF THE PREVIOUS COMPARISONS AND PROPOSED CORRECTION FOR FOCAL SALINITIES WEST OF 0°

	TABLE 3		TABLE 4		TABLE 5	CORRECTION
	4W	23W	4W	23W		
F0	Ref.	Ref.			Ref.	.00
F1	- .015	.007	Réf.-.015	Ref.	- .005	
F2	- .005		- .003	- .005	0	- .004
F3	- .030	- .026	- .032	- .032	- .029	+ .032
F4	- .027	- .034	- .030	- .036	- .032	+ .030
F5	- .039	- .033	- .043	- .036	- .037	+ .042
F6	- .034	- .017	- .034	- .025	- .028	+ .034
F7	- .048	- .048	- .048	- .054	- .048	+ .048
F8	- .045	- .036	- .048	- .043	- .042	+ .048