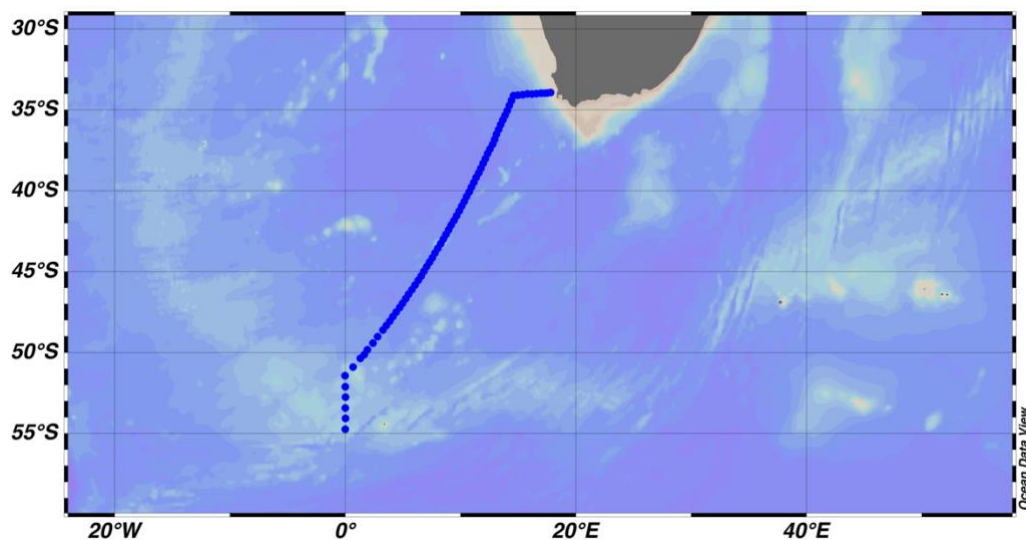


CRUISE REPORT: Good Hope

Created: January 2026



Highlights

Cruise Summary Information

Section Designation	SR02
Expedition Designation (ExpoCode)	90AV20041104
Chief Scientist	Sergey Gladyshev and Sabrina Speich
Dates	4 November – 8 December 2004
Ship	R/V <i>A.S. Vavilov</i>
Ports of Call	Cape Town, South Africa – Cape Town
Geographic Boundaries	33.93°S 0.01°E 17.81°E 54.74°N
Stations	72
Floats and Drifters Deployed	0
Moorings Deployed and Recovered	0

Contact Information:

Sabrina Speich

Ecole Normale Supérieure, Department of Geosciences

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Links to Selected Topics

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Cruise Summary Information	Hydrographic Measurements
Description of Scientific Program	CTD Data:
Geographic Boundaries	Acquisition
Cruise Track (Figure): PI CCHDO	Processing
Description of Stations	Calibration
Description of Parameters Sampled	Temperature Pressure
Bottle Depth Distribution (figure)	Conductivity Oxygen
Deployments	Bottle Data
Moorings Deployed or Recovered	Salinity
	Oxygen
Programs and Principal Investigators	Nutrients
Scientific Personnel	Total CO ₂
	CFCs and SF ₆
Problems and Goals Not Achieved	Total Alkalinity
	pH
Underway Data Information	Lowered Acoustic Doppler Current Profiler
Navigation Bathymetry	
Acoustic Doppler Current Profiler	
Thermosalinograph	
XBT and/or XCTD	
pCO ₂	Acknowledgements
Atmospheric Chemistry Data	
Meteorological Observations	

GOODHOPE 2004

Contract number: IFREMER 2004 2423094

**Mesures de carbone anthropique pendant la campagne CTD
GoodHope de novembre 2004**

Marta Álvarez

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FINAL SCIENTIFIC REPORT

April 2006

GoodHope-2004 CO₂ Parameters Final Report.

Marta Álvarez.

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During the GoodHope 2004 cruise (Figure 1) carried out between 8th and 26th November on board the Akademik Vavilov pH and TA measurements were sampled from bottle depths at selected stations (Table 1) and analysed on board. Samples for TIC were also taken, but will be analyzed at lab, concretely by Prof. Andrew Dickson in Scripps Institution of Oceanography (USA).

Table 1. Stations sampled for pH, Total Alkalinity (TA) and Total Inorganic Carbon (TIC).

Station	pH	TA	TIC
1545	1	1	
1547	1		
1549	1	1	
1551	1	1	
1553	1		
1555	1	1	
1557	1		
1559	1	1	
1561	1		
1563	1	1	1
1565	1		
1567	1	1	
1569	1		
1571	1	1	
1573	1		
1575	1	1	
1577	1		
1579	1	1	
1581	1		
1583	1	1	
1585	1		
1587	1	1	
1589	1		
1591	1	1	
1593	1		
1595	1	1	
1597	1		
1599	1	1	
1601	1		
1603	1	1	
1605	1		
1607	1	1	
1609	1		
1611	1	1	
1613	1		
1615	1	1	1

Station	pH	TA	TIC
1617	1		
1619	1	1	
1621	1		
1623	1	1	
1625	1		
1627	1	1	
1629	1		
1631	1		
1633	1		
1635	1	1	
1637	1		
1639	1	1	
1641	1		
1643	1	1	
1645	1		
1647	1	1	1
1649	1		
1651	1	1	
1653	1		
1655	1	1	
1657	1		
1659	1	1	1
1661	1		
1663	1	1	
1666	1	1	
1669	1	1	1
1672	1	1	
1674	1	1	
1676	1	1	
1680	1	1	1
1684	1	1	
1688	1	1	1
1692	1	1	
1696	1	1	
1700	1	1	1
1704	1	1	1

	pH	TA	TIC
Total	72	43	9

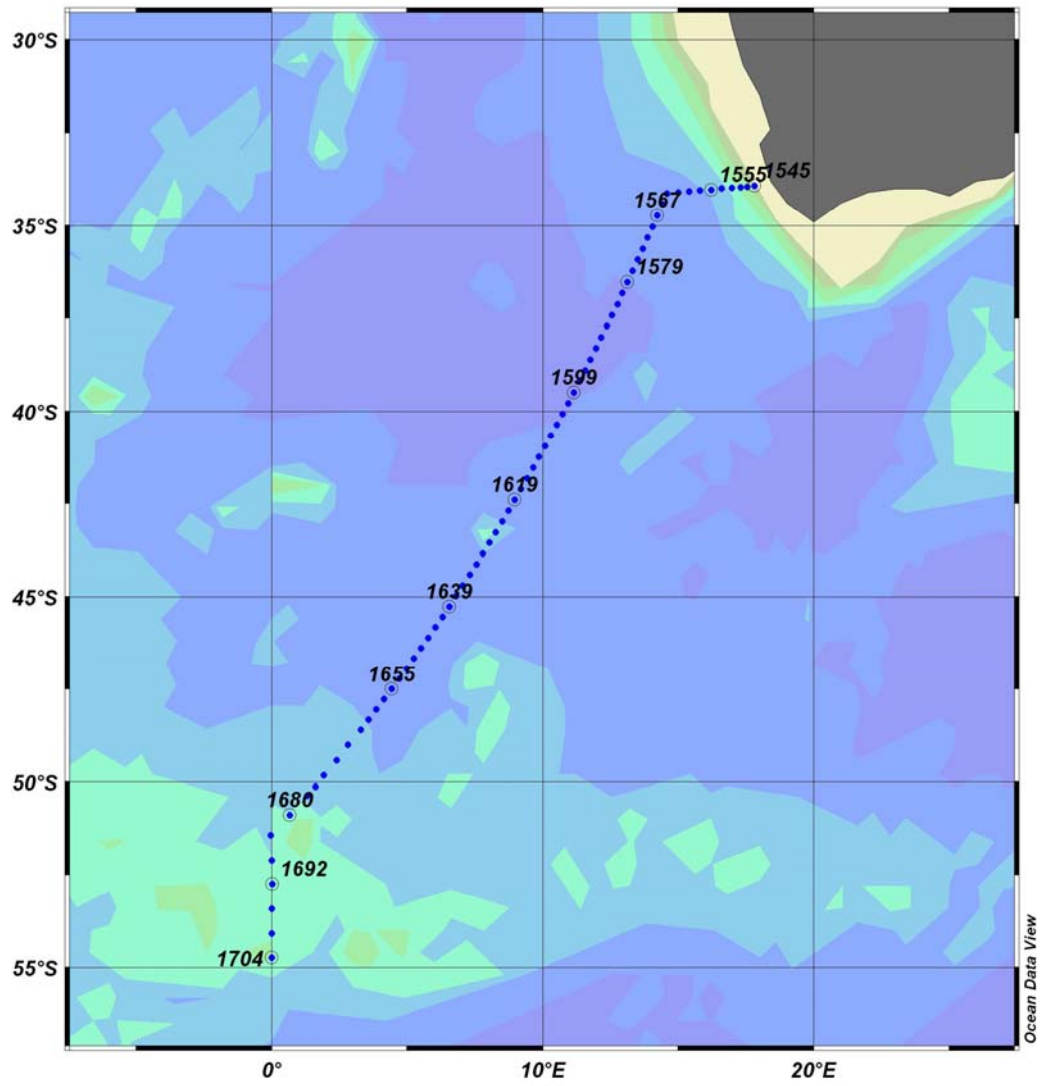


Figure 1. Stations in the Southern Ocean sampled during the GoodHope 2004 cruise. Some stations are highlighted.

a) pH analysis.

pH was measured spectrophotometrically following Clayton and Byrne (1993). Roughly, this method consists on adding a dye solution to the seawater sample, so that the ratio between two absorbances at two different wavelengths is proportional to the sample pH.

Sampling and analytical methods.

Seawater samples for pH were collected after oxygen samples from depth using cylindrical optical glass 10-cm pathlength cells, which were filled to overflowing and immediately stoppered.

Seawater pH was measured using a double-wavelength spectrophotometric procedure (Byrne, 1987). The indicator was a solution of m-cresol purple prepared in seawater.

After sampling all the samples were stabilised at 25°C. All the absorbance measurements were obtained in the thermostatted (25±0.2 °C) cell compartment of a SHIMADZU UV-2401PC spectrophotometer.

After blanking with the sampled seawater without dye, 50 µl of the dye solution were added to each sample using an adjustable repeater pipette. The absorbance was measured at three different fixed wavelengths (434, 578 and 730 nm), pH, on the total hydrogen ion concentration scale, is calculated using the following formula (Clayton and Byrne, 1993):

$$\text{pH}_T = 1245.69/T + 3.8275 + (2.11 \cdot 10^{-3})(35-S) + \log((R-0.0069)/(2.222-R \cdot 0.133))$$

where R is the ratio of the absorbances of the acidic and basic forms of the indicator corrected for baseline absorbance at 730 nm ($R = A_{578}/A_{434}$), T is temperature in Kelvin scale and S is salinity.

DeIvals and Dickson (1998) in a revision of the pH values initially assigned to the 'tris' buffers used to characterise the indicator, have suggested an increase of 0.0047, which translate into a comparable increase in the pH_T values finally calculated.

As the injection of the indicator into the seawater perturbs the sample pH slightly, the absorbance ratios measured in the seawater samples (R_m) should be corrected to the R values that would have been observed in an unperturbed analysis (R_{real}). In order to do this, we obtain the correction in the absorbance ratio of every sample as a function of the absorbance ratio measured (R_m). This linear function was calculated from second additions of the indicator over samples with a wide range of pH:

$$R_{\text{real}} = R_m - (-0.0015 \pm 0.0007 \cdot R_m + 0.002 \pm 0.001); \quad r^2 = 0.14, \quad n=27$$

This function also corrects for deviations in the linear relationship between absorbance and the indicator concentration; i.e., deviations from the Beer Law in the spectrophotometer.

All the pH measurements are referred to 25°C and corrected for the addition of the indicator using the former formula. The magnitude of that correction over our range of pH is small ranging from 0.0003 to -0.0005 pH units.

Accuracy.

In order to check the precision of the pH measurements, samples of CO₂ reference material (CRM, batch 64, distributed by A.G. Dickson from the Scripps Institution of Oceanography, SIO) were analyzed during the cruise.

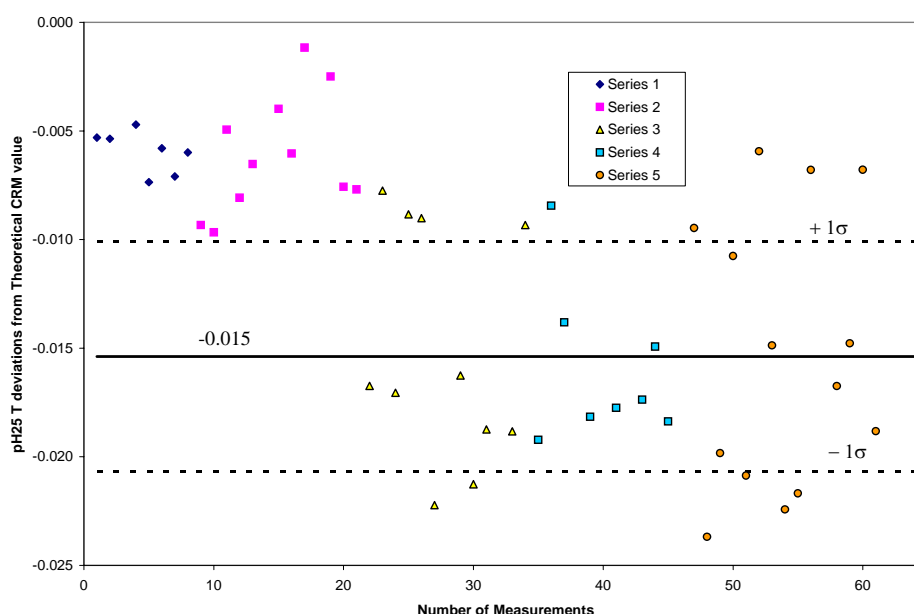


Figure 1. Deviations from the theoretical CRM pH value on the CRM pH measurements carried out during the cruise. The solid line is the mean value and the dotted lines are the standard deviations (1σ) from the mean.

Five series of CRMs measurements were done to a total of 51 measurements. The first two series are anomalously different from the others. Figure 1 shows the deviation from the theoretical CRM pH value, the mean and standard deviation of the last three series of measurements are showed. The mean pH_{25T} values obtained over the last 33 measurements was 8.041 ± 0.005 . The corresponding theoretical pH_{25T} values for this batch using the dissociation constants from Lueker *et al.* (2000) is 8.0566. Therefore, our pH measurements are lower than the theoretical values and should be increased in 0.0154 ± 0.0052 pH units. I will discuss this point at the end of this report.

Reproducibility

Regarding the reproducibility of our measurements, no quality control cast was performed during the cruise. So after finishing the line, we analysed 16 pH samples from surface water stabilised on a 25 litres tank. The mean value obtained on these samples discarding 3 of them was 7.740 ± 0.0017 .

b) Alkalinity analysis.

Sampling and analytical methods.

Following the sampling sequence proposed during WOCE (World Ocean Circulation Experiment), seawater samples for Total Alkalinity (TA) were collected after pH samples, in 600 ml glass bottles. Samples were filled to overflowing and immediately stopped. TA profiles were usually sampled and analysed every other station (Table 1), except station 631 where we were exhausted with no bottles to sample and missed it, and at the end of the cruise were the stations were much apart and we decided to sample all of them. Twenty four samples were taken at each profile, except the shallowest ones where about twelve samples were taken.

TA was measured using an automatic potentiometric titrator "Titrino Metrohm", with a Metrohm 6.0233.100 combination glass electrode and a Pt-100 probe to check the temperature. Potentiometric titrations were carried out with hydrochloric acid ($[HCl] = 0.1\text{ N}$) to a final pH of 4.40 (Pérez and Fraga, 1987). The electrodes were standardised using a buffer of pH 4.41 made in CO_2 free seawater (Pérez *et al.*, 2002). Table 2 shows the value of the asymmetrical pH (pH_{as}), which is the value of the electrode pH after its calibration. The 0.1 N hydrochloric acid was prepared mixing 0.5 mol (18.231 g) of commercially HCl supplied by Riedel-deHaën® (Fixanal 38285) with mili-Q water into a graduated 5-L beaker at controlled temperature conditions. The HCl normality is exactly referred to 20°C. The variation of salinity after the titration is lower than 0.1 units, which is taken into account in the final TA calculation.

Quality control.

Usually, each sample is analysed twice for alkalinity. Table 2 shows the average standard deviation of the replicates analysed during each batch of analysis. This difference was about $1.0\text{ }\mu\text{mol}\cdot\text{kg}^{-1}$.

CRM analyses were performed in order to control the accuracy of our TA measurements. Accordingly, the final pH of every batch of analyses was corrected to obtain the closest mean TA on the CRM analyses to the certified value. Table 2 shows the pH (ΔpH) correction applied to each batch.

In order to check the precision of the TA measurements, surface seawater was used as a “quasi-steady” seawater substandard (SB). It consists in surface seawater taken from the non-toxic supply and stored in the dark into a large container (25 liters) during 2 days before use. This substandard seawater was analysed at the beginning and at the end of each batch of analyses. The estimated drift for each day was very low (Table 2).

During the analysis of batch 18 no CRM measurements were done, so the correction applied to the final pH on the titrations was taken from the previous batch, as well, the nominal value for SB after this correction is applied gives a consistent result, giving confidence on the ΔpH correction applied.

Table 2. Daily calibrations of the pH electrode during the TA analyses. *pH_{as}* is the asymmetrical pH, *T* is the temperature at which the electrode was calibrated with the buffer solution which has a very stable pH of 4.41 despite the temperature variation. ΔpH is the pH correction applied to each set of measurements to refer the TA determinations on the CRM to the corresponding nominal value. At the beginning and the end of each batch of measurements a series of substandard (SB, during the cruise 3 SB were used) analyses were done, the drift obtained from those analyses is also shown. The average of the standard deviation for each two samples analysed in each batch of measurements is also shown.

Batch	1000-Station Number	Date	pH Buffer	T °C	pH as	ΔpH	SB $\mu\text{mol/kg}$	Drift %	Average $\mu\text{mol/kg}$
							SB1		
1	545-549-551	9-11	4.40	24.8	6.83	0.015	2332.7	-0.0005	1.20
2	555-559	10-11	4.40	25.3	6.82	0.021	2330.5	-0.0002	1.03
3	563-567	11-11	4.40	23.3	6.83	0.017	2330.5	-0.0007	1.77
4	571-575	12-11	4.42	22.9	6.86	-0.003	2332.4	-0.0006	1.51
5	579-583	13-11	4.40	24.6	6.84	0.017	2332.4	-0.0003	0.97
6	587-591	14-11	4.40	23.0	6.84	0.012	2331.3	0.0007	1.50
7	595-599	15-11	4.41	21.9	6.86	0.006	2331.9	-0.0008	1.19
8	603-607	16-11	4.41	21.7	6.86	0.014	2331.1	0.0004	1.01
9	611-615	17-11	4.41	20.2	6.87	0.013	2333.0	0.0009	1.05
10	619-623-627	18-11	4.41	19.6	6.87	0.010	2331.7	0.0000	1.27
							SB2		
11	635-639	19-11	4.41	21.0	6.87	0.017	2290.9	0.0013	1.33
12	643-647	20-11	4.41	20.9	6.89	0.000	2289.9	0.0004	1.07
13	651-655	21-11	4.41	20.5	6.89	0.009	2289.0	0.0006	1.04
14	659-663	22-11	4.41	18.7	6.89	0.010	2288.9	0.0001	1.12
15	666-669-672	23-11	4.41	19.2	6.90	0.012	2288.0	-0.0008	1.84
16	674	24-11	4.41	19.6	6.90	0.010	2289.6	0.0018	2.39

Batch	1000-Station Number	Date	pH Buffer	T °C	pH as	Δ pH	SB $\mu\text{mol/kg}$	Drift %	Average $\mu\text{mol/kg}$
17	676-680	24-11	4.41	18.8	6.90	0.057	SB3 2289.1	-0.0038	1.27
18	684-688	25-11	4.41	19.1	6.90	0.057	2295.1	-0.0048	1.77
19	692-696-700	26-11	4.41	19.3	6.84	0.084	2298.9	-0.0008	1.62
20	700-704	27-11	4.41	22.3	6.85	0.067	2299.1	0.0025	1.41

Reproducibility.

At the end of the line in order to check the reproducibility of our analysis 45 samples from the substandard were analysed. Figure 3 shows the analyses made, the standard deviation of all the TA determinations for these 45 analyses was $1.1 \mu\text{mol}\cdot\text{kg}^{-1}$.

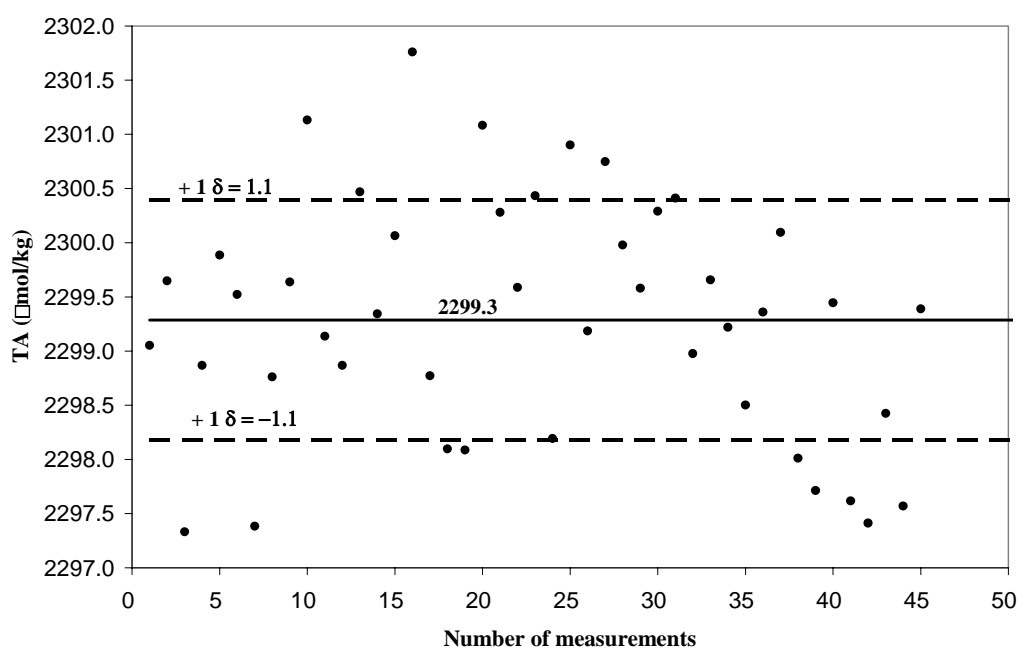


Figure 3. TA values obtained in the reproducibility test. The mean and standard deviation of all samples was $2299.3 \pm 1.1 \mu\text{mol}\cdot\text{kg}^{-1}$.

c) Total Inorganic Carbon sampling.

Samples for Total Inorganic Carbon to be analysed at lab were collected at selected stations and depths (Table 1). Emptied and clean Certified Reference Material bottles were rinsed twice and filled from the bottom, overflowing half a volume while taking care not to entrain any bubbles. Then 0.2 ml of saturated mercuric chloride solution was added to the sample as a preservative and the bottle was sealed with glass stoppers covered with Apiezon-L grease and stored in the dark at room temperature. These samples are to be analysed by Dr. Dickson at SIO, a reference CO_2 laboratory. The results will allow us to perform an internal consistency analysis. We hope to have them in the near future.

d) Further quality control.

After the whole bottle data from the cruise: temperature, salinity, dissolved oxygen, nutrient salts, pH_{25T} and TA, is compiled we can perform a more detailed analysis of the quality of our data.

First we calculate NTA , the normalised to salinity TA, $NTA=35 \cdot TA/Sal$ so that, we can observe changes in TA not associated with salinity. Then we perform a visual analysis station by station of the pH and NTA profiles by depth and also their relation with potential temperature (Tpot), salinity (Sal) or nutrients, nitrate (NO₃), phosphate (PO₄) and silicate (SiO₂) and oxygen (O₂). In this way we can detect bad fired bottles which show anomalous values for all the biogeochemical variables. These data are flagged as 8.

After this first visual inspection, a residual analysis is done to detect any bias in the data from wrong calibrations, technical problems or bad calculations:

- every biogeochemical variable is calculated as a multiple linear regression from Tpot, Sal, pressure, latitude and longitude. See Table 3

Table 3. Regression coefficients, R^2 and standard error of the residuals for each variable.

	NO ₃	PO ₄	SiO ₂	O ₂	pH _{25T}	NTA
Intercept	-53.64	-8.76	-1589.76	4124.65	10.65	2368.09
Tpot (°C)	-2.18	-0.15	-4.36	9.30	0.03	-2.96
Sal (psu)	3.01	0.31	42.86	-115.10	-0.09	-0.66
Pres (dbar)	-0.00147	-0.00012	0.01101	0.01524	0.00003	0.01
Lat (°)	0.31	-0.01	-3.42	-0.81	0.002	-0.39
Lon (°)	-0.16	0.02	1.63	-1.22	-0.01	-0.94
R ²	0.87	0.87	0.92	0.57	0.88	0.93
STD	2.96	0.22	10.12	26.52	0.04	6.41

- the mean and standard deviation of the corresponding residuals for each station are calculated.

- within each station samples far from the mean plus one std are further inspected to check any inconsistent value.

- the tendency of the mean residual along the cruise track for the set of variables is inspected to detect any problem for each station subset and variable (Figure 4).

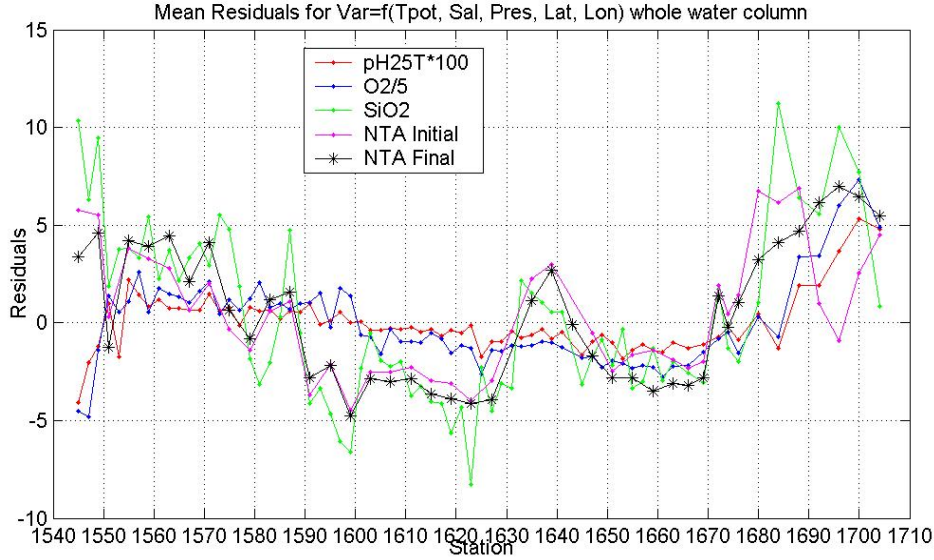


Figure 4. Mean residual for each station and different variables. Note the close relationship between the pH and O₂ residuals and somehow between SiO₂ and NTA.

Figure 4 shows the close relationship between the pH and O₂ mean residual for each station, these two variables are measured by completely independent methods and work groups. Consequently, the covariation is given by the own physico-chemical variability and biological activity within the water masses crossed during the cruise. At station 1553 the pH mean residual is much lower than that of O₂ because we lost the lower water column data, so the mean residual is biased to the upper water values. This result give us confidence about the pH data, there is no systematic variability between stations due to any instrument error.

NTA and SiO₂ present a close variability in the ocean, therefore their residuals should also have a close relationship. Figure 4 shows the along-track variability of the station mean residuals for NTA and SiO₂, although they present similar trends, SiO₂ has some dubious spikes up and down, and NTA from station 1680 to 1704 presents a dissimilar trend compared to SiO₂, O₂ or pH. So, a closer look at the NTA and SiO₂ residuals was done (Figure 5).

Figure 5 shows the relationship between the NTA and SiO₂ mean residual for each station along the GoodHope-2004 cruise (blue points) and the linear fit between them ($\text{ResNTA} = -0.112 + 0.57 \cdot \text{ResSiO}_2$; $R^2 = 0.59$, $p < 0.001$), the points corresponding to stations from 1680 to 1704 are highlighted with red circles. Each station subset for NTA is modified adding or subtracting a constant quantity so that the final mean residual for the group of stations follow somehow the tendency in the SiO₂, O₂ and pH residuals (Figure 4 and 5). The final station means for the NTA residuals are also shown in figure 4 and 5.

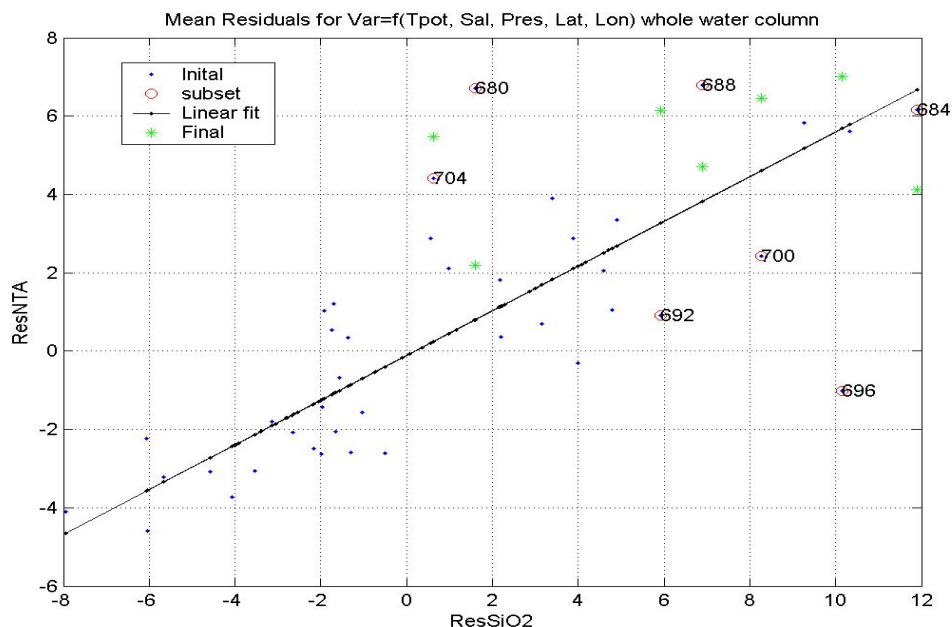


Figure 5. Mean station residual for SiO_2 and NTA, the linear fit between them is shown. Data from station 1680 till 1704 are highlighted with red circles. The NTA final means for the former subset are shown as green stars.

The former corrections are handmade, they are not supported by the real measurements or calibrations of the titrino instrument. However, more consistent TA data are obtained. A final comparison will be done with the TA and TIC measurements done by Dr. Dickson to check the internal consistency of the CO_2 measurements.

Following is a list with the pH and TA data modified or dubious (Table 4 and 5, respectively). The quality flag legend is: 4=questionable, 8=bad, 3=modified, data with QF 4 or 8 are deleted from the final data base, they usually correspond to bad fired bottles.

Table 4. Dubious and modified pH data.

Station	Bottle	QF	pH new-old
1547	11	3	-0.040
1547	10	3	-0.050
1549	19	4	
1555	23	3	-0.020
1571	18	4	
1589	3	3	-0.020
1591	18	3	-0.080
1593	24	3	0.020
1623	17	3	-0.012
1639	13	8	
1651	22	8	
1659	2	4	

Station	Bottle	QF	pH new-old
1672	4	3	-0.010
1680	1	4	
1684	8	3	-0.028
1684	4	3	-0.007
1684	3	8	
1688	6	3	0.006
1692	9	3	0.010
1692	2	8	
1692	2	8	
1696	2	8	
1696	2	8	

Table 5. *Dubious and modified TA data.*

Station	Bottle	QF	TA new-old (umol/kg)
1591	12	3	20
1639	13	8	
1651	22	8	
1655	2	3	-2
1659	20	3	4
1659	2	8	
1663	17	3	-10
1663	3	3	2
1672	12	3	-9
1672	1	3	-5
1676	3	3	4
1676	1	3	4
1680	24	3	-4
1680	23	3	-4
1680	20	3	-4
1680	20	3	-4
1680	19	3	-4
1680	17	3	-4
1680	16	3	-4
1680	16	3	-4
1680	13	3	-4
1680	11	3	-4
1680	9	3	-4
1680	7	3	-4
1680	5	3	-4
1680	3	3	-4
1680	3	3	-4
1680	1	3	-4
1684	24	3	-4
1684	23	3	-4
1684	21	3	-4
1684	21	3	-4
1684	19	3	-4
1684	19	3	-4
1684	17	3	-4
1684	15	3	-4
1684	15	3	-4
1684	13	3	-4
1684	11	3	-4
1684	9	3	-4
1684	7	3	-4
1684	5	3	-4
1684	4	3	-4
1684	3	3	-4
1684	1	3	-4
1688	24	3	-1
1688	22	3	-1

Station	Bottle	QF	TA new-old (umol/kg)
1688	20	3	-1
1688	18	3	-1
1688	16	3	-1
1688	14	3	-1
1688	12	3	-1
1688	9	3	-1
1688	7	3	-1
1688	5	3	-1
1688	4	3	-1
1688	3	3	-1
1688	1	3	-1
1692	24	3	6
1692	21	3	6
1692	21	3	6
1692	18	3	6
1692	16	3	6
1692	16	3	6
1692	14	3	6
1692	13	3	6
1692	11	3	6
1692	9	3	6
1692	7	3	6
1692	5	3	6
1692	3	3	6
1692	3	3	6
1692	1	3	6
1696	24	3	11
1696	23	3	11
1696	23	3	11
1696	19	3	11
1696	15	3	11
1696	15	3	11
1696	14	3	11
1696	12	3	11
1696	10	3	11
1696	8	3	11
1696	7	3	11
1696	6	3	11
1696	5	3	11
1696	3	3	11
1696	3	3	11
1696	1	3	11
1700	24	3	8
1700	21	3	8
1700	19	3	8
1700	16	3	8
1700	15	3	8

Station	Bottle	QF	TA new-old (umol/kg)
1700	14	3	8
1700	12	3	8
1700	10	3	8
1700	9	3	8
1700	8	3	8
1700	7	3	8
1700	6	3	6
1700	5	3	8
1700	3	3	8
1700	1	3	8
1704	21	3	6

Station	Bottle	QF	TA new-old (umol/kg)
1704	19	3	6
1704	18	3	6
1704	17	3	6
1704	14	3	6
1704	12	3	6
1704	10	3	6
1704	8	3	6
1704	6	3	3
1704	4	3	6
1704	1	3	6

e) Final considerations.

Unfortunately, we could not check the internal consistency of the CO₂ data studying the relationship between measured TA by Dr. Dickson and us, and also between calculated TIC from our pH and TA values and measured TIC by coulometry (Dr. Dickson). This kind of comparison allows the detection of any systematic bias in the TA or pH data for the whole data set. The pH_{25T} values submitted are not corrected for any bias like the 0.0047 (DellValls and Dickson, 1998) or the 0.0154±0.0052 pH units mismatch between measured and theoretical pH on CRM batch 64 along the GoodHope 2004 cruise. We hope to perform this internal consistency analysis in the near future. On the other hand, the stations along the prime meridian could overlap some of the stations sampled during the same year by Dr. Hoppema (AWI, Bremenhaven), a crossover analysis for the physical and chemical variables will be done.

Following is the final list of data submitted to Dr. Sergey Gladyshev (Shirshov Institute of Oceanology, Moscow) and Dr. Sabrina Speich (Ifremer, Brest) and some figures with the distribution of pH_{25T} and NTA.

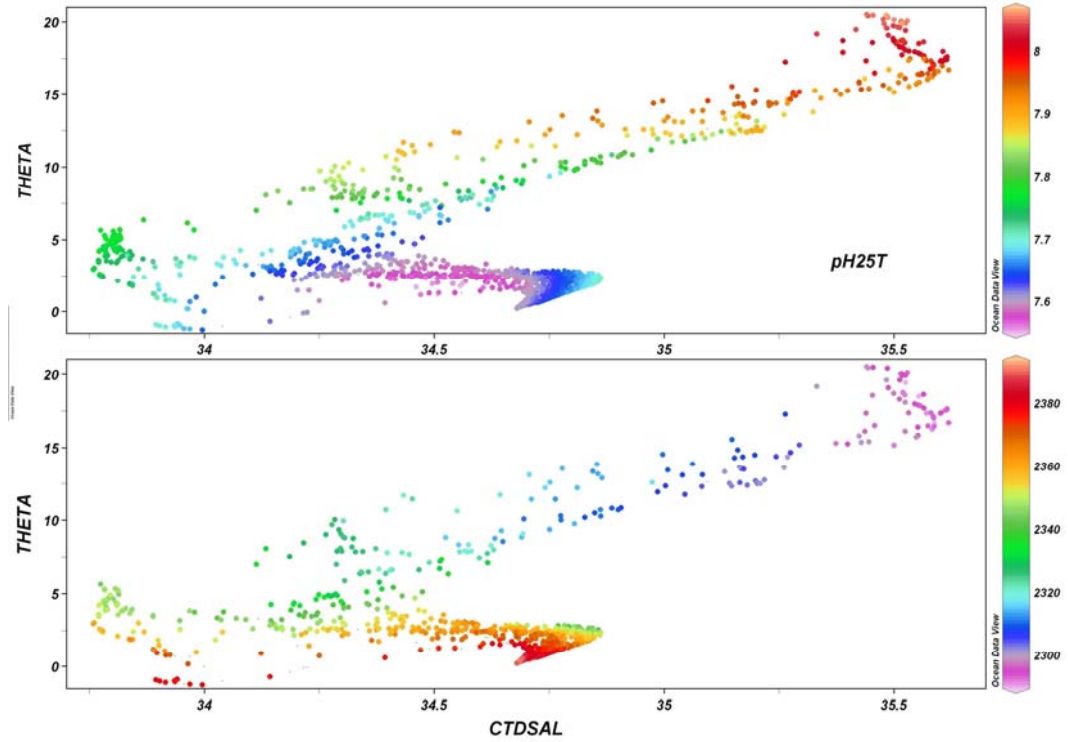


Figure 6. Temperature-salinity plots overlaid with a colour distribution of pH_{25T} and NTA ($\mu\text{mol/kg}$).

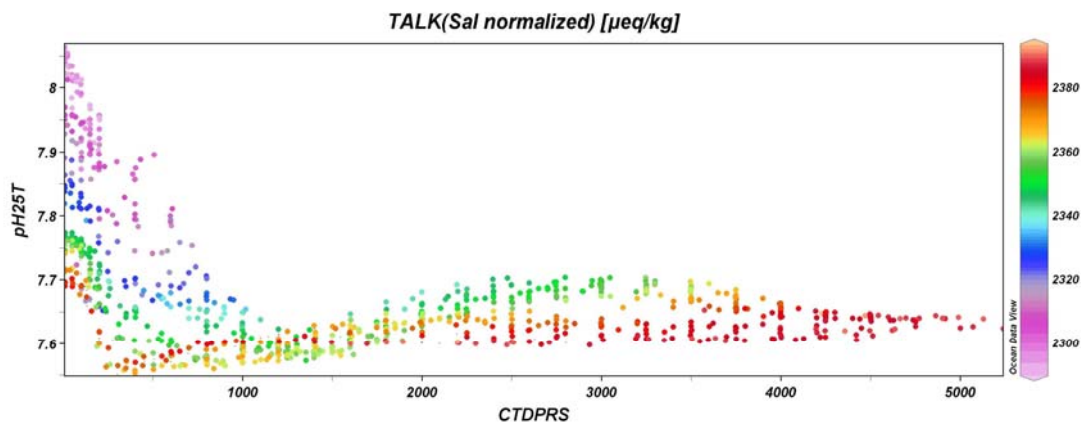


Figure 7. Vertical distribution of pH_{25T} with a colour distribution of NTA ($\mu\text{mol/kg}$).

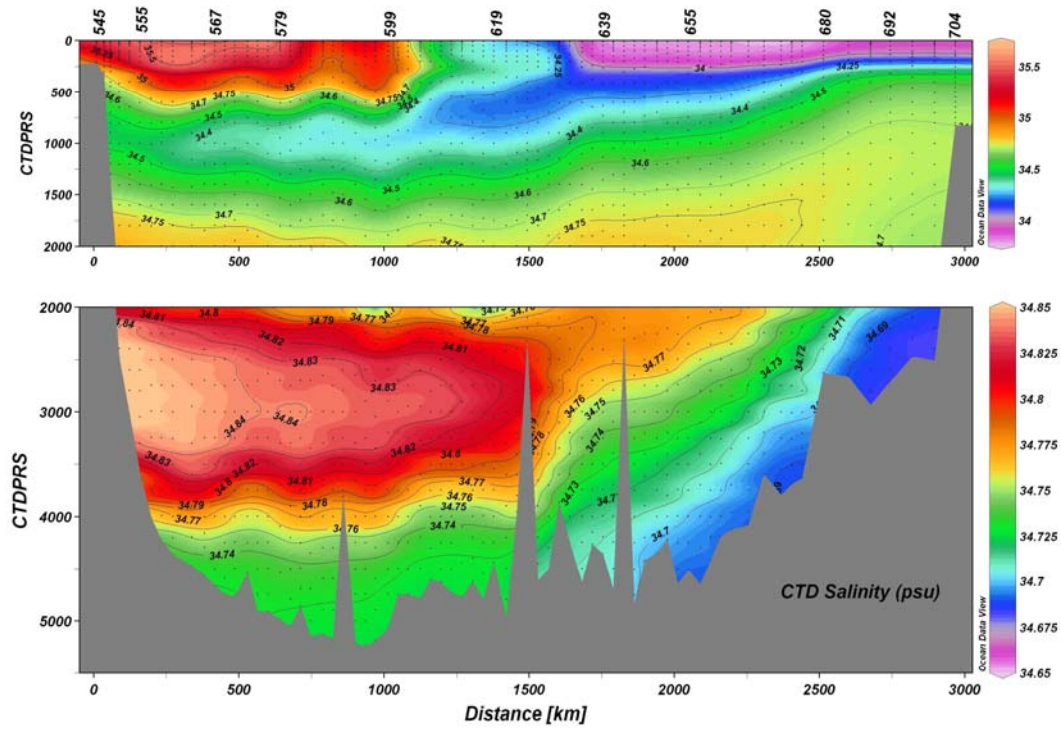


Figure 8. Vertical distribution of salinity (psu), the stations positions marked on the top axis are shown in Figure 1.

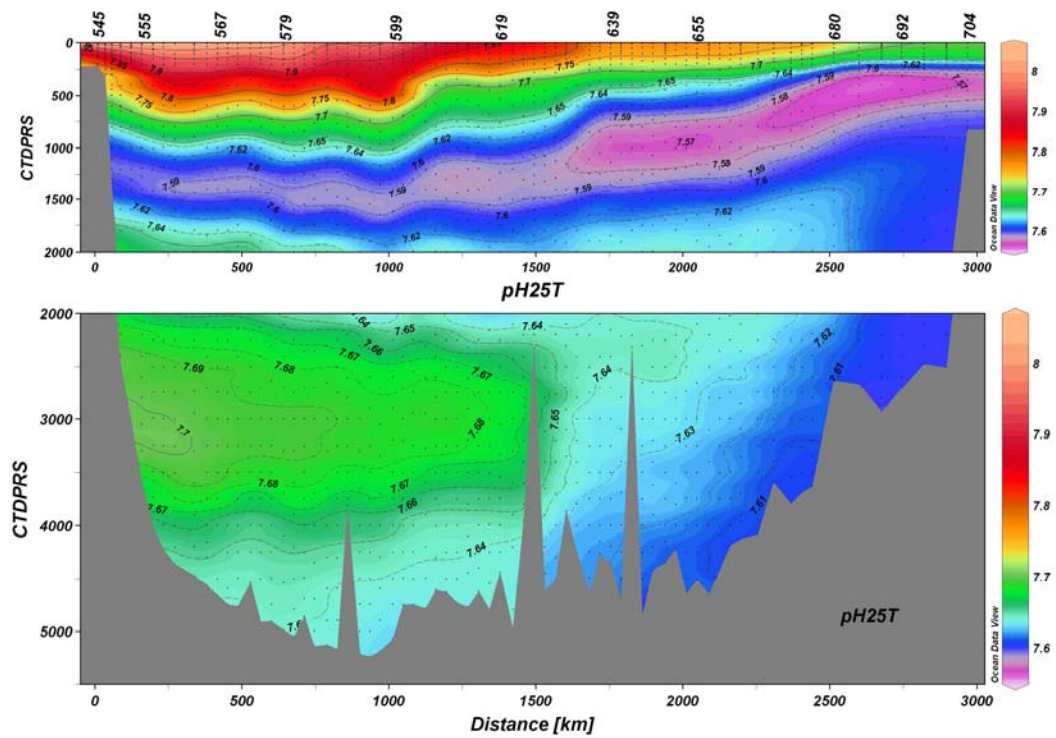


Figure 9. Vertical distribution of pH_{25T} , the stations positions marked on the top axis are shown in Figure 1.

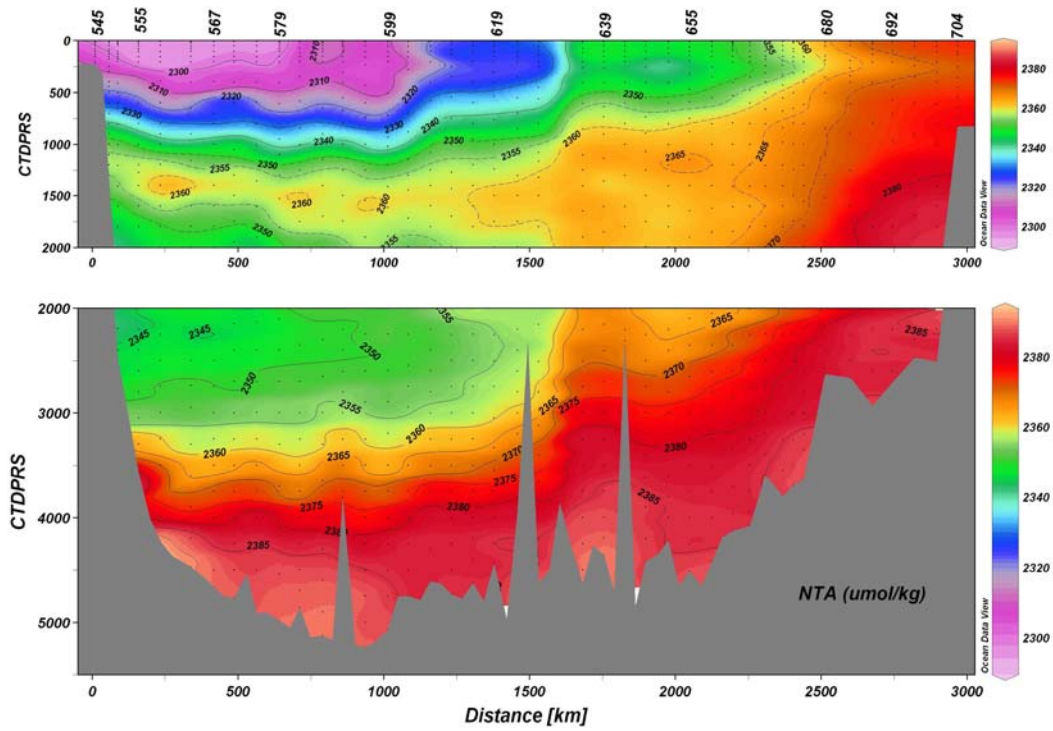


Figure 10. Vertical distribution of NTA (umol/kg) the stations positions marked on the top axis are shown in Figure 1.

ACKNOWLEDGEMENTS

My special thanks to Monica Castaño for her hard work and endurance during the cruise, to all the Russian scientific staff, specially to S. Gladyshev, A. Sokov and Shasha for making our cruise much funnier, to V. Zubarevich and his group for sharing the nutrient data and P. Branellec and team for the oxygen and salinity data; and as well to I. Ansorge for the cappuccinos and A. Demidov for introducing me to ODV.

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LIST OF pH AND TA DATA

April 2006

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1545	20	8.039	0	2322	0	Labels	0=ok
1545	18	8.012	0	2326	0		4=questioned
1545	15	7.866	0	2316	0		3= changed
1545	14	7.723	0	2303	0		8=bad
1545	12	7.686	0	2297	0		
1545	10	7.667	0	2293	0		
1545	8	7.670	0	2291	0		
1545	6	7.659	0	2292	0		
1545	4	7.653	0	2293	0		
1547	12	8.044	0	-999	0		
1547	11	8.022	3	-999	0		
1547	10	8.001	3	-999	0		
1547	9	7.900	0	-999	0		
1547	8	7.841	0	-999	0		
1547	7	7.824	0	-999	0		
1547	6	7.822	0	-999	0		
1547	5	7.787	0	-999	0		
1547	4	7.699	0	-999	0		
1547	3	7.674	0	-999	0		
1547	2	7.658	0	-999	0		
1547	1	7.667	0	-999	0		
1549	23	8.054	0	2329	0		
1549	22	8.053	0	2327	0		
1549	21	8.019	0	2327	0		
1549	20	7.993	0	2325	0		
1549	19	7.873	4	2325	0		
1549	18	7.937	0	2322	0		
1549	17	7.909	0	2318	0		
1549	16	7.875	0	2310	0		
1549	14	7.808	0	2309	0		
1549	13	7.788	0	2297	0		
1549	12	7.745	0	2294	0		
1549	11	7.677	0	2292	0		
1549	10	7.668	0	2291	0		
1549	9	7.658	0	2295	0		
1549	8	7.640	0	2298	0		
1549	7	7.619	0	2305	0		
1549	6	7.601	0	2317	0		
1549	5	7.590	0	2322	0		
1549	4	7.589	0	2327	0		
1549	3	7.592	0	2332	0		
1549	2	7.612	0	2329	0		
1549	1	7.623	0	2328	0		
1551	23	8.055	0	2327	0		
1551	22	8.055	0	2328	0		
1551	21	8.032	0	2324	0		
1551	20	7.984	0	2326	0		
1551	19	7.943	0	2328	0		
1551	18	7.947	0	2328	0		
1551	17	7.916	0	2329	0		
1551	16	7.915	0	2329	0		
1551	15	7.903	0	2325	0		
1551	14	7.794	0	2284	0		
1551	13	7.741	0	2289	0		
1551	12	7.691	0	2296	0		
1551	11	7.662	0	2306	0		
1551	10	7.629	0	2305	0		
1551	9	7.598	0	2317	0		
1551	8	7.589	0	2326	0		
1551	7	7.609	0	2331	0		
1551	6	7.647	0	2327	0		
1551	5	7.666	0	2330	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1551	4	7.681	0	2330	0		
1551	3	7.692	0	2331	0		
1551	2	7.701	0	2336	0		
1551	1	7.703	0	2337	0		
1553	24	8.053	0	-999	0		
1553	23	8.051	0	-999	0		
1553	22	8.024	0	-999	0		
1553	21	8.010	0	-999	0		
1553	20	7.941	0	-999	0		
1553	19	7.891	0	-999	0		
1553	18	7.899	0	-999	0		
1553	17	7.914	0	-999	0		
1553	16	7.909	0	-999	0		
1553	15	7.841	0	-999	0		
1553	14	7.721	0	-999	0		
1553	13	7.658	0	-999	0		
1553	12	7.615	0	-999	0		
1553	11	7.588	0	-999	0		
1553	10	7.586	0	-999	0		
1553	9	7.598	0	-999	0		
1553	8	7.632	0	-999	0		
1555	24	8.063	0	2329	0		
1555	23	8.036	3	2326	0		
1555	22	8.014	0	2330	0		
1555	21	8.018	0	2331	0		
1555	20	8.012	0	2329	0		
1555	19	7.967	0	2331	0		
1555	18	7.950	0	2331	0		
1555	16	7.785	0	2302	0		
1555	15	7.679	0	2299	0		
1555	14	7.622	0	2313	0		
1555	13	7.590	0	2327	0		
1555	12	7.586	0	2329	0		
1555	11	7.588	0	2335	0		
1555	10	7.617	0	2334	0		
1555	9	7.654	0	2332	0		
1555	8	7.663	0	2333	0		
1555	7	7.682	0	2333	0		
1555	6	7.690	0	2335	0		
1555	5	7.695	0	2335	0		
1555	4	7.704	0	2339	0		
1555	3	7.703	0	2344	0		
1555	2	7.693	0	2355	0		
1555	1	7.653	0	2371	0		
1557	24	8.069	0	-999	0		
1557	23	8.065	0	-999	0		
1557	22	7.962	0	-999	0		
1557	21	7.997	0	-999	0		
1557	20	8.009	0	-999	0		
1557	19	7.944	0	-999	0		
1557	18	7.927	0	-999	0		
1557	17	7.856	0	-999	0		
1557	16	7.788	0	-999	0		
1557	15	7.678	0	-999	0		
1557	14	7.624	0	-999	0		
1557	13	7.593	0	-999	0		
1557	12	7.590	0	-999	0		
1557	11	7.620	0	-999	0		
1557	10	7.651	0	-999	0		
1557	9	7.668	0	-999	0		
1557	8	7.681	0	-999	0		
1557	7	7.691	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1557	6	7.699	0	-999	0		
1557	5	7.697	0	-999	0		
1557	4	7.702	0	-999	0		
1557	3	7.687	0	-999	0		
1557	2	7.668	0	-999	0		
1557	1	7.651	0	-999	0		
1559	24	8.063	0	2328	0		
1559	23	8.034	0	2326	0		
1559	22	7.917	0	2332	0		
1559	21	7.943	0	2331	0		
1559	20	7.936	0	2327	0		
1559	19	7.865	0	2316	0		
1559	18	7.800	0	2301	0		
1559	17	7.706	0	2299	0		
1559	16	7.658	0	2305	0		
1559	15	7.629	0	2305	0		
1559	14	7.599	0	2318	0		
1559	13	7.587	0	2336	0		
1559	12	7.604	0	2338	0		
1559	11	7.637	0	2334	0		
1559	10	7.662	0	2334	0		
1559	9	7.677	0	2337	0		
1559	8	7.692	0	2338	0		
1559	7	7.691	0	2341	0		
1559	6	7.700	0	2343	0		
1559	5	7.703	0	2348	0		
1559	4	7.697	0	2353	0		
1559	2	7.663	0	2364	0		
1559	1	7.648	0	2376	0		
1561	24	8.059	0	-999	0		
1561	22	7.978	0	-999	0		
1561	21	7.916	0	-999	0		
1561	20	7.909	0	-999	0		
1561	19	7.852	0	-999	0		
1561	18	7.802	0	-999	0		
1561	17	7.699	0	-999	0		
1561	16	7.664	0	-999	0		
1561	15	7.624	0	-999	0		
1561	14	7.586	0	-999	0		
1561	13	7.606	0	-999	0		
1561	12	7.634	0	-999	0		
1561	11	7.650	0	-999	0		
1561	10	7.674	0	-999	0		
1561	9	7.689	0	-999	0		
1561	8	7.696	0	-999	0		
1561	7	7.704	0	-999	0		
1561	6	7.705	0	-999	0		
1561	5	7.701	0	-999	0		
1561	4	7.685	0	-999	0		
1561	3	7.660	0	-999	0		
1561	2	7.649	0	-999	0		
1561	1	7.645	0	-999	0		
1563	24	8.051	0	2328	0		
1563	23	8.050	0	2328	0		
1563	22	8.011	0	2330	0		
1563	21	8.015	0	2330	0		
1563	20	7.988	0	2333	0		
1563	19	7.933	0	2334	0		
1563	18	7.921	0	2335	0		
1563	17	7.857	0	2317	0		
1563	16	7.758	0	2299	0		
1563	15	7.656	0	2299	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1563	14	7.601	0	2316	0		
1563	13	7.583	0	2332	0		
1563	12	7.617	0	2330	0		
1563	11	7.635	0	2334	0		
1563	10	7.661	0	2334	0		
1563	9	7.685	0	2334	0		
1563	8	7.692	0	2338	0		
1563	7	7.696	0	2340	0		
1563	6	7.699	0	2341	0		
1563	5	7.698	0	2346	0		
1563	4	7.694	0	2352	0		
1563	3	7.671	0	2358	0		
1563	2	7.652	0	2369	0		
1563	1	7.644	0	2374	0		
1565	24	8.048	0	-999	0		
1565	23	8.006	0	-999	0		
1565	22	7.967	0	-999	0		
1565	21	7.963	0	-999	0		
1565	20	7.920	0	-999	0		
1565	19	7.842	0	-999	0		
1565	18	7.790	0	-999	0		
1565	17	7.677	0	-999	0		
1565	16	7.634	0	-999	0		
1565	15	7.593	0	-999	0		
1565	14	7.587	0	-999	0		
1565	13	7.601	0	-999	0		
1565	12	7.643	0	-999	0		
1565	11	7.669	0	-999	0		
1565	10	7.679	0	-999	0		
1565	9	7.692	0	-999	0		
1565	8	7.692	0	-999	0		
1565	7	7.698	0	-999	0		
1565	6	7.703	0	-999	0		
1565	5	7.691	0	-999	0		
1565	4	7.670	0	-999	0		
1565	3	7.665	0	-999	0		
1565	2	7.655	0	-999	0		
1565	1	7.650	0	-999	0		
1567	24	8.053	0	2325	0		
1567	23	7.968	0	2326	0		
1567	22	7.990	0	2331	0		
1567	21	7.951	0	2332	0		
1567	20	7.957	0	2328	0		
1567	19	7.857	0	2312	0		
1567	18	7.711	0	2298	0		
1567	17	7.674	0	2289	0		
1567	16	7.629	0	2299	0		
1567	15	7.597	0	2313	0		
1567	14	7.587	0	2328	0		
1567	13	7.606	0	2332	0		
1567	12	7.628	0	2334	0		
1567	11	7.651	0	2334	0		
1567	10	7.675	0	2333	0		
1567	9	7.692	0	2335	0		
1567	8	7.697	0	2340	0		
1567	7	7.696	0	2343	0		
1567	6	7.698	0	2346	0		
1567	5	7.692	0	2351	0		
1567	4	7.675	0	2356	0		
1567	3	7.654	0	2362	0		
1567	2	7.643	0	2370	0		
1567	1	7.640	0	2371	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1569	24	8.048	0	-999	0		
1569	23	8.013	0	-999	0		
1569	22	7.964	0	-999	0		
1569	21	7.932	0	-999	0		
1569	20	7.908	0	-999	0		
1569	19	7.831	0	-999	0		
1569	18	7.708	0	-999	0		
1569	17	7.660	0	-999	0		
1569	16	7.615	0	-999	0		
1569	15	7.590	0	-999	0		
1569	14	7.585	0	-999	0		
1569	13	7.609	0	-999	0		
1569	12	7.635	0	-999	0		
1569	11	7.658	0	-999	0		
1569	10	7.678	0	-999	0		
1569	9	7.693	0	-999	0		
1569	8	7.689	0	-999	0		
1569	7	7.695	0	-999	0		
1569	6	7.700	0	-999	0		
1569	5	7.686	0	-999	0		
1569	4	7.648	0	-999	0		
1569	3	7.643	0	-999	0		
1569	2	7.640	0	-999	0		
1569	1	7.633	0	-999	0		
1571	24	8.043	0	2331	0		
1571	23	8.019	0	2333	0		
1571	22	7.943	0	2328	0		
1571	21	7.913	0	2321	0		
1571	20	7.882	0	2314	0		
1571	19	7.795	0	2299	0		
1571	18	7.794	4	2301	0		
1571	16	7.609	0	2311	0		
1571	15	7.586	0	2329	0		
1571	14	7.595	0	2335	0		
1571	13	7.635	0	2334	0		
1571	12	7.671	0	2330	0		
1571	11	7.674	0	2335	0		
1571	10	7.682	0	2337	0		
1571	9	7.688	0	2338	0		
1571	8	7.691	0	2343	0		
1571	7	7.689	0	2348	0		
1571	6	7.687	0	2353	0		
1571	5	7.670	0	2360	0		
1571	4	7.655	0	2363	0		
1571	3	7.645	0	2365	0		
1571	2	7.642	0	2367	0		
1571	1	7.640	0	2369	0		
1573	24	8.037	0	-999	0		
1573	23	8.017	0	-999	0		
1573	22	7.952	0	-999	0		
1573	21	7.907	0	-999	0		
1573	20	7.865	0	-999	0		
1573	19	7.800	0	-999	0		
1573	18	7.709	0	-999	0		
1573	17	7.660	0	-999	0		
1573	16	7.614	0	-999	0		
1573	15	7.586	0	-999	0		
1573	14	7.590	0	-999	0		
1573	13	7.618	0	-999	0		
1573	12	7.646	0	-999	0		
1573	11	7.655	0	-999	0		
1573	10	7.678	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1573	9	7.690	0	-999	0		
1573	8	7.687	0	-999	0		
1573	7	7.692	0	-999	0		
1573	6	7.693	0	-999	0		
1573	5	7.686	0	-999	0		
1573	4	7.660	0	-999	0		
1573	3	7.648	0	-999	0		
1573	2	7.646	0	-999	0		
1573	1	7.643	0	-999	0		
1575	24	8.043	0	2330	0		
1575	23	8.033	0	2332	0		
1575	22	7.991	0	2327	0		
1575	21	7.936	0	2322	0		
1575	20	7.878	0	2312	0		
1575	19	7.802	0	2302	0		
1575	18	7.711	0	2290	0		
1575	17	7.653	0	2292	0		
1575	16	7.616	0	2304	0		
1575	15	7.585	0	2327	0		
1575	14	7.616	0	2329	0		
1575	13	7.654	0	2328	0		
1575	12	7.670	0	2332	0		
1575	11	7.681	0	2334	0		
1575	10	7.686	0	2339	0		
1575	9	7.693	0	2344	0		
1575	8	7.687	0	2348	0		
1575	7	7.683	0	2354	0		
1575	6	7.663	0	2358	0		
1575	5	7.650	0	2366	0		
1575	4	7.647	0	2369	0		
1575	3	7.646	0	2368	0		
1575	1	7.640	0	2368	0		
1577	24	8.044	0	-999	0		
1577	23	7.925	0	-999	0		
1577	22	7.931	0	-999	0		
1577	21	7.952	0	-999	0		
1577	20	7.925	0	-999	0		
1577	19	7.850	0	-999	0		
1577	18	7.778	0	-999	0		
1577	17	7.687	0	-999	0		
1577	16	7.663	0	-999	0		
1577	15	7.608	0	-999	0		
1577	14	7.586	0	-999	0		
1577	13	7.613	0	-999	0		
1577	12	7.645	0	-999	0		
1577	11	7.671	0	-999	0		
1577	10	7.687	0	-999	0		
1577	9	7.690	0	-999	0		
1577	8	7.689	0	-999	0		
1577	7	7.680	0	-999	0		
1577	6	7.665	0	-999	0		
1577	5	7.653	0	-999	0		
1577	4	7.648	0	-999	0		
1577	3	7.644	0	-999	0		
1577	2	7.645	0	-999	0		
1577	1	7.643	0	-999	0		
1579	24	8.022	0	2333	0		
1579	23	8.021	0	2334	0		
1579	22	8.017	0	2333	0		
1579	21	8.009	0	2333	0		
1579	20	8.005	0	2333	0		
1579	19	7.973	0	2332	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1579	18	7.954	0	2331	0		
1579	17	7.875	0	2318	0		
1579	16	7.811	0	2303	0		
1579	15	7.702	0	2288	0		
1579	14	7.669	0	2283	0		
1579	13	7.638	0	2297	0		
1579	12	7.598	0	2315	0		
1579	11	7.587	0	2334	0		
1579	10	7.616	0	2338	0		
1579	9	7.656	0	2335	0		
1579	8	7.674	0	2338	0		
1579	7	7.685	0	2341	0		
1579	6	7.690	0	2343	0		
1579	5	7.693	0	2348	0		
1579	4	7.679	0	2356	0		
1579	3	7.656	0	2364	0		
1579	2	7.645	0	2370	0		
1579	1	7.642	0	2372	0		
1581	24	8.023	0	-999	0		
1581	23	8.011	0	-999	0		
1581	22	8.004	0	-999	0		
1581	21	7.981	0	-999	0		
1581	20	7.961	0	-999	0		
1581	19	7.873	0	-999	0		
1581	18	7.810	0	-999	0		
1581	17	7.678	0	-999	0		
1581	16	7.630	0	-999	0		
1581	15	7.591	0	-999	0		
1581	14	7.581	0	-999	0		
1581	13	7.611	0	-999	0		
1581	12	7.643	0	-999	0		
1581	11	7.665	0	-999	0		
1581	10	7.679	0	-999	0		
1581	9	7.683	0	-999	0		
1581	8	7.689	0	-999	0		
1581	7	7.696	0	-999	0		
1581	6	7.688	0	-999	0		
1581	5	7.672	0	-999	0		
1581	4	7.655	0	-999	0		
1581	3	7.647	0	-999	0		
1581	2	7.644	0	-999	0		
1581	1	7.633	0	-999	0		
1583	24	7.969	0	2319	0		
1583	23	7.955	0	2319	0		
1583	22	7.946	0	2319	0		
1583	21	7.927	0	2315	0		
1583	20	7.912	0	2305	0		
1583	19	7.829	0	2306	0		
1583	18	7.745	0	2290	0		
1583	17	7.665	0	2286	0		
1583	16	7.649	0	2296	0		
1583	15	7.594	0	2316	0		
1583	14	7.588	0	2333	0		
1583	13	7.606	0	2337	0		
1583	12	7.646	0	2335	0		
1583	11	7.671	0	2336	0		
1583	10	7.687	0	2339	0		
1583	9	7.698	0	2343	0		
1583	8	7.692	0	2346	0		
1583	7	7.689	0	2348	0		
1583	6	7.685	0	2354	0		
1583	5	7.663	0	2360	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1583	4	7.649	0	2366	0		
1583	3	7.647	0	2368	0		
1583	2	7.641	0	2370	0		
1583	1	7.644	0	2369	0		
1585	24	7.968	0	-999	0		
1585	23	7.952	0	-999	0		
1585	22	7.935	0	-999	0		
1585	21	7.912	0	-999	0		
1585	20	7.893	0	-999	0		
1585	19	7.865	0	-999	0		
1585	18	7.798	0	-999	0		
1585	17	7.711	0	-999	0		
1585	16	7.674	0	-999	0		
1585	15	7.639	0	-999	0		
1585	14	7.589	0	-999	0		
1585	13	7.582	0	-999	0		
1585	12	7.611	0	-999	0		
1585	11	7.653	0	-999	0		
1585	10	7.673	0	-999	0		
1585	9	7.684	0	-999	0		
1585	8	7.688	0	-999	0		
1585	7	7.686	0	-999	0		
1585	6	7.673	0	-999	0		
1585	5	7.657	0	-999	0		
1585	4	7.644	0	-999	0		
1585	3	7.639	0	-999	0		
1585	2	7.636	0	-999	0		
1585	1	7.638	0	-999	0		
1587	24	7.942	0	2304	0		
1587	23	7.942	0	2303	0		
1587	22	7.918	0	2304	0		
1587	21	7.914	0	2299	0		
1587	20	7.899	0	2299	0		
1587	19	7.896	0	2302	0		
1587	18	7.872	0	2297	0		
1587	17	7.783	0	2291	0		
1587	16	7.688	0	2284	0		
1587	15	7.648	0	2292	0		
1587	14	7.601	0	2311	0		
1587	13	7.587	0	2331	0		
1587	12	7.612	0	2337	0		
1587	11	7.649	0	2336	0		
1587	10	7.670	0	2338	0		
1587	9	7.686	0	2340	0		
1587	8	7.693	0	2344	0		
1587	7	7.694	0	2348	0		
1587	6	7.680	0	2356	0		
1587	5	7.659	0	2363	0		
1587	4	7.650	0	2369	0		
1587	3	7.642	0	2370	0		
1587	2	7.640	0	2371	0		
1587	1	7.639	0	2371	0		
1589	24	7.958	0	-999	0		
1589	23	7.951	0	-999	0		
1589	22	7.932	0	-999	0		
1589	21	7.864	0	-999	0		
1589	20	7.797	0	-999	0		
1589	19	7.711	0	-999	0		
1589	18	7.667	0	-999	0		
1589	17	7.628	0	-999	0		
1589	16	7.588	0	-999	0		
1589	15	7.589	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1589	14	7.620	0	-999	0		
1589	13	7.654	0	-999	0		
1589	12	7.671	0	-999	0		
1589	11	7.683	0	-999	0		
1589	10	7.689	0	-999	0		
1589	9	7.691	0	-999	0		
1589	8	7.689	0	-999	0		
1589	7	7.682	0	-999	0		
1589	6	7.668	0	-999	0		
1589	5	7.655	0	-999	0		
1589	4	7.644	0	-999	0		
1589	3	7.635	3	-999	0		
1589	2	7.639	0	-999	0		
1589	1	7.635	0	-999	0		
1591	24	7.950	0	2310	0		
1591	23	7.957	0	2319	0		
1591	22	7.922	0	2310	0		
1591	21	7.898	0	2311	0		
1591	20	7.876	0	2306	0		
1591	19	7.885	0	2312	0		
1591	18	7.819	3	2296	0		
1591	17	7.742	0	2286	0		
1591	16	7.694	0	2283	0		
1591	15	7.669	0	2282	0		
1591	14	7.633	0	2301	0		
1591	13	7.589	0	2319	0		
1591	12	7.585	0	2337	3		
1591	11	7.607	0	2338	0		
1591	10	7.639	0	2335	0		
1591	9	7.661	0	2336	0		
1591	8	7.674	0	2337	0		
1591	7	7.682	0	2339	0		
1591	6	7.686	0	2344	0		
1591	5	7.687	0	2346	0		
1591	4	7.681	0	2351	0		
1591	3	7.666	0	2358	0		
1591	2	7.657	0	2360	0		
1591	1	7.655	0	2361	0		
1593	24	7.966	3	-999	0		
1593	23	7.949	0	-999	0		
1593	22	7.941	0	-999	0		
1593	21	7.897	0	-999	0		
1593	20	7.871	0	-999	0		
1593	19	7.892	0	-999	0		
1593	18	7.759	0	-999	0		
1593	17	7.685	0	-999	0		
1593	16	7.664	0	-999	0		
1593	15	7.606	0	-999	0		
1593	14	7.582	0	-999	0		
1593	13	7.592	0	-999	0		
1593	12	7.636	0	-999	0		
1593	11	7.667	0	-999	0		
1593	10	7.682	0	-999	0		
1593	9	7.690	0	-999	0		
1593	8	7.689	0	-999	0		
1593	7	7.672	0	-999	0		
1593	6	7.651	0	-999	0		
1593	5	7.646	0	-999	0		
1593	4	7.641	0	-999	0		
1593	3	7.639	0	-999	0		
1593	2	7.640	0	-999	0		
1593	1	7.636	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1595	24	7.970	0	2323	0		
1595	23	7.958	0	2323	0		
1595	22	7.945	0	2321	0		
1595	21	7.905	0	2314	0		
1595	20	7.877	0	2310	0		
1595	19	7.888	0	2315	0		
1595	18	7.791	0	2296	0		
1595	17	7.720	0	2292	0		
1595	16	7.649	0	2292	0		
1595	15	7.597	0	2315	0		
1595	14	7.580	0	2335	0		
1595	13	7.621	0	2339	0		
1595	12	7.655	0	2337	0		
1595	11	7.674	0	2340	0		
1595	10	7.682	0	2343	0		
1595	9	7.687	0	2348	0		
1595	8	7.685	0	2351	0		
1595	7	7.676	0	2356	0		
1595	6	7.662	0	2360	0		
1595	5	7.650	0	2364	0		
1595	4	7.641	0	2367	0		
1595	3	7.638	0	2371	0		
1595	2	7.625	0	2368	0		
1595	1	7.624	0	2369	0		
1597	24	7.966	0	-999	0		
1597	23	7.961	0	-999	0		
1597	22	7.961	0	-999	0		
1597	21	7.946	0	-999	0		
1597	20	7.921	0	-999	0		
1597	19	7.903	0	-999	0		
1597	18	7.896	0	-999	0		
1597	17	7.892	0	-999	0		
1597	16	7.694	0	-999	0		
1597	15	7.670	0	-999	0		
1597	14	7.640	0	-999	0		
1597	13	7.600	0	-999	0		
1597	12	7.587	0	-999	0		
1597	11	7.625	0	-999	0		
1597	10	7.657	0	-999	0		
1597	9	7.674	0	-999	0		
1597	8	7.682	0	-999	0		
1597	7	7.685	0	-999	0		
1597	6	7.677	0	-999	0		
1597	5	7.658	0	-999	0		
1597	4	7.646	0	-999	0		
1597	3	7.637	0	-999	0		
1597	2	7.635	0	-999	0		
1597	1	7.634	0	-999	0		
1599	24	7.958	0	2321	0		
1599	23	7.932	0	2317	0		
1599	22	7.891	0	2315	0		
1599	21	7.897	0	2316	0		
1599	20	7.897	0	2316	0		
1599	19	7.896	0	2316	0		
1599	18	7.754	0	2290	0		
1599	17	7.670	0	2282	0		
1599	16	7.655	0	2289	0		
1599	15	7.623	0	2299	0		
1599	14	7.593	0	2318	0		
1599	13	7.582	0	2329	0		
1599	12	7.605	0	2335	0		
1599	11	7.645	0	2338	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1599	10	7.670	0	2337	0		
1599	9	7.682	0	2340	0		
1599	8	7.681	0	2345	0		
1599	7	7.681	0	2349	0		
1599	6	7.672	0	2356	0		
1599	5	7.656	0	2361	0		
1599	4	7.645	0	2366	0		
1599	3	7.642	0	2367	0		
1599	2	7.628	0	2367	0		
1599	1	7.627	0	2369	0		
1601	24	7.951	0	-999	0		
1601	23	7.927	0	-999	0		
1601	22	7.887	0	-999	0		
1601	21	7.875	0	-999	0		
1601	20	7.877	0	-999	0		
1601	19	7.896	0	-999	0		
1601	18	7.800	0	-999	0		
1601	17	7.697	0	-999	0		
1601	16	7.662	0	-999	0		
1601	15	7.609	0	-999	0		
1601	14	7.592	0	-999	0		
1601	13	7.586	0	-999	0		
1601	12	7.615	0	-999	0		
1601	11	7.643	0	-999	0		
1601	10	7.666	0	-999	0		
1601	9	7.682	0	-999	0		
1601	8	7.685	0	-999	0		
1601	7	7.687	0	-999	0		
1601	6	7.674	0	-999	0		
1601	5	7.662	0	-999	0		
1601	4	7.644	0	-999	0		
1601	3	7.643	0	-999	0		
1601	2	7.638	0	-999	0		
1601	1	7.635	0	-999	0		
1603	24	7.928	0	2300	0		
1603	23	7.918	0	2298	0		
1603	22	7.887	0	2293	0		
1603	21	7.857	0	2296	0		
1603	20	7.801	0	2303	0		
1603	19	7.692	0	2282	0		
1603	18	7.667	0	2283	0		
1603	17	7.640	0	2289	0		
1603	16	7.595	0	2312	0		
1603	15	7.583	0	2322	0		
1603	14	7.587	0	2332	0		
1603	13	7.613	0	2336	0		
1603	12	7.647	0	2336	0		
1603	11	7.669	0	2336	0		
1603	10	7.680	0	2339	0		
1603	9	7.683	0	2342	0		
1603	8	7.691	0	2344	0		
1603	7	7.678	0	2348	0		
1603	6	7.674	0	2353	0		
1603	5	7.656	0	2359	0		
1603	4	7.642	0	2362	0		
1603	3	7.637	0	2366	0		
1603	2	7.636	0	2365	0		
1603	1	7.635	0	2364	0		
1605	24	7.910	0	-999	0		
1605	23	7.910	0	-999	0		
1605	22	7.882	0	-999	0		
1605	21	7.887	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1605	20	7.870	0	-999	0		
1605	19	7.833	0	-999	0		
1605	18	7.814	0	-999	0		
1605	17	7.712	0	-999	0		
1605	16	7.677	0	-999	0		
1605	15	7.656	0	-999	0		
1605	14	7.616	0	-999	0		
1605	13	7.589	0	-999	0		
1605	12	7.584	0	-999	0		
1605	11	7.617	0	-999	0		
1605	10	7.654	0	-999	0		
1605	9	7.667	0	-999	0		
1605	8	7.683	0	-999	0		
1605	7	7.687	0	-999	0		
1605	6	7.683	0	-999	0		
1605	5	7.664	0	-999	0		
1605	4	7.651	0	-999	0		
1605	3	7.641	0	-999	0		
1605	2	7.637	0	-999	0		
1605	1	7.634	0	-999	0		
1607	24	7.890	0	2283	0		
1607	23	7.887	0	2287	0		
1607	22	7.856	0	2290	0		
1607	21	7.795	0	2291	0		
1607	20	7.694	0	2280	0		
1607	19	7.663	0	2286	0		
1607	18	7.636	0	2291	0		
1607	17	7.588	0	2310	0		
1607	16	7.577	0	2319	0		
1607	15	7.577	0	2327	0		
1607	14	7.601	0	2336	0		
1607	13	7.619	0	2338	0		
1607	12	7.642	0	2338	0		
1607	11	7.655	0	2338	0		
1607	10	7.673	0	2338	0		
1607	9	7.681	0	2341	0		
1607	8	7.686	0	2342	0		
1607	7	7.689	0	2345	0		
1607	6	7.684	0	2351	0		
1607	5	7.667	0	2355	0		
1607	4	7.651	0	2361	0		
1607	3	7.643	0	2365	0		
1607	2	7.640	0	2366	0		
1607	1	7.637	0	2366	0		
1609	24	7.896	0	-999	0		
1609	23	7.882	0	-999	0		
1609	22	7.848	0	-999	0		
1609	21	7.825	0	-999	0		
1609	20	7.772	0	-999	0		
1609	19	7.700	0	-999	0		
1609	18	7.660	0	-999	0		
1609	17	7.619	0	-999	0		
1609	16	7.588	0	-999	0		
1609	15	7.579	0	-999	0		
1609	14	7.590	0	-999	0		
1609	13	7.609	0	-999	0		
1609	12	7.635	0	-999	0		
1609	11	7.656	0	-999	0		
1609	10	7.671	0	-999	0		
1609	9	7.683	0	-999	0		
1609	8	7.685	0	-999	0		
1609	7	7.681	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1609	6	7.667	0	-999	0		
1609	4	7.644	0	-999	0		
1609	3	7.641	0	-999	0		
1609	2	7.637	0	-999	0		
1609	1	7.638	0	-999	0		
1611	24	7.864	0	2282	0		
1611	23	7.855	0	2276	0		
1611	22	7.821	0	2276	0		
1611	21	7.793	0	2275	0		
1611	20	7.742	0	2285	0		
1611	19	7.699	0	2283	0		
1611	18	7.674	0	2283	0		
1611	17	7.641	0	2291	0		
1611	16	7.594	0	2312	0		
1611	15	7.577	0	2327	0		
1611	14	7.589	0	2332	0		
1611	13	7.602	0	2339	0		
1611	12	7.640	0	2340	0		
1611	11	7.645	0	2339	0		
1611	10	7.673	0	2341	0		
1611	9	7.684	0	2342	0		
1611	8	7.686	0	2345	0		
1611	7	7.682	0	2349	0		
1611	6	7.670	0	2354	0		
1611	5	7.654	0	2361	0		
1611	4	7.646	0	2364	0		
1611	3	7.641	0	2366	0		
1611	2	7.638	0	2366	0		
1611	1	7.638	0	2366	0		
1613	24	7.881	0	-999	0		
1613	23	7.880	0	-999	0		
1613	22	7.869	0	-999	0		
1613	21	7.839	0	-999	0		
1613	20	7.816	0	-999	0		
1613	19	7.792	0	-999	0		
1613	18	7.783	0	-999	0		
1613	17	7.690	0	-999	0		
1613	16	7.674	0	-999	0		
1613	15	7.641	0	-999	0		
1613	14	7.601	0	-999	0		
1613	13	7.578	0	-999	0		
1613	12	7.578	0	-999	0		
1613	11	7.603	0	-999	0		
1613	10	7.631	0	-999	0		
1613	9	7.651	0	-999	0		
1613	8	7.675	0	-999	0		
1613	7	7.685	0	-999	0		
1613	6	7.681	0	-999	0		
1613	5	7.668	0	-999	0		
1613	4	7.650	0	-999	0		
1613	3	7.642	0	-999	0		
1613	2	7.637	0	-999	0		
1613	1	7.634	0	-999	0		
1615	24	7.844	0	2279	0		
1615	23	7.847	0	2279	0		
1615	22	7.830	0	2280	0		
1615	21	7.812	0	2282	0		
1615	20	7.701	0	2279	0		
1615	19	7.680	0	2280	0		
1615	18	7.651	0	2289	0		
1615	17	7.618	0	2301	0		
1615	16	7.583	0	2316	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1615	15	7.582	0	2328	0		
1615	14	7.593	0	2334	0		
1615	13	7.609	0	2339	0		
1615	12	7.630	0	2340	0		
1615	11	7.648	0	2340	0		
1615	10	7.666	0	2341	0		
1615	9	7.675	0	2344	0		
1615	8	7.681	0	2344	0		
1615	7	7.683	0	2350	0		
1615	6	7.670	0	2355	0		
1615	5	7.657	0	2359	0		
1615	4	7.645	0	2364	0		
1615	3	7.641	0	2366	0		
1615	2	7.640	0	2365	0		
1615	1	7.637	0	2366	0		
1617	24	7.859	0	-999	0		
1617	23	7.853	0	-999	0		
1617	22	7.805	0	-999	0		
1617	21	7.805	0	-999	0		
1617	20	7.812	0	-999	0		
1617	19	7.694	0	-999	0		
1617	18	7.660	0	-999	0		
1617	17	7.622	0	-999	0		
1617	16	7.591	0	-999	0		
1617	15	7.578	0	-999	0		
1617	14	7.587	0	-999	0		
1617	13	7.609	0	-999	0		
1617	12	7.626	0	-999	0		
1617	11	7.636	0	-999	0		
1617	10	7.671	0	-999	0		
1617	9	7.685	0	-999	0		
1617	8	7.679	0	-999	0		
1617	7	7.669	0	-999	0		
1617	6	7.659	0	-999	0		
1617	5	7.648	0	-999	0		
1617	4	7.642	0	-999	0		
1617	3	7.637	0	-999	0		
1617	2	7.638	0	-999	0		
1617	1	7.637	0	-999	0		
1619	24	7.848	0	2277	0		
1619	23	7.850	0	2280	0		
1619	22	7.835	0	2278	0		
1619	21	7.815	0	2279	0		
1619	20	7.809	0	2279	0		
1619	19	7.760	0	2284	0		
1619	18	7.702	0	2282	0		
1619	17	7.676	0	2283	0		
1619	16	7.654	0	2289	0		
1619	15	7.612	0	2306	0		
1619	14	7.586	0	2319	0		
1619	13	7.585	0	2333	0		
1619	12	7.602	0	2339	0		
1619	11	7.633	0	2339	0		
1619	10	7.650	0	2340	0		
1619	9	7.665	0	2342	0		
1619	8	7.672	0	2344	0		
1619	7	7.674	0	2348	0		
1619	6	7.676	0	2353	0		
1619	5	7.669	0	2358	0		
1619	4	7.656	0	2360	0		
1619	3	7.644	0	2365	0		
1619	2	7.636	0	2368	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1619	1	7.639	0	2366	0		
1621	24	7.847	0	-999	0		
1621	23	7.851	0	-999	0		
1621	22	7.845	0	-999	0		
1621	21	7.843	0	-999	0		
1621	20	7.830	0	-999	0		
1621	19	7.807	0	-999	0		
1621	18	7.793	0	-999	0		
1621	17	7.703	0	-999	0		
1621	16	7.671	0	-999	0		
1621	15	7.625	0	-999	0		
1621	14	7.588	0	-999	0		
1621	13	7.582	0	-999	0		
1621	12	7.607	0	-999	0		
1621	11	7.633	0	-999	0		
1621	10	7.651	0	-999	0		
1621	9	7.672	0	-999	0		
1621	8	7.671	0	-999	0		
1621	7	7.673	0	-999	0		
1621	6	7.668	0	-999	0		
1621	5	7.652	0	-999	0		
1621	4	7.642	0	-999	0		
1621	2	7.639	0	-999	0		
1621	1	7.642	0	-999	0		
1623	24	7.838	0	2278	0		
1623	23	7.836	0	2284	0		
1623	22	7.811	0	2281	0		
1623	21	7.792	0	2282	0		
1623	20	7.768	0	2280	0		
1623	19	7.689	0	2279	0		
1623	18	7.671	0	2282	0		
1623	17	7.656	3	2287	0		
1623	16	7.629	0	2297	0		
1623	15	7.593	0	2312	0		
1623	14	7.592	0	2324	0		
1623	13	7.591	0	2334	0		
1623	12	7.605	0	2339	0		
1623	11	7.628	0	2339	0		
1623	10	7.646	0	2342	0		
1623	9	7.665	0	2342	0		
1623	8	7.666	0	2344	0		
1623	7	7.672	0	2346	0		
1623	6	7.675	0	2348	0		
1623	5	7.671	0	2353	0		
1623	4	7.667	0	2358	0		
1623	3	7.659	0	2362	0		
1623	2	7.656	0	2365	0		
1623	1	7.649	0	2367	0		
1625	24	7.824	0	-999	0		
1625	23	7.822	0	-999	0		
1625	22	7.815	0	-999	0		
1625	21	7.803	0	-999	0		
1625	20	7.777	0	-999	0		
1625	19	7.699	0	-999	0		
1625	18	7.680	0	-999	0		
1625	17	7.675	0	-999	0		
1625	16	7.665	0	-999	0		
1625	15	7.638	0	-999	0		
1625	14	7.613	0	-999	0		
1625	13	7.600	0	-999	0		
1625	12	7.594	0	-999	0		
1625	11	7.588	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1625	10	7.579	0	-999	0		
1625	9	7.584	0	-999	0		
1625	8	7.594	0	-999	0		
1625	7	7.602	0	-999	0		
1625	6	7.620	0	-999	0		
1625	5	7.622	0	-999	0		
1625	4	7.634	0	-999	0		
1625	3	7.641	0	-999	0		
1625	2	7.652	0	-999	0		
1625	1	7.654	0	-999	0		
1627	24	7.819	0	2274	0		
1627	23	7.813	0	2275	0		
1627	22	7.814	0	2279	0		
1627	21	7.811	0	2282	0		
1627	20	7.758	0	2278	0		
1627	19	7.713	0	2281	0		
1627	18	7.683	0	2280	0		
1627	17	7.671	0	2284	0		
1627	16	7.628	0	2296	0		
1627	15	7.587	0	2318	0		
1627	14	7.583	0	2323	0		
1627	13	7.587	0	2332	0		
1627	12	7.589	0	2335	0		
1627	11	7.622	0	2341	0		
1627	10	7.642	0	2341	0		
1627	9	7.656	0	2345	0		
1627	8	7.667	0	2348	0		
1627	7	7.657	0	2354	0		
1627	6	7.658	0	2358	0		
1627	5	7.653	0	2359	0		
1627	4	7.643	0	2363	0		
1627	3	7.629	0	2367	0		
1627	2	7.625	0	2365	0		
1627	1	7.621	0	2368	0		
1629	24	7.836	0	-999	0		
1629	23	7.836	0	-999	0		
1629	22	7.827	0	-999	0		
1629	21	7.821	0	-999	0		
1629	20	7.772	0	-999	0		
1629	19	7.708	0	-999	0		
1629	18	7.677	0	-999	0		
1629	17	7.648	0	-999	0		
1629	16	7.610	0	-999	0		
1629	15	7.582	0	-999	0		
1629	14	7.578	0	-999	0		
1629	13	7.578	0	-999	0		
1629	12	7.598	0	-999	0		
1629	11	7.615	0	-999	0		
1629	10	7.640	0	-999	0		
1629	9	7.652	0	-999	0		
1629	8	7.666	0	-999	0		
1629	7	7.661	0	-999	0		
1629	6	7.655	0	-999	0		
1629	5	7.653	0	-999	0		
1629	4	7.638	0	-999	0		
1629	3	7.626	0	-999	0		
1629	2	7.622	0	-999	0		
1629	1	7.619	0	-999	0		
1631	24	7.827	0	-999	0		
1631	23	7.837	0	-999	0		
1631	22	7.835	0	-999	0		
1631	21	7.824	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1631	20	7.821	0	-999	0		
1631	19	7.775	0	-999	0		
1631	18	7.719	0	-999	0		
1631	17	7.679	0	-999	0		
1631	16	7.658	0	-999	0		
1631	15	7.627	0	-999	0		
1631	14	7.602	0	-999	0		
1631	13	7.576	0	-999	0		
1631	12	7.586	0	-999	0		
1631	11	7.613	0	-999	0		
1631	10	7.625	0	-999	0		
1631	9	7.632	0	-999	0		
1631	8	7.644	0	-999	0		
1631	7	7.647	0	-999	0		
1631	6	7.650	0	-999	0		
1631	5	7.644	0	-999	0		
1631	4	7.639	0	-999	0		
1631	3	7.638	0	-999	0		
1631	2	7.641	0	-999	0		
1631	1	7.631	0	-999	0		
1633	24	7.788	0	-999	0		
1633	23	7.791	0	-999	0		
1633	22	7.774	0	-999	0		
1633	21	7.704	0	-999	0		
1633	20	7.669	0	-999	0		
1633	19	7.625	0	-999	0		
1633	18	7.590	0	-999	0		
1633	17	7.569	0	-999	0		
1633	16	7.576	0	-999	0		
1633	15	7.587	0	-999	0		
1633	14	7.608	0	-999	0		
1633	13	7.623	0	-999	0		
1633	12	7.638	0	-999	0		
1633	11	7.642	0	-999	0		
1633	10	7.642	0	-999	0		
1633	9	7.640	0	-999	0		
1633	8	7.630	0	-999	0		
1633	7	7.628	0	-999	0		
1633	6	7.632	0	-999	0		
1633	5	7.627	0	-999	0		
1633	4	7.635	0	-999	0		
1633	3	7.627	0	-999	0		
1633	2	7.624	0	-999	0		
1633	1	7.622	0	-999	0		
1635	24	7.769	0	2262	0		
1635	23	7.760	0	2265	0		
1635	22	7.754	0	2266	0		
1635	21	7.725	0	2270	0		
1635	20	7.697	0	2277	0		
1635	19	7.655	0	2288	0		
1635	18	7.602	0	2304	0		
1635	17	7.573	0	2324	0		
1635	16	7.574	0	2335	0		
1635	15	7.581	0	2338	0		
1635	14	7.598	0	2343	0		
1635	13	7.619	0	2347	0		
1635	12	7.633	0	2347	0		
1635	11	7.645	0	2351	0		
1635	10	7.639	0	2355	0		
1635	9	7.643	0	2356	0		
1635	8	7.633	0	2361	0		
1635	7	7.631	0	2365	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1635	6	7.635	0	2364	0		
1635	5	7.627	0	2365	0		
1635	4	7.626	0	2368	0		
1635	3	7.621	0	2368	0		
1635	2	7.621	0	2369	0		
1635	1	7.624	0	2369	0		
1637	24	7.773	0	-999	0		
1637	23	7.773	0	-999	0		
1637	22	7.761	0	-999	0		
1637	21	7.741	0	-999	0		
1637	20	7.691	0	-999	0		
1637	19	7.659	0	-999	0		
1637	18	7.631	0	-999	0		
1637	17	7.595	0	-999	0		
1637	16	7.570	0	-999	0		
1637	15	7.570	0	-999	0		
1637	14	7.583	0	-999	0		
1637	13	7.615	0	-999	0		
1637	12	7.624	0	-999	0		
1637	11	7.642	0	-999	0		
1637	10	7.647	0	-999	0		
1637	9	7.645	0	-999	0		
1637	8	7.640	0	-999	0		
1637	7	7.635	0	-999	0		
1637	6	7.636	0	-999	0		
1637	5	7.629	0	-999	0		
1637	4	7.628	0	-999	0		
1637	3	7.623	0	-999	0		
1637	2	7.620	0	-999	0		
1637	1	7.621	0	-999	0		
1639	24	7.762	0	2269	0		
1639	23	7.767	0	2269	0		
1639	22	7.753	0	2270	0		
1639	21	7.744	0	2271	0		
1639	20	7.713	0	2278	0		
1639	19	7.687	0	2282	0		
1639	18	7.650	0	2292	0		
1639	17	7.596	0	2310	0		
1639	16	7.577	0	2317	0		
1639	15	7.564	0	2326	0		
1639	14	7.574	0	2339	0		
1639	13	7.573	8	2332	8		
1639	12	7.614	0	2347	0		
1639	11	7.630	0	2348	0		
1639	10	7.635	0	2351	0		
1639	9	7.640	0	2354	0		
1639	8	7.634	0	2358	0		
1639	7	7.629	0	2361	0		
1639	6	7.632	0	2365	0		
1639	5	7.628	0	2365	0		
1639	4	7.622	0	2368	0		
1639	3	7.618	0	2367	0		
1639	2	7.623	0	2368	0		
1639	1	7.620	0	2371	0		
1641	24	7.774	0	-999	0		
1641	23	7.776	0	-999	0		
1641	22	7.770	0	-999	0		
1641	21	7.759	0	-999	0		
1641	20	7.753	0	-999	0		
1641	19	7.741	0	-999	0		
1641	18	7.714	0	-999	0		
1641	17	7.655	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1641	16	7.606	0	-999	0		
1641	15	7.577	0	-999	0		
1641	14	7.571	0	-999	0		
1641	13	7.582	0	-999	0		
1641	12	7.609	0	-999	0		
1641	11	7.634	0	-999	0		
1641	10	7.643	0	-999	0		
1641	9	7.638	0	-999	0		
1641	8	7.636	0	-999	0		
1641	7	7.630	0	-999	0		
1641	6	7.634	0	-999	0		
1641	5	7.627	0	-999	0		
1641	4	7.628	0	-999	0		
1641	3	7.622	0	-999	0		
1641	2	7.617	0	-999	0		
1641	1	7.618	0	-999	0		
1643	24	7.761	0	2266	0		
1643	23	7.768	0	2266	0		
1643	22	7.753	0	2267	0		
1643	21	7.746	0	2268	0		
1643	20	7.709	0	2274	0		
1643	18	7.653	0	2289	0		
1643	16	7.606	0	2304	0		
1643	14	7.580	0	2319	0		
1643	12	7.569	0	2331	0		
1643	10	7.592	0	2339	0		
1643	8	7.604	0	2343	0		
1643	6	7.625	0	2348	0		
1643	4	7.640	0	2353	0		
1643	2	7.643	0	2353	0		
1643	1	7.639	0	2354	0		
1645	24	7.764	0	-999	0		
1645	23	7.768	0	-999	0		
1645	22	7.757	0	-999	0		
1645	21	7.742	0	-999	0		
1645	20	7.688	0	-999	0		
1645	19	7.662	0	-999	0		
1645	18	7.615	0	-999	0		
1645	17	7.580	0	-999	0		
1645	16	7.570	0	-999	0		
1645	15	7.580	0	-999	0		
1645	14	7.600	0	-999	0		
1645	13	7.626	0	-999	0		
1645	12	7.636	0	-999	0		
1645	11	7.648	0	-999	0		
1645	10	7.638	0	-999	0		
1645	9	7.631	0	-999	0		
1645	8	7.628	0	-999	0		
1645	7	7.625	0	-999	0		
1645	6	7.625	0	-999	0		
1645	5	7.615	0	-999	0		
1645	4	7.610	0	-999	0		
1645	3	7.608	0	-999	0		
1645	2	7.599	0	-999	0		
1645	1	7.601	0	-999	0		
1647	24	7.769	0	2266	0		
1647	23	7.773	0	2267	0		
1647	22	7.756	0	2269	0		
1647	21	7.744	0	2268	0		
1647	20	7.698	0	2276	0		
1647	19	7.656	0	2288	0		
1647	18	7.617	0	2298	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1647	17	7.574	0	2313	0		
1647	16	7.572	0	2325	0		
1647	15	7.570	0	2334	0		
1647	14	7.580	0	2338	0		
1647	13	7.614	0	2341	0		
1647	12	7.630	0	2344	0		
1647	11	7.642	0	2346	0		
1647	10	7.642	0	2349	0		
1647	9	7.647	0	2353	0		
1647	8	7.638	0	2356	0		
1647	7	7.639	0	2358	0		
1647	6	7.635	0	2361	0		
1647	5	7.627	0	2363	0		
1647	4	7.633	0	2366	0		
1647	3	7.631	0	2367	0		
1647	2	7.618	0	2366	0		
1647	1	7.614	0	2365	0		
1649	24	7.780	0	-999	0		
1649	23	7.783	0	-999	0		
1649	22	7.778	0	-999	0		
1649	21	7.761	0	-999	0		
1649	20	7.754	0	-999	0		
1649	19	7.755	0	-999	0		
1649	18	7.734	0	-999	0		
1649	17	7.643	0	-999	0		
1649	16	7.582	0	-999	0		
1649	15	7.569	0	-999	0		
1649	14	7.580	0	-999	0		
1649	13	7.598	0	-999	0		
1649	12	7.620	0	-999	0		
1649	11	7.643	0	-999	0		
1649	10	7.643	0	-999	0		
1649	9	7.644	0	-999	0		
1649	8	7.634	0	-999	0		
1649	7	7.634	0	-999	0		
1649	6	7.632	0	-999	0		
1649	5	7.625	0	-999	0		
1649	4	7.629	0	-999	0		
1649	3	7.619	0	-999	0		
1649	2	7.614	0	-999	0		
1649	1	7.613	0	-999	0		
1651	24	7.774	0	2265	0		
1651	23	7.765	0	2266	0		
1651	22	7.741	8	2268	8		
1651	21	7.689	0	2277	0		
1651	20	7.657	0	2286	0		
1651	19	7.604	0	2304	0		
1651	18	7.578	0	2320	0		
1651	17	7.569	0	2329	0		
1651	16	7.581	0	2340	0		
1651	15	7.606	0	2341	0		
1651	14	7.617	0	2343	0		
1651	13	7.637	0	2344	0		
1651	12	7.641	0	2346	0		
1651	11	7.648	0	2349	0		
1651	10	7.651	0	2349	0		
1651	9	7.652	0	2352	0		
1651	8	7.636	0	2355	0		
1651	7	7.633	0	2358	0		
1651	6	7.632	0	2359	0		
1651	4	7.628	0	2362	0		
1651	3	7.628	0	2365	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1651	2	7.623	0	2364	0		
1651	1	7.611	0	2364	0		
1653	24	7.772	0	-999	0		
1653	23	7.773	0	-999	0		
1653	22	7.761	0	-999	0		
1653	21	7.711	0	-999	0		
1653	20	7.719	0	-999	0		
1653	19	7.590	0	-999	0		
1653	18	7.610	0	-999	0		
1653	17	7.565	0	-999	0		
1653	16	7.564	0	-999	0		
1653	15	7.580	0	-999	0		
1653	14	7.602	0	-999	0		
1653	13	7.620	0	-999	0		
1653	12	7.629	0	-999	0		
1653	11	7.634	0	-999	0		
1653	10	7.632	0	-999	0		
1653	9	7.629	0	-999	0		
1653	8	7.630	0	-999	0		
1653	7	7.628	0	-999	0		
1653	6	7.623	0	-999	0		
1653	5	7.622	0	-999	0		
1653	4	7.615	0	-999	0		
1653	3	7.611	0	-999	0		
1653	2	7.611	0	-999	0		
1653	1	7.620	0	-999	0		
1655	24	7.763	0	2267	0		
1655	23	7.763	0	2265	0		
1655	22	7.760	0	2266	0		
1655	21	7.739	0	2268	0		
1655	20	7.701	0	2275	0		
1655	19	7.659	0	2286	0		
1655	18	7.628	0	2293	0		
1655	17	7.597	0	2307	0		
1655	16	7.576	0	2318	0		
1655	15	7.568	0	2328	0		
1655	14	7.578	0	2342	0		
1655	13	7.596	0	2343	0		
1655	12	7.623	0	2344	0		
1655	11	7.633	0	2348	0		
1655	10	7.639	0	2347	0		
1655	9	7.634	0	2350	0		
1655	8	7.629	0	2356	0		
1655	7	7.629	0	2359	0		
1655	6	7.623	0	2362	0		
1655	5	7.621	0	2364	0		
1655	4	7.619	0	2364	0		
1655	3	7.613	0	2364	0		
1655	2	7.611	0	2361	3		
1655	1	7.613	0	2365	0		
1657	24	7.765	0	-999	0		
1657	23	7.760	0	-999	0		
1657	22	7.767	0	-999	0		
1657	21	7.762	0	-999	0		
1657	20	7.765	0	-999	0		
1657	19	7.746	0	-999	0		
1657	18	7.716	0	-999	0		
1657	17	7.643	0	-999	0		
1657	16	7.601	0	-999	0		
1657	15	7.574	0	-999	0		
1657	14	7.570	0	-999	0		
1657	13	7.595	0	-999	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1657	12	7.612	0	-999	0		
1657	11	7.632	0	-999	0		
1657	10	7.633	0	-999	0		
1657	9	7.639	0	-999	0		
1657	8	7.633	0	-999	0		
1657	7	7.628	0	-999	0		
1657	6	7.631	0	-999	0		
1657	5	7.622	0	-999	0		
1657	4	7.620	0	-999	0		
1657	3	7.613	0	-999	0		
1657	2	7.612	0	-999	0		
1657	1	7.608	0	-999	0		
1659	24	7.760	0	2268	0		
1659	23	7.760	0	2267	0		
1659	22	7.764	0	2267	0		
1659	21	7.735	0	2269	0		
1659	20	7.675	0	2284	3		
1659	19	7.648	0	2290	0		
1659	18	7.604	0	2302	0		
1659	17	7.569	0	2325	0		
1659	16	7.571	0	2334	0		
1659	15	7.583	0	2339	0		
1659	14	7.598	0	2342	0		
1659	13	7.627	0	2348	0		
1659	12	7.625	0	2348	0		
1659	11	7.637	0	2351	0		
1659	10	7.633	0	2354	0		
1659	9	7.623	0	2358	0		
1659	8	7.627	0	2358	0		
1659	7	7.628	0	2360	0		
1659	6	7.622	0	2361	0		
1659	5	7.622	0	2364	0		
1659	4	7.626	0	2363	0		
1659	3	7.610	0	2365	0		
1659	2	7.645	4	2318	8		
1659	1	7.606	0	2366	0		
1661	24	7.751	0	-999	0		
1661	23	7.762	0	-999	0		
1661	22	7.757	0	-999	0		
1661	21	7.747	0	-999	0		
1661	20	7.704	0	-999	0		
1661	19	7.641	0	-999	0		
1661	18	7.597	0	-999	0		
1661	17	7.571	0	-999	0		
1661	16	7.566	0	-999	0		
1661	15	7.576	0	-999	0		
1661	14	7.593	0	-999	0		
1661	13	7.606	0	-999	0		
1661	12	7.618	0	-999	0		
1661	11	7.639	0	-999	0		
1661	10	7.633	0	-999	0		
1661	9	7.634	0	-999	0		
1661	8	7.632	0	-999	0		
1661	7	7.628	0	-999	0		
1661	6	7.626	0	-999	0		
1661	5	7.616	0	-999	0		
1661	4	7.622	0	-999	0		
1661	3	7.613	0	-999	0		
1661	2	7.610	0	-999	0		
1661	1	7.603	0	-999	0		
1663	24	7.764	0	2267	0		
1663	23	7.764	0	2268	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1663	22	7.763	0	2268	0		
1663	21	7.760	0	2267	0		
1663	20	7.761	0	2265	0		
1663	19	7.749	0	2267	0		
1663	18	7.722	0	2271	0		
1663	17	7.642	0	2293	3		
1663	16	7.608	0	2304	0		
1663	15	7.578	0	2323	0		
1663	14	7.585	0	2330	0		
1663	13	7.572	0	2339	0		
1663	12	7.593	0	2344	0		
1663	11	7.613	0	2346	0		
1663	10	7.633	0	2347	0		
1663	9	7.641	0	2349	0		
1663	8	7.636	0	2353	0		
1663	7	7.636	0	2356	0		
1663	6	7.632	0	2358	0		
1663	5	7.623	0	2360	0		
1663	4	7.619	0	2361	0		
1663	3	7.612	0	2363	3		
1663	2	7.607	0	2363	0		
1663	1	7.608	0	2363	0		
1666	24	7.761	0	2269	0		
1666	23	7.762	0	2268	0		
1666	22	7.748	0	2268	0		
1666	21	7.715	0	2278	0		
1666	20	7.687	0	2281	0		
1666	19	7.642	0	2290	0		
1666	18	7.604	0	2309	0		
1666	17	7.580	0	2315	0		
1666	16	7.569	0	2328	0		
1666	15	7.579	0	2335	0		
1666	14	7.597	0	2343	0		
1666	13	7.614	0	2347	0		
1666	12	7.638	0	2344	0		
1666	11	7.647	0	2348	0		
1666	10	7.648	0	2346	0		
1666	9	7.644	0	2355	0		
1666	8	7.630	0	2356	0		
1666	7	7.631	0	2358	0		
1666	6	7.627	0	2359	0		
1666	5	7.616	0	2361	0		
1666	4	7.614	0	2363	0		
1666	3	7.608	0	2363	0		
1666	2	7.608	0	2363	0		
1666	1	7.606	0	2364	0		
1669	24	7.745	0	2272	0		
1669	23	7.754	0	2269	0		
1669	22	7.743	0	2267	0		
1669	21	7.701	0	2274	0		
1669	20	7.688	0	2280	0		
1669	19	7.651	0	2287	0		
1669	18	7.631	0	2294	0		
1669	17	7.605	0	2301	0		
1669	16	7.584	0	2312	0		
1669	15	7.566	0	2323	0		
1669	14	7.566	0	2333	0		
1669	13	7.586	0	2339	0		
1669	12	7.600	0	2343	0		
1669	11	7.619	0	2349	0		
1669	10	7.629	0	2347	0		
1669	9	7.635	0	2348	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1669	8	7.636	0	2351	0		
1669	7	7.637	0	2356	0		
1669	6	7.626	0	2359	0		
1669	5	7.622	0	2361	0		
1669	4	7.613	0	2360	0		
1669	3	7.609	0	2360	0		
1669	2	7.609	0	2363	0		
1669	1	7.606	0	2363	0		
1672	24	7.754	0	2278	0		
1672	23	7.751	0	2277	0		
1672	22	7.748	0	2280	0		
1672	21	7.709	0	2283	0		
1672	20	7.686	0	2284	0		
1672	19	7.656	0	2286	0		
1672	18	7.608	0	2305	0		
1672	17	7.583	0	2314	0		
1672	16	7.565	0	2325	0		
1672	15	7.565	0	2333	0		
1672	14	7.560	0	2339	0		
1672	13	7.578	0	2344	0		
1672	12	7.587	0	2347	3		
1672	11	7.607	0	2350	0		
1672	10	7.621	0	2351	0		
1672	9	7.619	0	2354	0		
1672	8	7.619	0	2355	0		
1672	7	7.618	0	2358	0		
1672	6	7.620	0	2361	0		
1672	5	7.611	0	2361	0		
1672	4	7.613	3	2361	0		
1672	3	7.608	0	2363	0		
1672	2	7.604	0	2363	0		
1672	1	7.605	0	2364	3		
1674	23	7.760	0	2276	0		
1674	22	7.761	0	2275	0		
1674	20	7.754	0	2274	0		
1674	19	7.737	0	2275	0		
1674	18	7.725	0	2276	0		
1674	17	7.690	0	2280	0		
1674	16	7.610	0	2295	0		
1674	15	7.566	0	2318	0		
1674	14	7.564	0	2330	0		
1674	13	7.572	0	2336	0		
1674	12	7.579	0	2345	0		
1674	11	7.600	0	2349	0		
1674	10	7.627	0	2352	0		
1674	9	7.626	0	2354	0		
1674	8	7.631	0	2355	0		
1674	7	7.617	0	2360	0		
1674	6	7.612	0	2362	0		
1674	5	7.612	0	2364	0		
1674	4	7.606	0	2365	0		
1674	3	7.607	0	2367	0		
1674	2	7.608	0	2368	0		
1674	1	7.604	0	2366	0		
1676	24	7.760	0	2275	0		
1676	23	7.761	0	2277	0		
1676	22	7.754	0	2277	0		
1676	21	7.700	0	2280	0		
1676	20	7.662	0	2291	0		
1676	19	7.609	0	2304	0		
1676	18	7.587	0	2312	0		
1676	17	7.563	0	2330	0		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1676	16	7.575	0	2342	0		
1676	15	7.594	0	2346	0		
1676	14	7.608	0	2351	0		
1676	13	7.629	0	2353	0		
1676	12	7.631	0	2352	0		
1676	11	7.637	0	2355	0		
1676	10	7.634	0	2357	0		
1676	9	7.630	0	2360	0		
1676	8	7.628	0	2361	0		
1676	7	7.622	0	2362	0		
1676	6	7.617	0	2363	0		
1676	5	7.614	0	2362	0		
1676	4	7.614	0	2366	0		
1676	3	7.606	0	2366	3		
1676	2	7.607	0	-999	0		
1676	1	7.609	0	2368	3		
1680	24	7.741	0	2287	3		
1680	23	7.744	0	2285	3		
1680	22	7.731	0	-999	3		
1680	21	7.685	0	-999	3		
1680	21	7.685	0	-999	3		
1680	20	7.689	0	2289	3		
1680	20	7.689	0	2289	3		
1680	19	7.658	0	2291	3		
1680	18	7.605	0	-999	3		
1680	17	7.571	0	2324	3		
1680	16	7.559	0	2335	3		
1680	16	7.559	0	2335	3		
1680	15	7.555	0	-999	3		
1680	15	7.555	0	-999	3		
1680	14	7.568	0	-999	3		
1680	13	7.590	0	2349	3		
1680	12	7.595	0	-999	3		
1680	11	7.603	0	2351	3		
1680	10	7.616	0	-999	3		
1680	9	-999.000	0	2352	3		
1680	8	7.624	0	-999	3		
1680	7	7.624	0	2356	3		
1680	6	7.629	0	-999	3		
1680	5	7.625	0	2357	3		
1680	4	7.617	0	-999	3		
1680	3	7.609	0	2360	3		
1680	3	7.609	0	2360	3		
1680	1	7.608	4	2360	3		
1684	24	7.716	0	2293	3		
1684	23	7.718	0	2290	3		
1684	22	7.689	0	-999	3		
1684	21	7.595	0	2308	3		
1684	21	7.595	0	2308	3		
1684	20	7.603	0	-999	3		
1684	20	7.603	0	-999	3		
1684	19	7.566	0	2318	3		
1684	19	7.566	0	2318	3		
1684	18	7.565	0	-999	3		
1684	18	7.565	0	-999	3		
1684	17	7.558	0	2331	3		
1684	16	7.555	0	-999	3		
1684	16	7.555	0	-999	3		
1684	15	7.557	0	2337	3		
1684	15	7.557	0	2337	3		
1684	14	7.565	0	-999	3		
1684	13	7.581	0	2346	3		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1684	12	7.584	0	-999	3		
1684	11	7.599	0	2350	3		
1684	10	7.610	0	-999	3		
1684	9	7.620	0	2352	3		
1684	8	7.620	3	-999	3		
1684	7	7.618	0	2357	3		
1684	6	7.618	0	-999	3		
1684	5	7.613	0	2360	3		
1684	4	7.612	3	2363	3		
1684	3	7.603	8	2363	3		
1684	2	7.606	0	-999	3		
1684	1	7.598	0	2361	3		
1688	24	7.715	0	2298	3		
1688	23	7.714	0	-999	3		
1688	22	7.715	0	2296	3		
1688	21	7.713	0	-999	3		
1688	20	7.710	0	2298	3		
1688	19	7.709	0	-999	3		
1688	18	7.699	0	2296	3		
1688	17	7.665	0	-999	3		
1688	16	7.620	0	2312	3		
1688	15	7.551	0	-999	3		
1688	14	7.553	0	2339	3		
1688	13	7.570	0	-999	3		
1688	12	7.590	0	2351	3		
1688	11	7.608	0	-999	3		
1688	10	7.614	0	-999	3		
1688	9	7.607	0	2360	3		
1688	8	7.610	0	-999	3		
1688	7	7.603	0	2361	3		
1688	6	7.601	3	-999	3		
1688	5	7.601	0	2364	3		
1688	4	7.604	0	2366	3		
1688	3	7.603	0	2364	3		
1688	2	7.601	0	-999	3		
1688	1	7.598	0	2364	3		
1692	24	7.713	0	2298	3		
1692	23	7.713	0	-999	3		
1692	22	7.678	0	-999	3		
1692	22	7.678	0	-999	3		
1692	21	7.677	0	2301	3		
1692	21	7.677	0	2301	3		
1692	20	7.659	0	-999	3		
1692	20	7.659	0	-999	3		
1692	19	7.664	0	-999	3		
1692	19	7.664	0	-999	3		
1692	18	7.600	0	2319	3		
1692	17	7.549	0	-999	3		
1692	16	7.565	0	2350	3		
1692	16	7.565	0	2350	3		
1692	15	7.565	0	-999	3		
1692	15	7.565	0	-999	3		
1692	14	7.573	0	2354	3		
1692	13	7.593	0	2354	3		
1692	12	7.598	0	-999	3		
1692	11	7.605	0	2357	3		
1692	10	7.611	0	-999	3		
1692	9	7.613	3	2361	3		
1692	8	7.611	0	-999	3		
1692	7	7.604	0	2364	3		
1692	6	7.602	0	-999	3		
1692	5	7.601	0	2365	3		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1692	4	7.602	0	-999	3		
1692	3	7.603	0	2364	3		
1692	3	7.603	0	2364	3		
1692	2	7.598	8	-999	3		
1692	2	7.598	8	-999	3		
1692	1	7.602	0	2366	3		
1696	24	7.691	0	2308	3		
1696	23	7.690	0	2307	3		
1696	23	7.690	0	2307	3		
1696	22	7.695	0	-999	3		
1696	22	7.695	0	-999	3		
1696	21	7.686	0	-999	3		
1696	20	7.684	0	-999	3		
1696	19	7.652	0	2310	3		
1696	18	7.609	0	-999	3		
1696	18	7.609	0	-999	3		
1696	17	7.606	0	-999	3		
1696	17	7.606	0	-999	3		
1696	16	7.568	0	-999	3		
1696	16	7.568	0	-999	3		
1696	15	7.563	0	2336	3		
1696	15	7.563	0	2336	3		
1696	14	7.561	0	2347	3		
1696	13	7.572	0	-999	3		
1696	12	7.586	0	2359	3		
1696	11	7.594	0	-999	3		
1696	10	7.603	0	2360	3		
1696	8	7.606	0	2366	3		
1696	7	7.602	0	2367	3		
1696	6	7.600	0	2367	3		
1696	5	7.603	0	2370	3		
1696	4	7.600	0	-999	3		
1696	3	7.600	0	2367	3		
1696	3	7.600	0	2367	3		
1696	2	7.597	8	-999	3		
1696	2	7.597	8	-999	3		
1696	1	7.598	0	2367	3		
1700	24	7.695	0	2303	3		
1700	23	7.695	0	-999	3		
1700	22	7.698	0	-999	3		
1700	21	7.694	0	2304	3		
1700	20	7.693	0	-999	3		
1700	19	7.691	0	2304	3		
1700	18	7.690	0	-999	3		
1700	17	7.674	0	-999	3		
1700	16	7.619	0	2319	3		
1700	15	7.565	0	2342	3		
1700	14	7.570	0	2353	3		
1700	13	7.575	0	-999	3		
1700	12	7.584	0	2359	3		
1700	11	7.596	0	-999	3		
1700	10	7.598	0	2361	3		
1700	9	7.603	0	2361	3		
1700	8	7.604	0	2363	3		
1700	7	7.603	0	2365	3		
1700	6	7.599	0	2369	3		
1700	5	7.603	0	2369	3		
1700	4	7.601	0	-999	3		
1700	3	7.603	0	2371	3		
1700	1	7.602	0	2368	3		
1704	21	7.697	0	2304	3		
1704	19	7.702	0	2305	3		

Station	Bottle	pH25T	QF pH	TA (umol/kg)	QF TA		
1704	18	7.690	0	2303	3		
1704	17	7.673	0	2307	3		
1704	14	7.593	0	2335	3		
1704	12	7.573	0	2344	3		
1704	10	7.579	0	2348	3		
1704	8	7.580	0	2354	3		
1704	6	7.587	0	2358	3		
1704	4	7.602	0	2360	3		
1704	3	7.598	0	-999	3		
1704	3	7.598	0	-999	3		
1704	1	7.601	0	2362	3		

GoodHope-2004 CO₂ Parameters Comparison Report.

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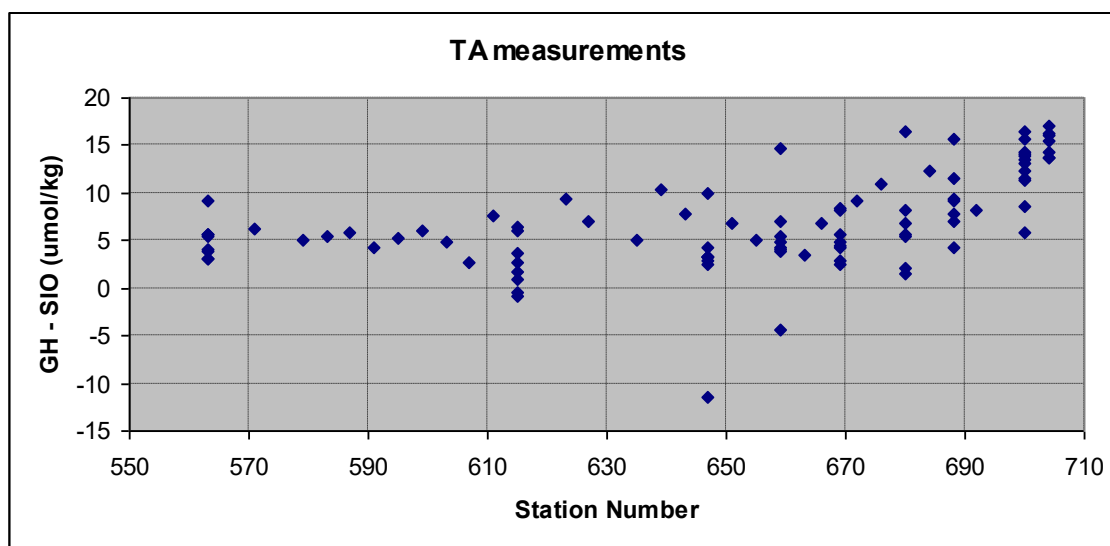
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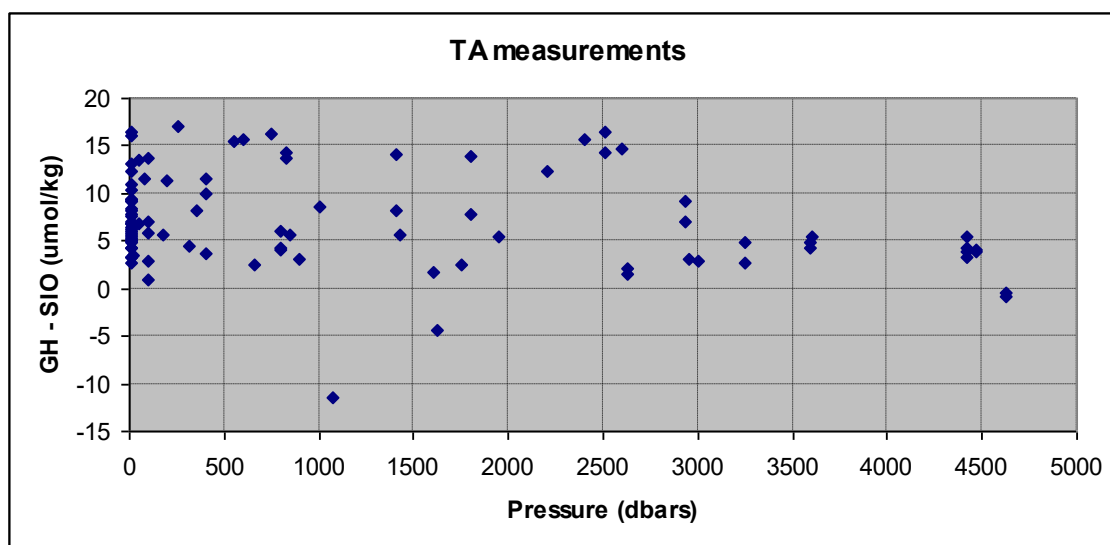
During the GoodHope (GH) 2004 cruise carried out between 8th and 26th November on board the Akademik Vavilov pH and TA measurements were sampled from bottle depths at selected stations and analysed on board. Samples for TIC and TA were also taken and analyzed in the laboratory of Prof. Andrew Dickson in Scripps Institution of Oceanography (SIO, USA) in July 2005. In the whole set of samples, TIC and TA were determined, according to the SIO report TIC were done first (26,27 and 28 July) and TA after (26, 30 and 31 July).

Here the relationship between GH and SIO TA measurements and between calculated GH and measured SIO TIC is presented.

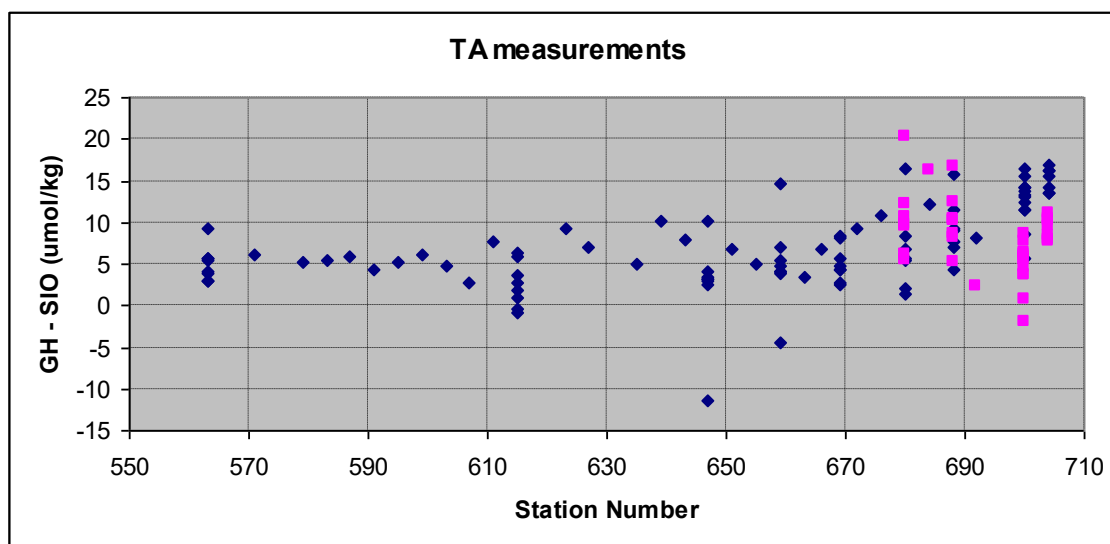
Alkalinity comparison

96 samples for TA were analysed at SIO, mainly from surface samples. The following plot shows the difference between TA from GH and SIO against station number and pressure.

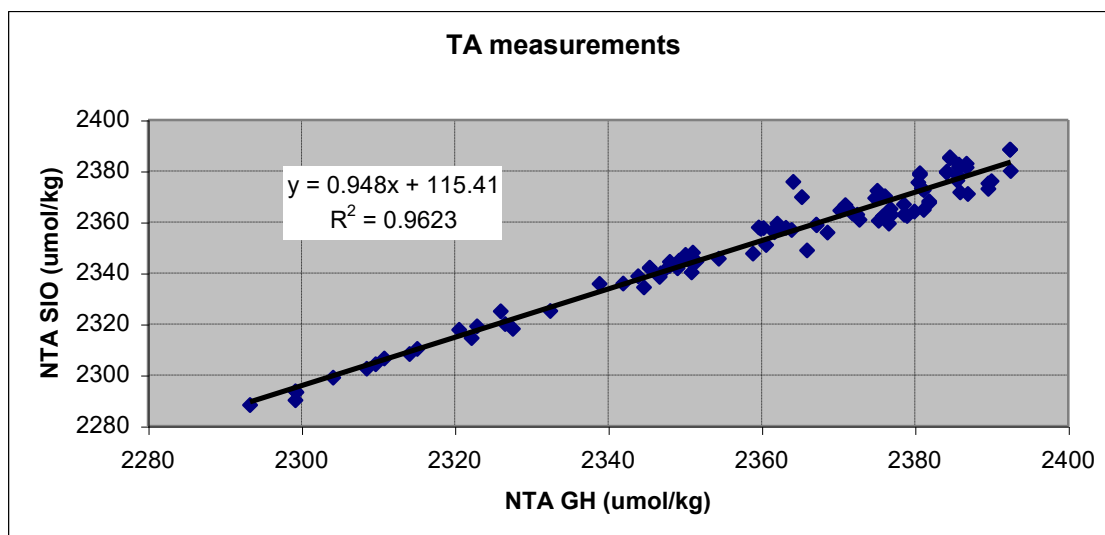




The former figure clearly shows the high differences between SIO and GH TA values, being the GH values higher in about $7 \pm 5 \mu\text{mol} \cdot \text{kg}^{-1}$. There is no clear pattern in these differences with station or depth. From station 680 to 704 some corrections according to correlations between nutrients and oxygen (see former report on CO_2 samples) were applied to the GH TA data increasing the final value. If these corrections are cancelled the differences change from $11 \pm 4 \mu\text{mol} \cdot \text{kg}^{-1}$ to $8 \pm 4 \mu\text{mol} \cdot \text{kg}^{-1}$. The pink points below correspond to the uncorrected data.

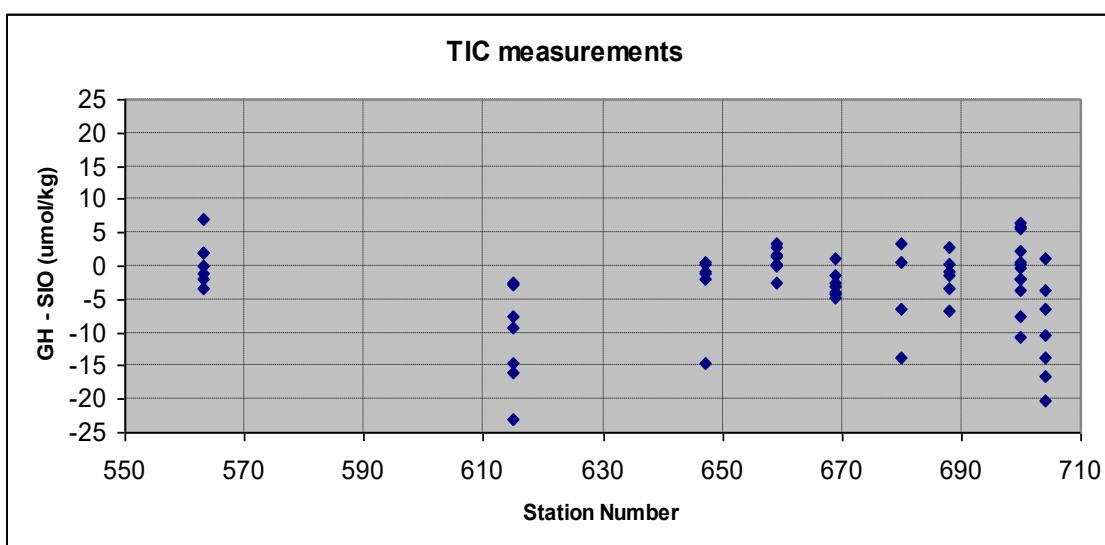


No clear explanation for these discrepancies was found taking into account that the accuracy of both methods is lower than $2 \mu\text{mol} \cdot \text{kg}^{-1}$, while the mismatch is $7 \pm 5 \mu\text{mol} \cdot \text{kg}^{-1}$.

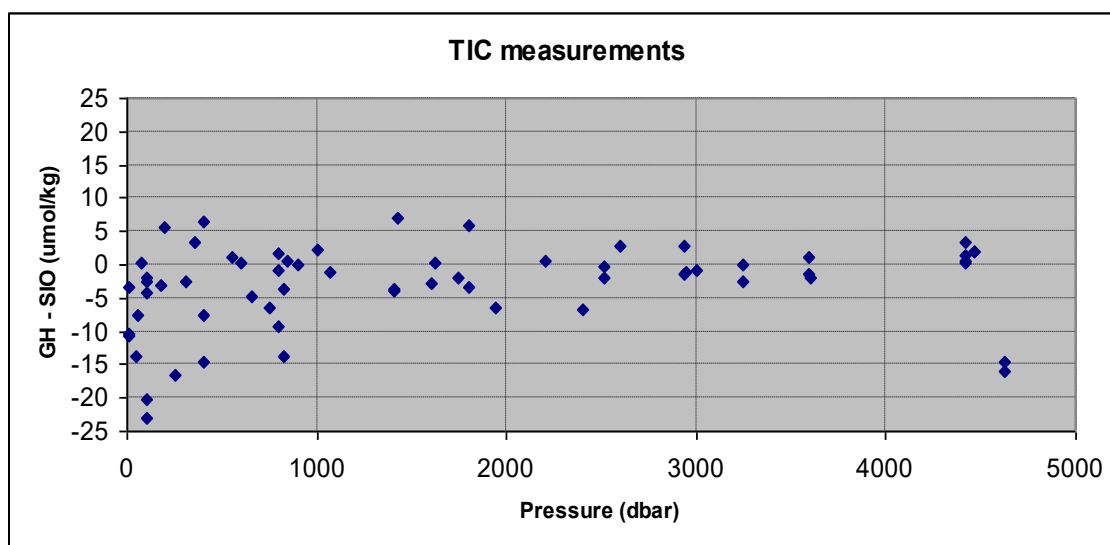


Total inorganic carbon comparison:

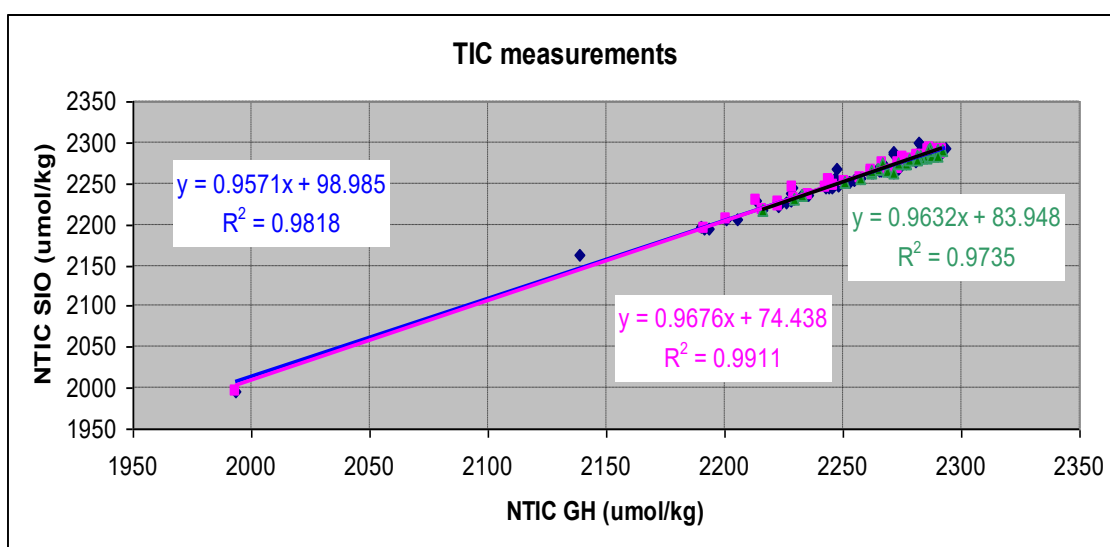
In the case of TIC, the mean difference between GH minus SIO values is $-3 \pm 6 \mu\text{mol} \cdot \text{kg}^{-1}$. However if station 615 and 704 are not taken into account the mean difference is $-1 \pm 4.5 \mu\text{mol} \cdot \text{kg}^{-1}$.



The differences seem to be higher in the upper 1000 dbars of the water column, except for the deepest sampled analysed twice in SIO, taken out of the mean. Therefore, the mean difference for waters below 1000 dbar is $-0.3 \pm 3 \mu\text{mol} \cdot \text{kg}^{-1}$.



The following figure shows the relationship between GH and SIO normalized TIC for the whole set of samples (blue), excluding station 615 and 704 (pink) and excluding those stations and the samples in the upper 1000 dbar (green).



Again, I cannot find any explanation for these differences, is it a storing or analysis problem or a combination of both?.

Curiously the same sort of differences were found in samples from the Ovide 2004 cruise, where TA and pH samples were measured by IIM (Vigo-Spain) using the same methodology as in GH compared to TA and TIC measurements by SIO.

GoodHope-2004

Chemical variables comments

April 2006

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After the whole bottle data from the cruise, temperature, salinity, dissolved oxygen, nutrient salts, pH25_T and alkalinity (TA) is compiled we can perform a more detailed analysis of the quality of our chemical data.

First we calculate NTA, the normalised to salinity TA, $NTA=35 \cdot TA/Sal$ so that, we can observe changes in TA not associated with salinity. Then we perform a visual analysis station by station of the pH and NTA profiles with depth and also their relation with potential temperature (T_{pot}), salinity (Sal) or nutrients, nitrate (NO₃), phosphate (PO₄) and silicate (SiO₂) and oxygen (O₂). In this way we can detect bad fired bottles which show anomalous values for all the biogeochemical variables.

After this first visual inspection, a residual analysis is done to detect any bias in the data from wrong calibrations, technical problems or bad calculations:

- every biogeochemical variable is calculated as a multiple linear regression from T_{pot}, Sal, pressure, latitude and longitude. See following table.

Table. Regression coefficients, R^2 and standard error of the residuals for each variable.

	NO ₃	PO ₄	SiO ₂	O ₂	pH25T	NTA
Intercept	-53.64	-8.76	-1589.76	4124.65	10.65	2368.09
T _{pot} (°C)	-2.18	-0.15	-4.36	9.30	0.03	-2.96
Sal (psu)	3.01	0.31	42.86	-115.10	-0.09	-0.66
Pres (dbar)	-0.00147	-0.00012	0.01101	0.01524	0.00003	0.01
Lat (°)	0.31	-0.01	-3.42	-0.81	0.002	-0.39
Lon (°)	-0.16	0.02	1.63	-1.22	-0.01	-0.94
R ²	0.87	0.87	0.92	0.57	0.88	0.93
STD	2.96	0.22	10.12	26.52	0.04	6.41

- the mean and standard deviation of the corresponding residuals for each station are calculated.

- within each station samples far from the mean plus/minus one std are further inspected to check any inconsistent value.

- the tendency of the residual mean along the cruise track for the set of variables is inspected to detect any problem for each station subset and variable.

Here are some figures showing the residuals distribution along the GH-2004 cruise for different variables.

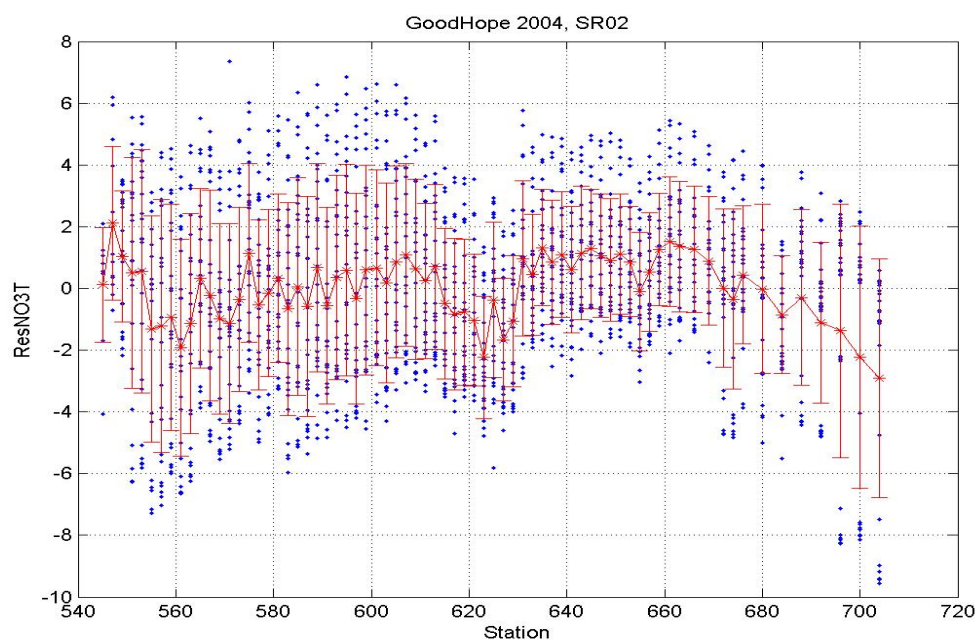


Figure 1. $\text{NO}_{3\text{T}}$ ($\mu\text{mol/kg}$) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise. Note the spikes up and down and some descending and ascending trends in the red line.

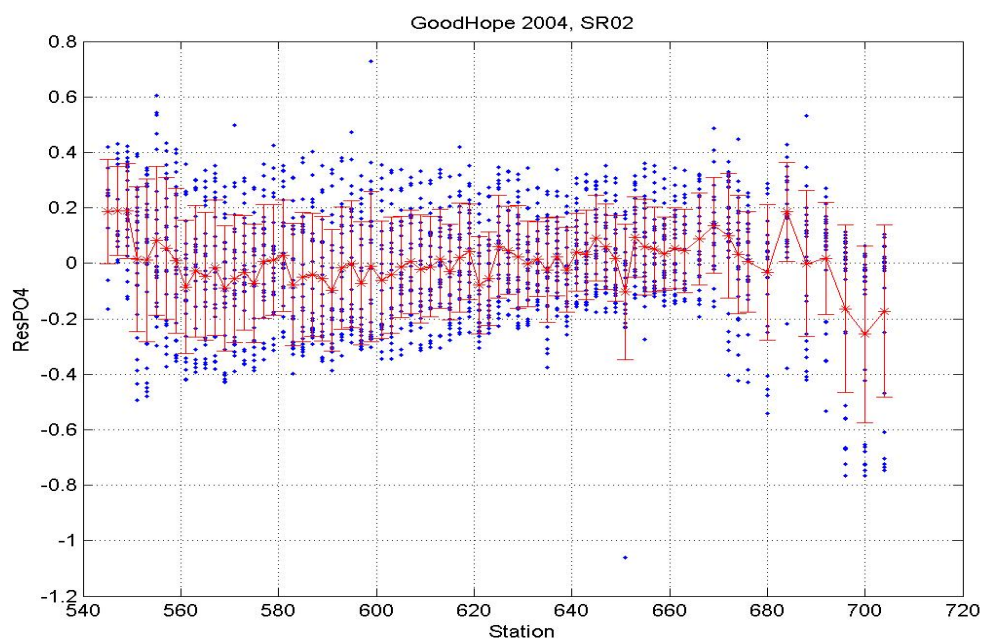


Figure 2. PO_4 ($\mu\text{mol/kg}$) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise. Note some outliers.

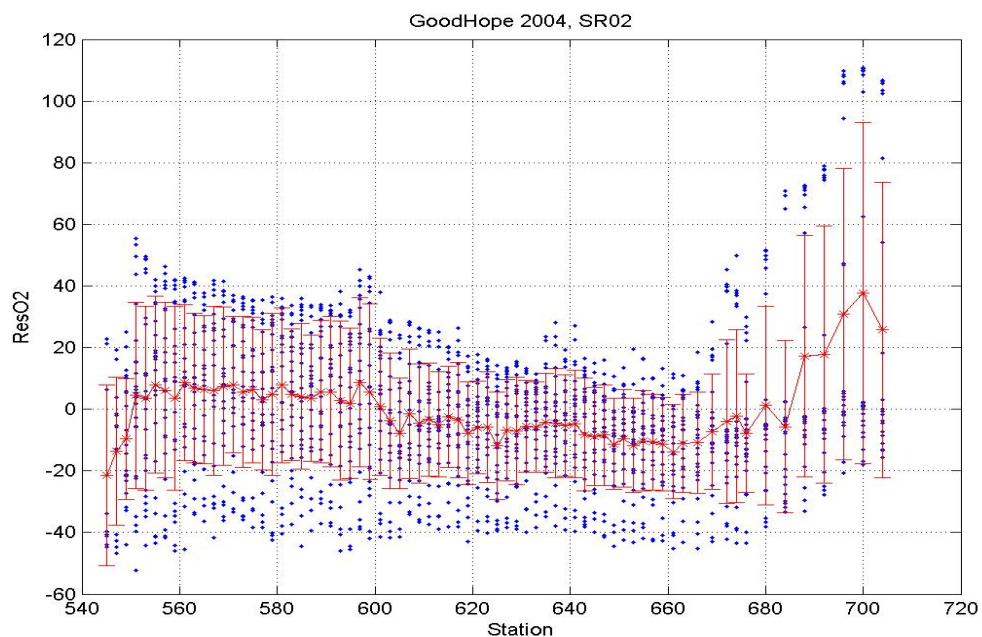


Figure 3. O₂ (umol/kg) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise.

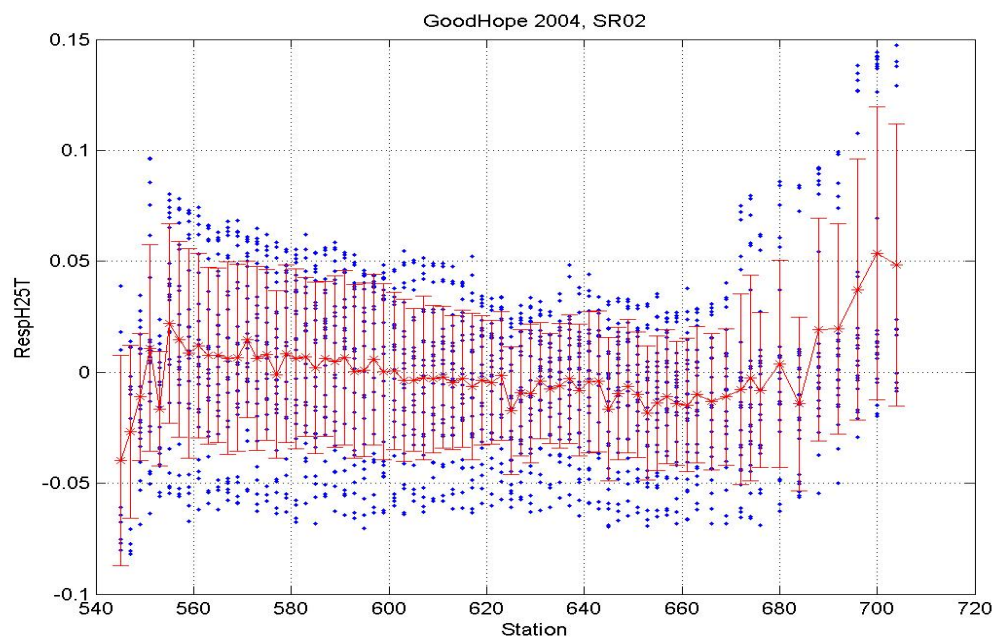


Figure 4. Individual pH_{25T} residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise. Note the similarity between the pH and O₂ mean residual trends.

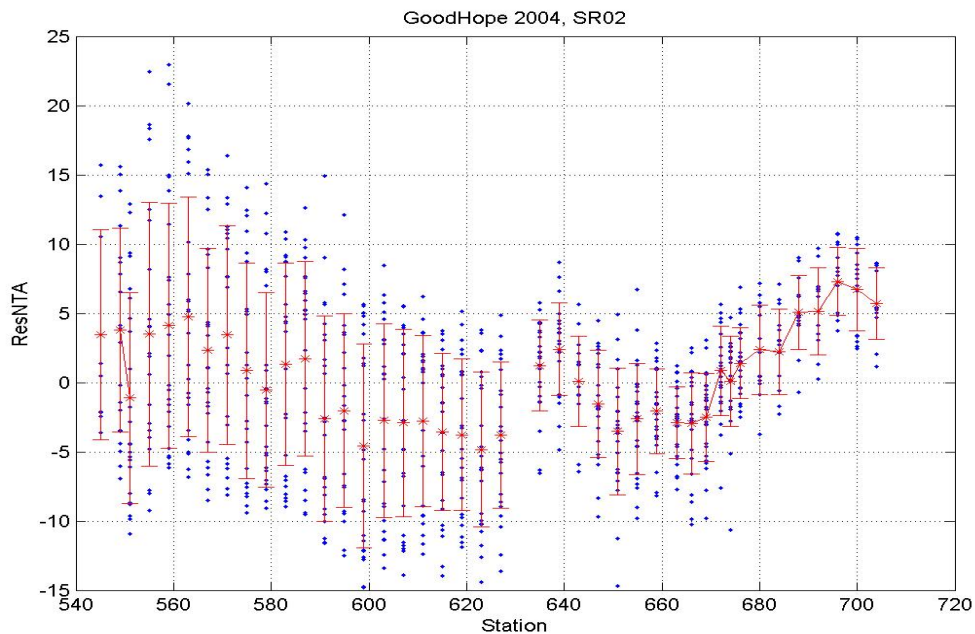


Figure 5. Individual NTA ($\mu\text{mol/kg}$) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise.

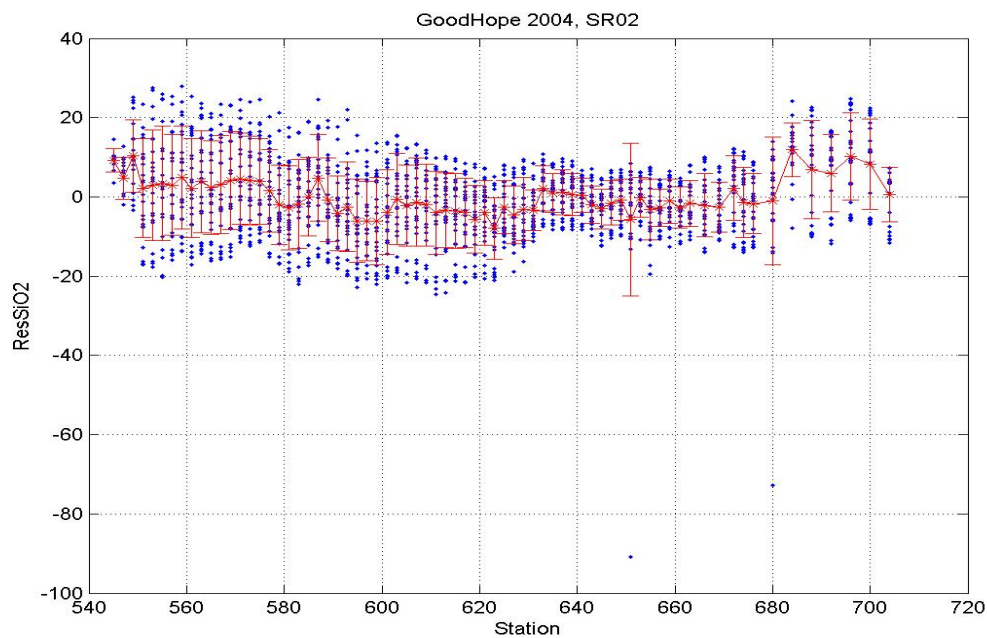


Figure 6. Individual SiO_2 ($\mu\text{mol/kg}$) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise. Note the outliers.

The residuals for the conservative variables $\text{NO} (= \text{O}_2 + 10.6 \cdot \text{NO}_3)$ and $\text{PO} (= \text{O}_2 + 170 \cdot \text{PO}_4)$ are also shown, as they are conservative their trends could better reflect any problem with the analysis or data.

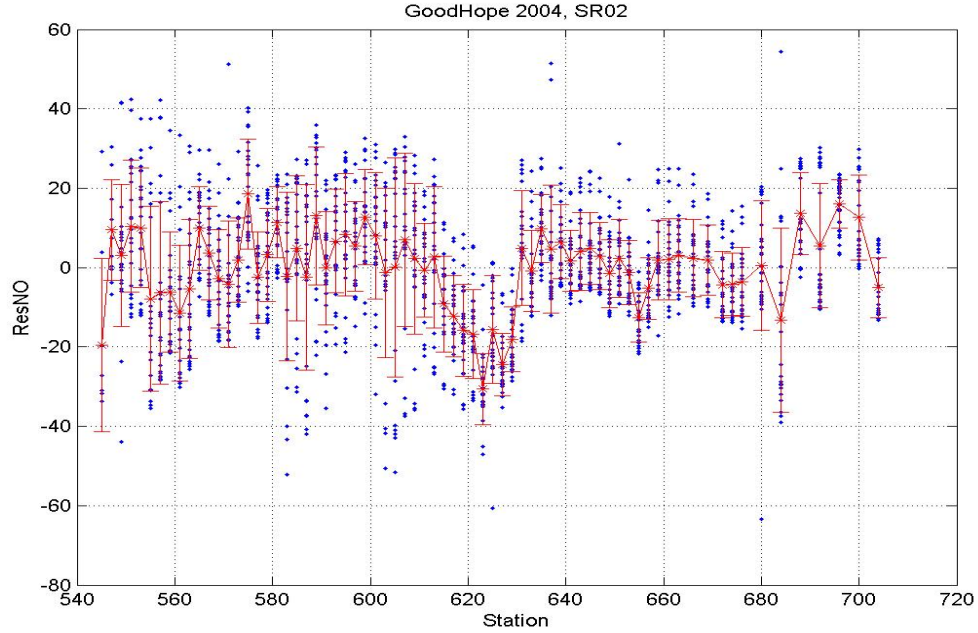


Figure 7. Individual NO (umol/kg) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise. Note some outliers also seen in the NO_3 figure and the trends and spikes very much resemble that of NO_3 .

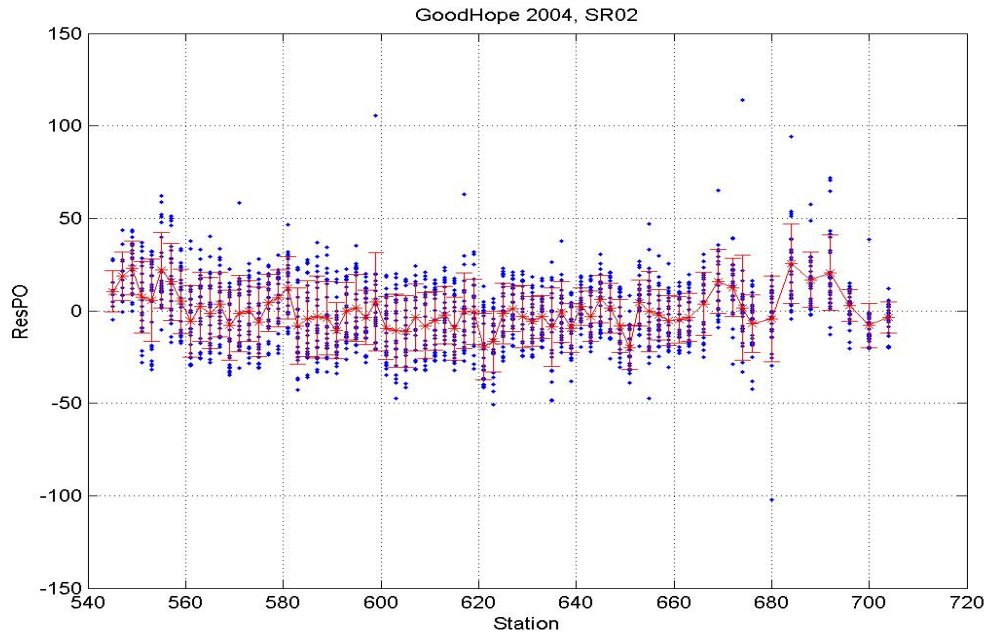


Figure 8. Individual PO (umol/kg) residuals as blue dots and the mean and standard deviation residual in red for every station along the GH2004 cruise. Note some outliers also seen in the PO_4 figure and the trends and spikes very much resemble that of PO_4 .

Following are some plots showing just the mean residual by station, to check the consistency in the trends between variables. For example, note the consistency in the trends of O_2 and pH. On the other hand, PO_4 and NO_3 have similar trends but much noisier and inversely correlated to O_2 and pH. The SiO_2 and NTA trends are correlated but SiO_2 is noisier and they resemble somehow the pH residuals.

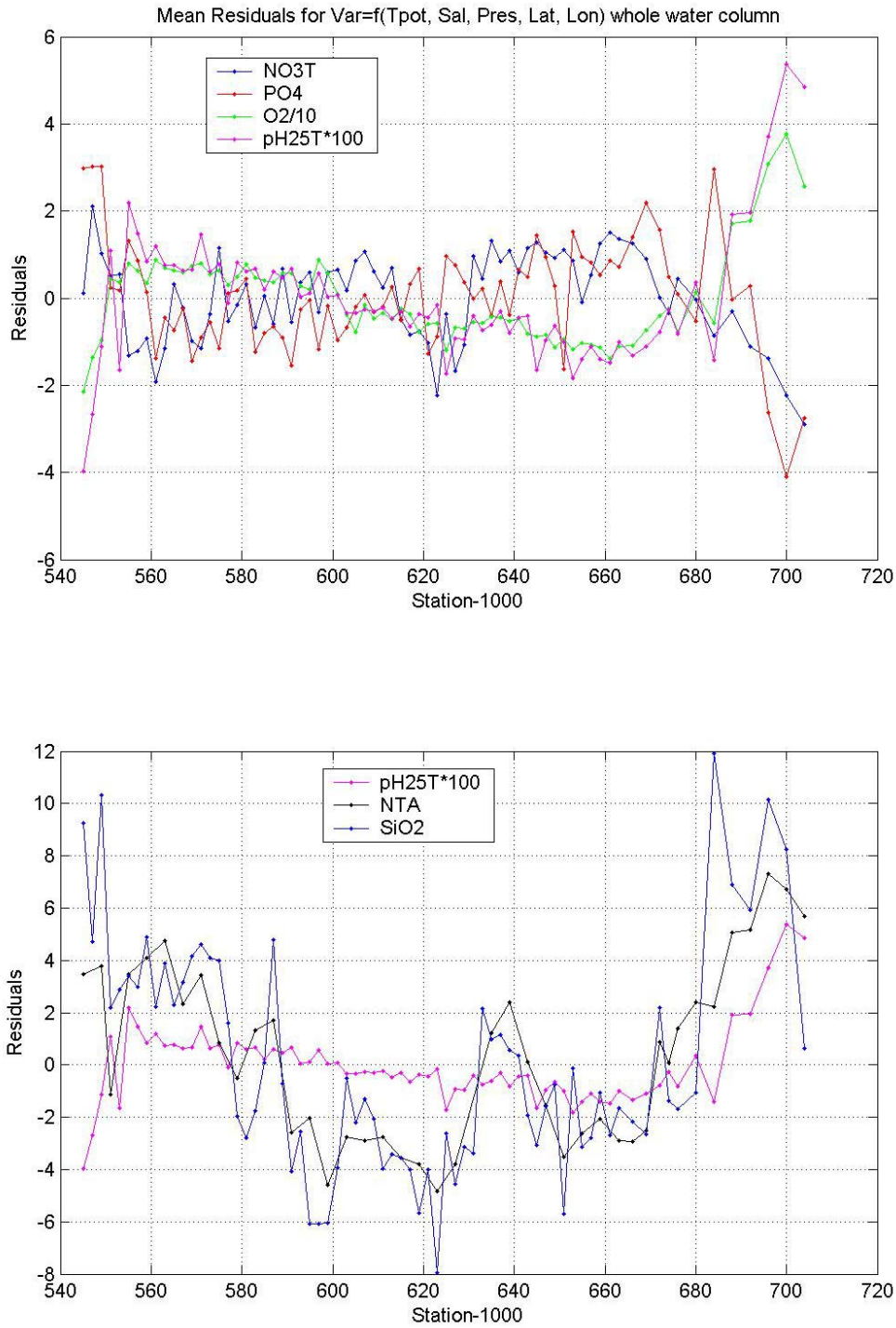


Figure 9. Mean residual by station for different variables, some of them are scaled, see the legend, all in $\mu\text{mol/kg}$ except pH. Note the consistency or inconsistency in the trends.

Here are the trends for the mean residuals of NO, PO and O₂. The NO and PO residuals are noisier than the O₂ ones so pointing to likely wrong adjustments in the calibration for the NO₃ and PO₄ analysis.

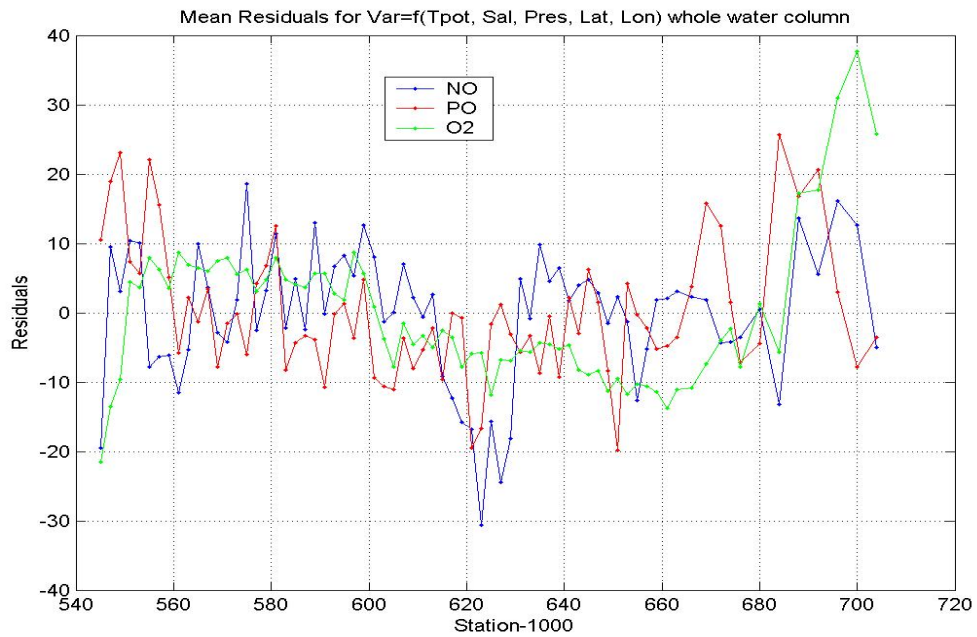


Figure 10. Mean residual by station for NO, PO and O₂, all in umol/kg. Note the consistency or inconsistency in the trends.

Here are some regression lines between the mean residuals by station. They give us an idea of the correlation between them and help to detect some “wrong” stations, those one far from the regression line. The R^2 for each line in the following subplots are 0.88, 0.35 and 0.48 with $p < 0.001$ for all of them.

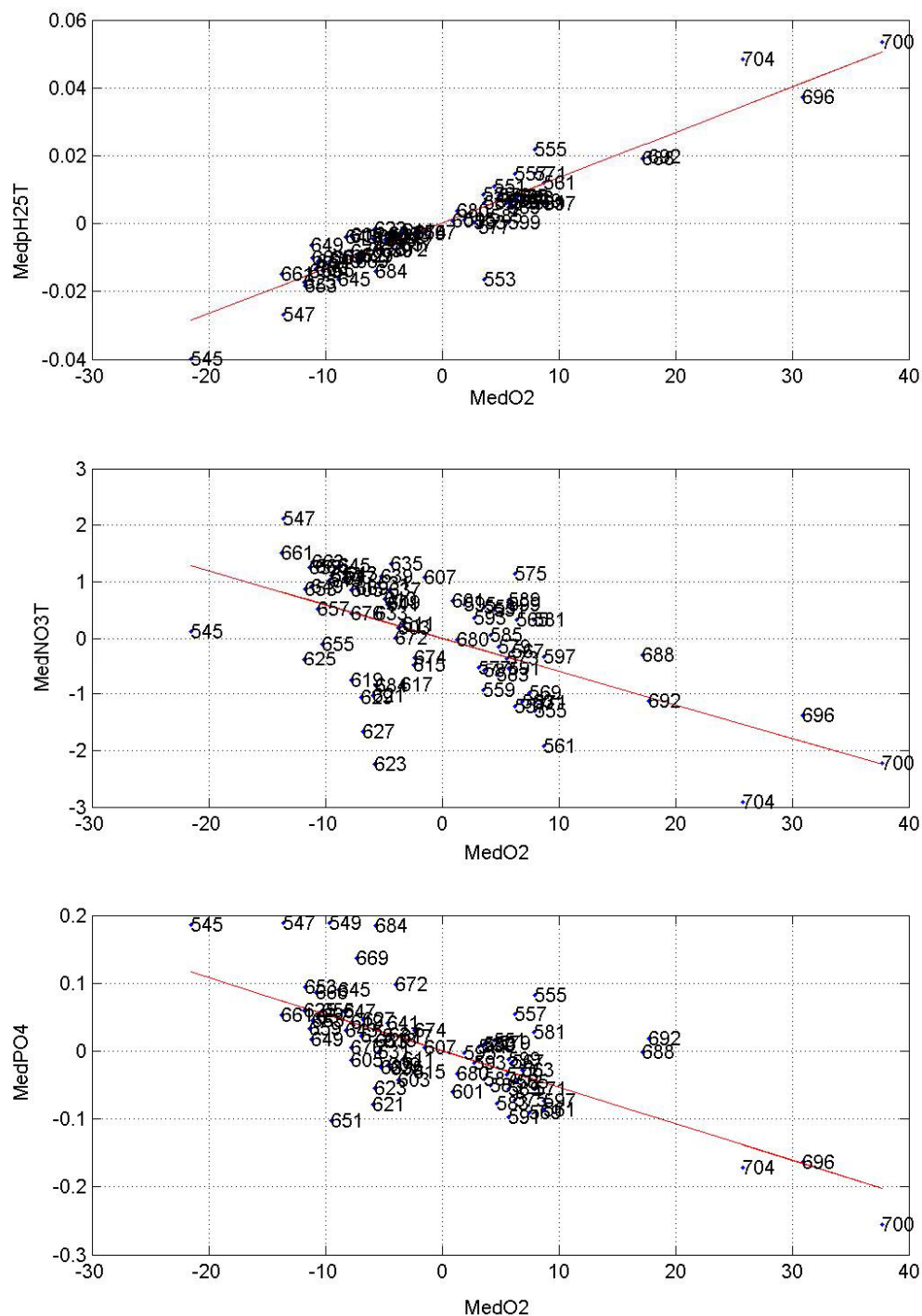
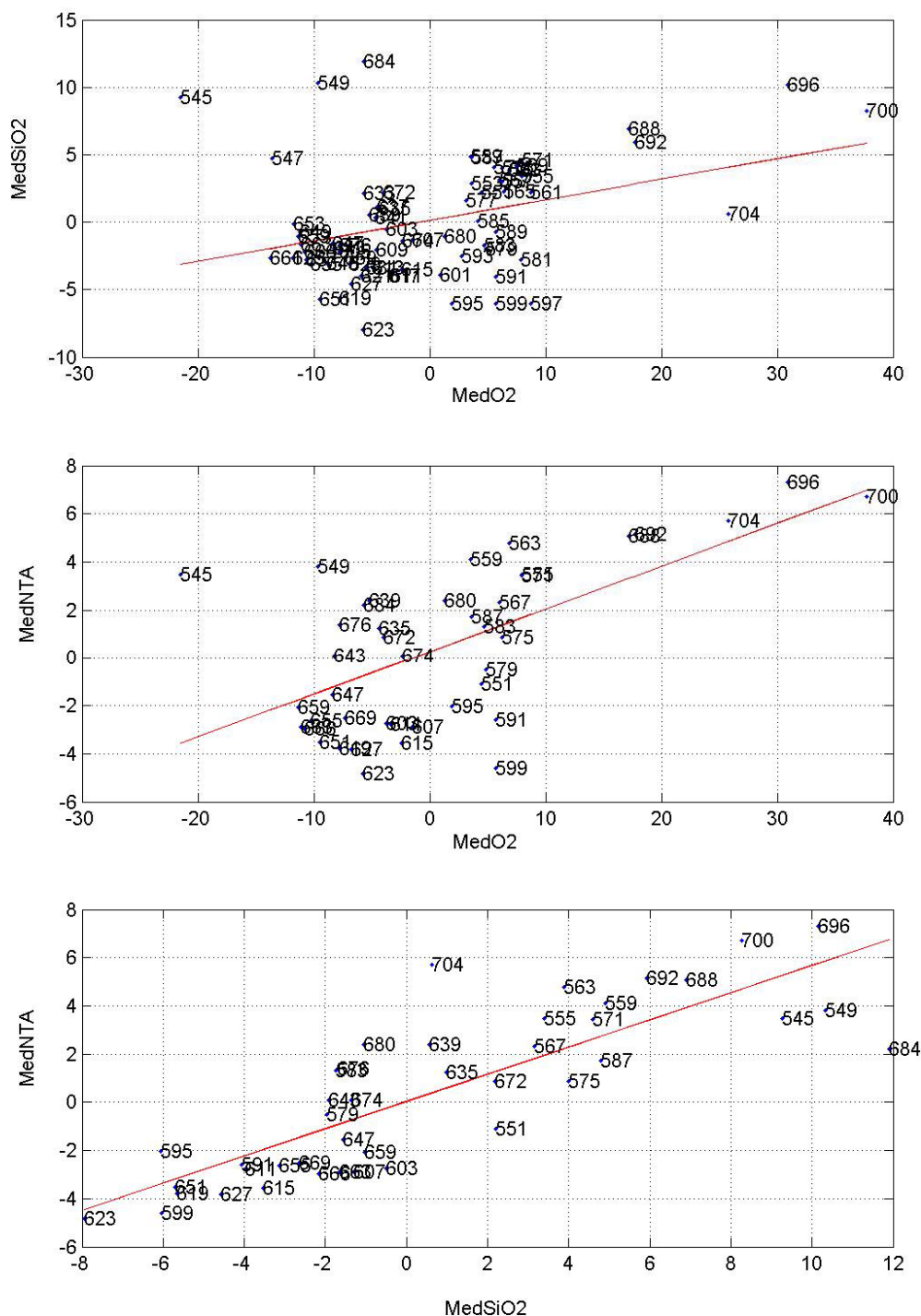


Figure 11. Correlation between mean residuals by station for different variables (in $\mu\text{mol/kg}$, except pH). Numbers represent the station number – 1000.

More regression lines between the mean residuals by station. They give us an idea of the correlation between them and help to detect some “wrong” stations, those one far from the regression line. The R^2 for each line in the following subplots are 0.13 ($p < 0.01$), 0.39 and 0.69 with $p < 0.001$ for the second and third ones, respectively.



Finally, I would suggest a careful checking of the mean residual trends along GH2004 for the different variables, specially the nutrients and confirm whether the spikes correspond to any change in the standards or substandards. There is a natural variability in the nutrient content of the water masses, it reflects mixing and biological activity, and consequently a correlation between those changes (mean residuals by station) is expected between the NO₃ and PO₄ and O₂. The regression lines shown before could help to detect “wrong” stations, as I did with the final set of TA measurements from station 680 till the end.

Here is a list of some samples I inspected visually and considered dubious.

Station	Bottle	Comments	
545	all	NO3-PO4 relation low	
549	19	O2 low	
549	12	NO3 low	
551	14	O2 high	
557	21	NO3 & PO4	
557	22	NO3 & PO4	
559	2	bad bottle?	
561	between 700-1000		O2 change
561	21	PO4 low	
571	18	NO3 & PO4 high	
573	5	PO4 high	
575	6	PO4 low	
575	1	PO4 low	
575	21	NO3 & PO4 high	
579	1000 m	O2 spike	
583	22	PO4 high	
599	17	PO4 high	
617	2	PO4high	
617	12	PO4high	
619	20	PO4 high	
625	24	NO3 low	
633	24	NO3 high	
635	24-21	PO4 low	
651	5	PO4 low	
659	1-2	PO4 ??	
674	22	PO4 high	
674	21	PO4 high	
680	1	NO3 low	
680	1	bad bottle	
688	14	PO4 high	

Best regards to all.

Marta.

RV AKADEMIK SERGEY VAVILOV: Final Report of CFC sampling and measurement

Bremen, 07 June 2006

RV AKADEMIK SERGEY VAVILOV cruise

GOOD HOPE

4.11.2004 – 8.12.2004

Cape Town – Cape Town

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Report Oliver Huhn (ohuhn@physik.uni-bremen.de)

1. Data file “vavilov.woc”

The attached file “vavilov.woc” is an ASCII written file with a header describing the following sequence of data columns:

```

      T R A C E R - O C E A N O G R A P H Y - B R E M E N
-----
vavilov - Freondata from the 6.6.2006

Quality byte: 1= --
               2= Acceptable measurement
               3= Questionable measurement
               4= Bad measurement
               5= --
               6= Mean of replicate measurements
               7= --
               8= --
               9= Sample not drawn for this measurment from this bottle

Quality byte: CFC-11/CFC-12
               1         2

Stat Cast Botl Bedford Deep  F-11  F-12 Qualit
               [m]      [pmol/kg]
```

CFC-11 and CFC-12 are both reported in [pmol/kg] and calibrated on SIO98 scale.

As the header describes, the file includes

column 6: 650 CFC-11 measurements [pmol/kg]
column 7: 651 CFC-12 measurements [pmol/kg]

combined with

column 1	station number (545-704, i.e. add 1000 to column 1 to get correct station number)
column 2	cast number
column 3	bottle number (1-24)
column 4	bedford number (not used here)
column 5	approx. depth of sample
column 8	quality flag

The quality flag digit 1 contains the flag for CFC- 11 and digit 2 the flag for CFC-12. Digits 3 and 4 are without meaning here.

flag = 2 = “good”

flag = 6 = mean from replicates (samples from the same bottle,
tapped directly after another)

flag = 3 = “questionable” (i.e. something suspicious during the measurement or
suspicious in compare to other samples)

flag = 4 = “bad” (i.e. obvious outliers, possibly contaminated, something very suspicious
during measurement or in compare to other samples or
any other very strange thing –
however, these samples cannot be used!)

Altogether 688 samples have been analyzed for chlorofluorocarbon (CFC) components CFC-11 and CFC-12. Some are replicate samples (i.e. samples from same bottle), from which the mean was taken. This leads to a total number of 651 data points.

CFC-11 has 551 measurements flag = 2 (good), 22 measurements flag = 6 (“good” and mean replicates), 3 measurements flag = 7 (questionable), 71 measurements flag = 4 (bad, i.e. never use these, they are nonsense or have something very doubtful occurred during the measurement).

CFC-12 has 576 measurements flag = 2 (good), 33 measurements flag = 6 (“good” and mean from replicates), 3 measurements flag = 3 (questionable), 39 measurements flag = 4 (bad, i.e. never use these, they are nonsense or have something very doubtful occurred during the measurement).

2. Sampling on the ship

The CFC samples during the cruise were taken immediately after the rosette system was brought back to the ship and before anybody else used water from the Niskin bottles. They were tapped into 100 ml glass ampoules preventing any contact to atmospheric air and after flushing the ampoule several minutes (i.e. about 3 times completely). Under a flow of trace-

gas-free nitrogen (N₂) the glass ampoules were flame-sealed. The amount of gas (CFC) in the headspace was accounted for later during the analysis/measurement procedure.

3. Measurement in the lab

The measurement was performed in March and April 2006 our lab in Bremen by Klaus Bulsiewicz. It was carried out in a gas chromatographic (GC) system on a capillary column and detected by an electron capture detector (ECD).

Only the gases in the water can be transferred into the GC/ECD system. Thus the CFC concentrations in the headspace and the volume of the headspace have to be determined.

- *Volume of the headspace:* Before the cruise, the empty ampoules had been individually weighted and tagged. After returning from sea, the full ampoules are weighted again. Once the glass ampoules are opened and the water sample analyzed, the headspace is determined by filling the ampoule with distilled water.
- *CFC concentration in the headspace:* In order to ascertain that the solubility equilibrium between the water and the headspace is achieved, the glass ampoules are brought in an ultrasonic water bath at a constant temperature ($\delta T < 0.1^\circ\text{C}$) for 24 hours.
- *CFC analysis:* The determination of the chlorofluorocarbons CFC-11 and CFC-12 is accomplished by purge and trap sample pre-treatment followed by gas chromatographic separation on capillary column and electron capture detector (ECD). The system is calibrated by analyzing several different volumes of a known standard gas. Additionally the blank of the system has to be analyzed regularly.

A more detailed description of the analysis can be found at:

BULSIEWICZ, K., H. ROSE, O. KLATT, A. PUTZKA, W. ROETHER (1998): A capillary-column chromatographic system for efficient chlorofluoromethane measurement in ocean waters; Journal of Geophysical Research, Vol. 103, No. C8, 15959-15970

4. Error estimate

4.1. Precision or reproducibility (from replicate samples)

CFC-11	$\pm 0.9\%$	for values $> 0.15 \dots 0.2$ pmol/kg and
	± 0.005 pmol/kg	for values $< 0.15 \dots 0.2$ pmol/kg
CFC-12	$\pm 0.7\%$	for values > 0.1 pmol/kg and
	± 0.004 pmol/kg	for values < 0.1 pmol/kg

4.2. Accuracy (error over all, including error of headspace, calibration, sample volume, etc.)

CFC-11	$\pm 2.0 \dots 2.5\%$	for values $> 0.15 \dots 0.2$ pmol/kg and
	± 0.005 pmol/kg	for values $< 0.15 \dots 0.2$ pmol/kg
CFC-12	$\pm 1.5\%$	for values > 0.1 pmol/kg and
	± 0.004 pmol/kg	for values < 0.1 pmol/kg

5. Description and comments

In the following some plots of the VAVILOV CFC data are presented and are briefly discussed. The CFC measurements are reported in pmol/kg or ppt = parts per trillion or partial pressure, using the solubility function from Warner and Weiss (1985) and the hydrographic data set (depth, temperature, and salinity) provided to us by Pierre Branellec in December 2005.

The surface water values (0 – 30m) are in saturation with southern hemisphere atmospheric partial pressure for 96 ± 13 % (CFC-11) and 98 ± 8 % (CFC-12).

The extraordinary high concentrations (particularly for CFC-11, pink circles in Fig. 3a) indicate problems with a possible CFC contamination of the ship environment. Fig. 3 suggests, that extraordinary high CFC concentrations might have contaminated some of the samples, and that this contamination decreased with the time of the cruise. All of these data point have quality flag = 4. Extraordinary high concentrations were more often measured for CFC-11 than for CFC-12. Even for some of the replicate measurements one of the CFC-11 measurements was good and one was bad, while both CFC-12 measurements were good.

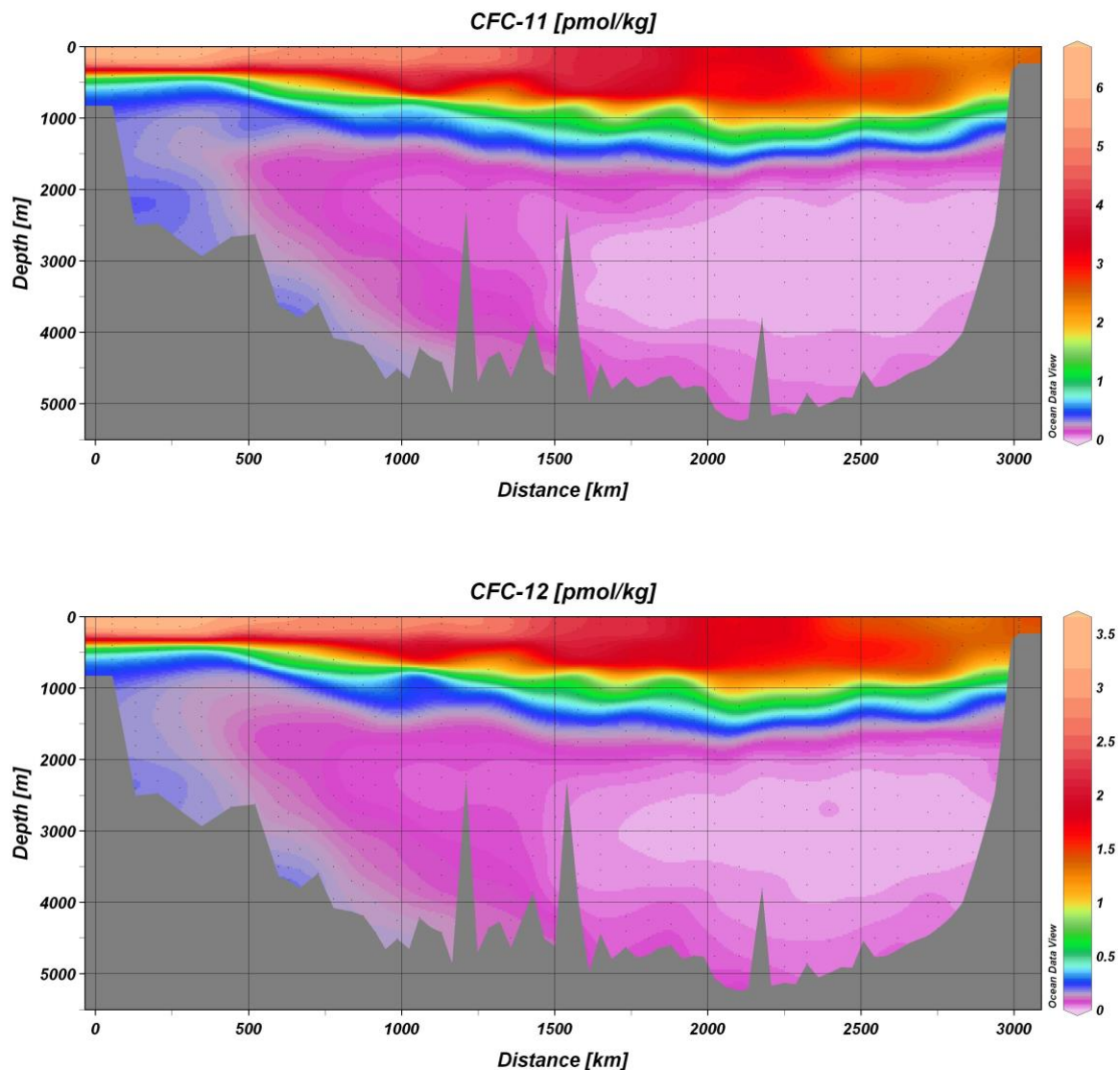


Fig. 1a and b: Contour plots of CFC-11 and CFC-12 along the cruise track of VAVILOV. Left is the MAR, right the African continental slope. Only data points flags 2 (good) and 6 (mean from good replicates) had been used.

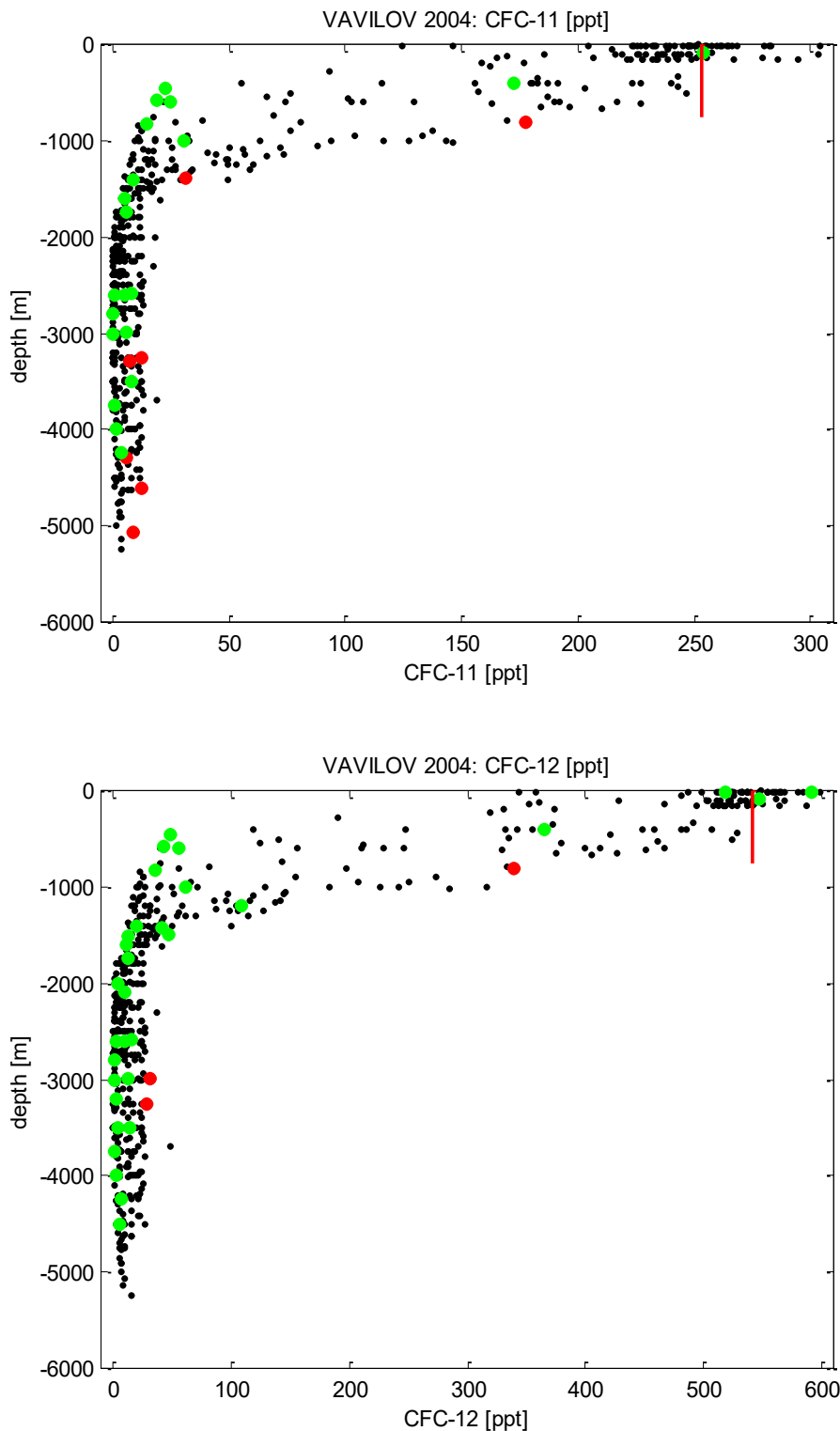


Figure 2a and b: CFC-11 and CFC-12 versus depth. Bad measurements (flag = 4) had been excluded, red dots are questionable (flag = 3) and green are replicates (flag = 6). The red line indicates the atmospheric partial pressure at the time of the sampling. The mean over all surface values (0 to 30 m) is in the order of 96 ± 13 % for CFC-11 and 98 ± 8 % for CFC-12. In mid depth the concentrations are close to zero.

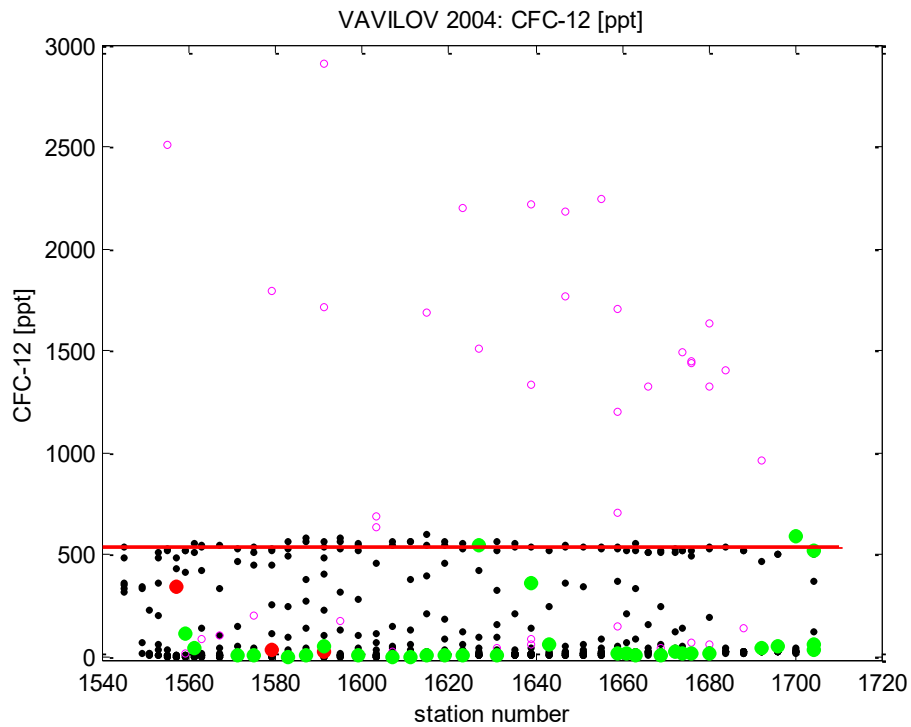
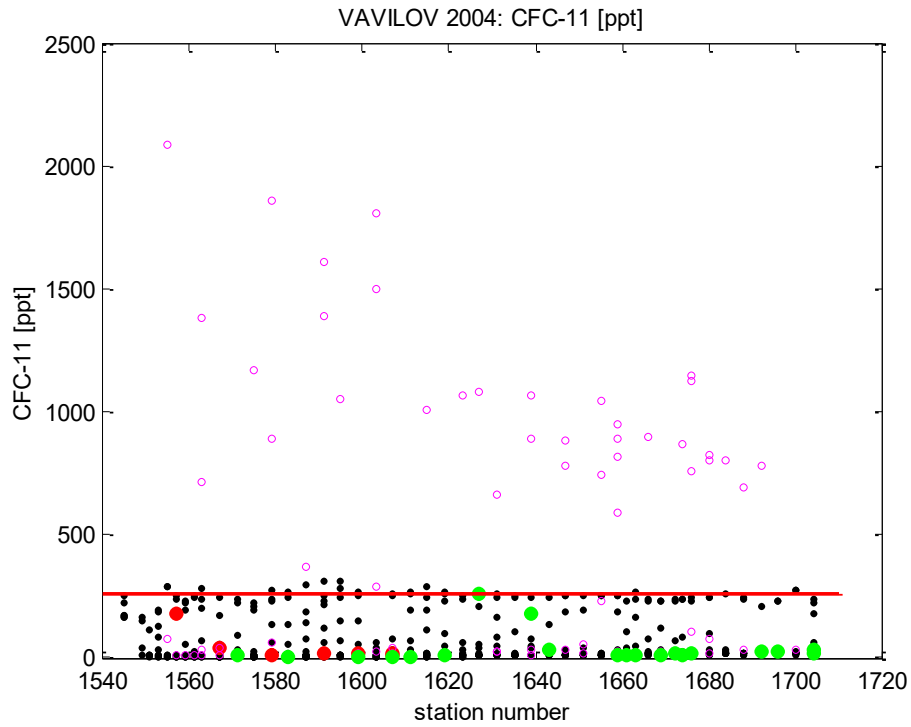


Figure 3a and b: CFC-11 and CFC-12 versus station number. Pink circles are bad (flag = 44), red dots are questionable (flag = 3) and green are replicates (flag = 6). The red line indicates the atmospheric partial pressure at the time of sampling. Note the “temporal decrease of the very, very high data points, particularly for CFC-11. That might indicate a decreasing contamination of the ship environment.

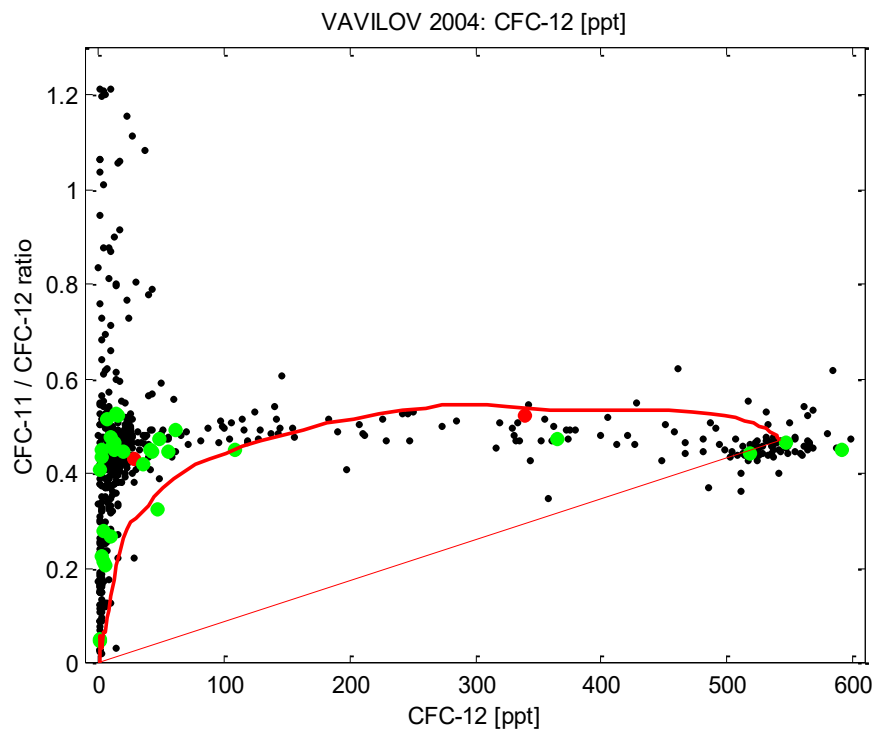
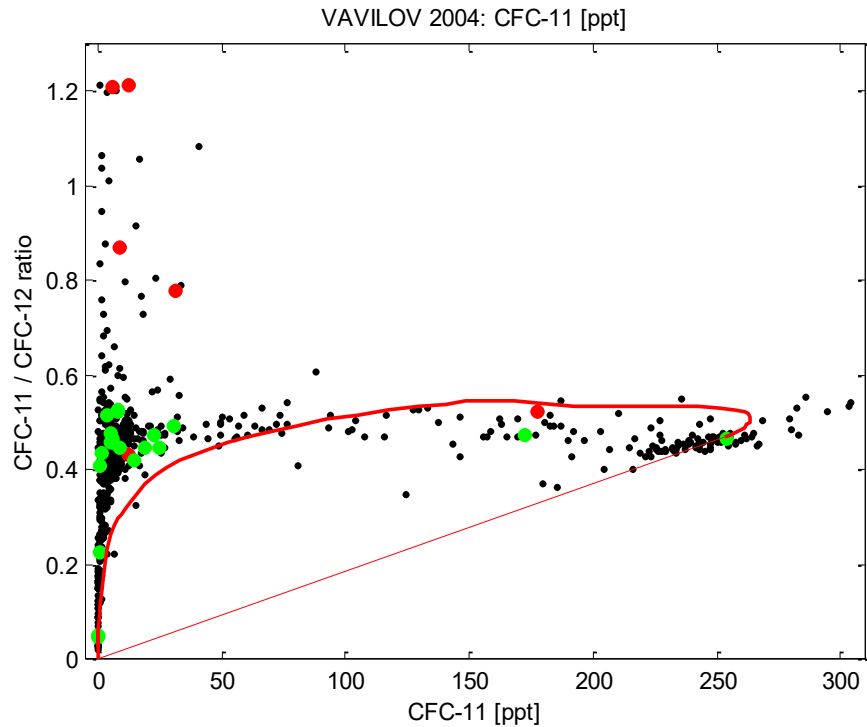


Figure 3a and b: CFC-11/CFC-12 ratio versus CFC-11 and CFC-12. Bad measurements had been excluded, red dots are questionable (flag = 3) and green are replicates (flag = 6). The thick red line indicates the temporal evolution of atmospheric partial pressure, the thin line is the mixing line between old and tracer free water and the atmospheric values at the time of the sampling. Note that for samples with small CFC concentrations the CFC ratios are highly sensitive for even small errors and become meaningless.