Oceanographic Data beneath South Pacific Sea Ice
N.B. Palmer Cruise 9405, September-October 1994

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Introduction

This report includes the primary ocean station data collected in the Pacific sector of the Southern Ocean during cruise 9405 of the *Nathaniel B. Palmer*. The cruise began on 10 September 1994, in Punta Arenas, Chile and ended on 16 October in Lyttleton, New Zealand (Hellmer et al. 1995). Here we describe data acquisition and reduction procedures for the vertical profiling of conductivity - temperature - depth (CTD) and dissolved oxygen, and the processing of water samples for salinity, oxygen, nutrients, carbon dioxide and chlorofluorocarbons. All CTD stations were occupied in the late winter/early spring sea ice field, in a zonal band extending from 65-72°S (Fig. 1). Originally intended as a winter reoccupation of the stations and track of NBP 9402 (Jacobs et al. 1994; Giulivi & Jacobs 1997), the work was subsequently combined with the second of two cruises focusing on sea ice properties (Jeffries et al. 1995). In addition, the sea ice and its snow cover effectively limited this cruise to the region north of the Antarctic continental shelf. Nevertheless, 16 deep stations sampled on cruise 9402 and on World Ocean Circulation Experiment (WOCE) lines S4 and P19S were revisited. The overall project objective was to obtain the first modern measurements in this largely unsampled region, at its seasonal extremes, in order to better understand the large-scale stratification and circulation, and ice-ocean interactions.

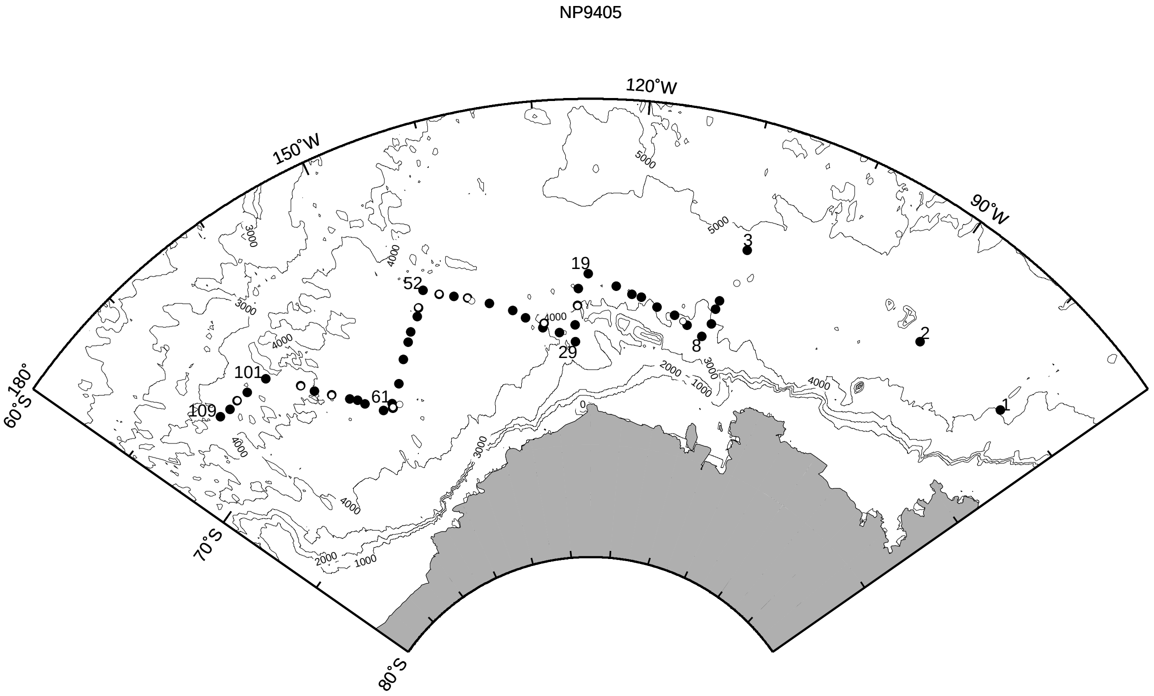

Figure 1. Distribution of CTD stations taken during cruise NP9405. Closed circles indicate the locations of casts where water samples were taken. The bottom bathymetry in meters is taken from the Etopo-5 data set.

CTD/Rosette Data Acquisition

Vertical profiles of temperature, conductivity and oxygen were made at the locations in Fig. 1, with time-series profiling at 10 sites for a total of 109 casts. A SeaBird 911^+ system with Seasoft 4.035 data acquisition software was used for the CTD measurements, with seawater pumped past the conductivity cell. The data were acquired at a rate of 24 Hz, with pressure, temperature and conductivity supplemented by measurements of dissolved oxygen.

At 51 stations, up to twenty-four 10-liter and 5-liter General Oceanics and Ocean Test Equipment water bottles were mounted on a General Oceanics rosette above the CTD for water sampling. Depending on water column characteristics, various depths were sampled during the CTD ascent (upcast) for salinity, dissolved oxygen, nutrients (phosphate, silicate and nitrate), carbon dioxide, oxygen isotopes, chlorophyll and chlorofluorocarbons (CFCs). ‘Baked’ o-rings were utilized for the CFC work. Substantial problems were encountered with the available water bottles, necessitating continual repair and monitoring to ensure sample integrity. Most stations were shallow, allowing sample loss to be minimized by double tripping, and the better bottles were used at the deeper levels.

Table 1. NP9405 CTD stations. From left to right, read: station, number of bottles closed, time series station, GMT date and time, station coordinates and maximum CTD depth. Station 65 is missing.

ST	BTL	TS	YR/MO/DA	GTIME	LATITUDE	LONGITUDE	MAXDPTH
1	4	-	94/09/14	23:50	-65.499	-76.997	4166
2	22	-	94/09/16	8:04	-65.666	-88.007	4580
3	11	-	94/09/18	19:06	-65.497	-108.498	990
4		-	94/09/19	7:30	-66.986	-108.554	4563
5	23	-	94/09/20	3:27	-67.936	-109.915	3892
6	12	-	94/09/20	12:10	-68.326	-110.120	986
7	12	-	94/09/20	21:21	-68.985	-110.137	988
8	24	-	94/09/21	23:47	-69.615	-110.906	3579
9	9	-	94/09/22	12:13	-69.289	-113.004	988
10	-	1	94/09/22	19:29	-68.986	-114.753	988
11	-	2	94/09/22	20:16	-68.976	-114.747	986
12	-	3	94/09/22	20:58	-68.970	-114.741	987
13	-	4	94/09/22	21:43	-68.965	-114.737	988
14	8	-	94/09/22	22:26	-68.959	-114.735	993
15	9	-	94/09/23	5:47	-68.739	-116.996	996
16	8	-	94/09/23	13:29	-68.399	-119.003	986
17	17	-	94/09/23	19:27	-68.309	-120.128	4184
18	9	-	94/09/24	6:32	-68.006	-122.014	1272
19	19	-	94/09/24	21:11	-67.494	-125.263	4295
20	7	-	94/09/25	10:40	-68.137	-126.435	985
21	-	1	94/09/25	19:39	-68.892	-126.614	987
22	-	2	94/09/25	20:25	-68.887	-126.604	987
23	-	3	94/09/25	21:10	-68.883	-126.596	991
24	-	4	94/09/25	21:57	-68.878	-126.587	989
25	-	5	94/09/25	22:41	-68.875	-126.579	988
26	-	6	94/09/25	23:25	-68.875	-126.579	988
27	10	7	94/09/26	0:05	-68.871	-126.557	987
28	8	-	94/09/26	10:43	-69.703	-126.964	1353
29	17	-	94/09/26	21:37	-70.436	-126.970	3716
30	8	-	94/09/27	9:43	-70.018	-128.991	986
31	7	-	94/09/27	18:09	-69.730	-130.999	979
32	-	1	94/09/27	21:53	-69.543	-130.828	986
33	-	2	94/09/27	22:35	-69.542	-130.830	986
34	-	3	94/09/27	23:20	-69.542	-130.832	987
35	-	4	94/09/28	0:02	-69.542	-130.832	985
36	6	5	94/09/28	0:43	-69.542	-130.832	987
37	7	-	94/09/28	13:06	-69.219	-133.010	987
38	22	-	94/09/28	22:50	-68.806	-134.423	4366
39	9	-	94/09/29	15:30	-68.320	-136.985	989
40	-	-	94/09/30	14:34	-68.041	-138.949	987
41	-	1	94/09/30	21:32	-67.843	-139.329	985
42	-	2	94/09/30	22:15	-67.853	-139.324	986
43	-	3	94/09/30	22:56	-67.853	-139.324	985
44	-	4	94/09/30	23:37	-67.868	-139.319	987
45	12	5	94/10/01	0:25	-67.878	-139.316	987
46	9	-	94/10/01	11:27	-67.645	-140.774	987
47	-	1	94/10/01	21:36	-67.343	-142.315	987
48	-	2	94/10/01	22:23	-67.357	-142.321	986
49	-	3	94/10/01	23:06	-67.368	-142.322	985
50	-	4	94/10/01	23:48	-67.373	-142.322	991
51	10	5	94/10/02	0:40	-67.385	-142.320	988
52	23	-	94/10/02	9:39	-67.000	-143.917	3800
53	-	1	94/10/02	21:42	-67.628	-145.064	988
54	-	2	94/10/02	22:29	-67.642	-145.065	987

55	12	3	94/10/02	23:16	-67.655	-145.065	987
56	9	-	94/10/03	6:54	-67.983	-145.517	989
57	10	-	94/10/03	15:19	-68.496	-146.885	984
58	21	-	94/10/03	21:26	-68.885	-147.648	4357
59	9	-	94/10/04	11:34	-69.483	-149.017	987
60	20	-	94/10/04	23:12	-70.363	-150.829	4308
61	7	-	94/10/05	12:47	-71.004	-152.810	985
62	-	1	94/10/05	20:34	-71.213	-153.111	985
63	-	2	94/10/05	21:23	-71.210	-153.099	985
64	-	3	94/10/05	22:11	-71.208	-153.089	989
66	-	4	94/10/05	23:43	-71.205	-153.075	986
67	-	5	94/10/06	0:28	-71.205	-153.075	986
68	12	6	94/10/06	1:16	-71.202	-153.060	986
69	-	7	94/10/06	3:24	-71.197	-153.040	987
70	-	8	94/10/06	4:12	-71.196	-153.030	987
71	-	9	94/10/06	5:05	-71.195	-153.022	986
72	-	10	94/10/06	5:56	-71.196	-153.015	987
73	-	11	94/10/06	6:55	-71.196	-153.008	974
74	7	12	94/10/06	7:52	-71.196	-153.003	986
75	-	13	94/10/06	9:59	-71.195	-152.991	988
76	-	14	94/10/06	10:49	-71.194	-152.987	986
77	-	15	94/10/06	11:39	-71.193	-152.983	987
78	-	16	94/10/06	12:39	-71.193	-153.000	987
79	7	17	94/10/06	13:38	-71.192	-152.978	986
80	-	18	94/10/06	15:53	-71.187	-152.970	987
81	-	19	94/10/06	16:48	-71.185	-152.963	999
82	-	20	94/10/06	17:42	-71.182	-152.956	986
83	-	21	94/10/06	18:30	-71.179	-152.953	988
84	-	22	94/10/06	19:13	-71.175	-152.949	493
85	23	23	94/10/06	19:37	-71.172	-152.949	4300
86	8	-	94/10/07	4:22	-71.088	-154.312	987
87	12	-	94/10/07	15:53	-70.450	-155.985	987
88	17	-	94/10/07	23:40	-70.132	-156.549	4053
89	9	-	94/10/08	13:22	-69.909	-157.346	987
90	-	-	94/10/08	23:14	-69.358	-159.001	1004
91	-	1	94/10/09	0:02	-69.349	-158.990	988
92	-	2	94/10/09	0:44	-69.341	-158.982	986
93	-	3	94/10/09	1:32	-69.331	-158.974	985
94	9	4	94/10/09	2:17	-69.322	-158.967	988
95	9	-	94/10/09	13:06	-68.767	-160.436	986
96	-	1	94/10/09	23:25	-68.236	-161.485	987
97	-	2	94/10/10	0:13	-68.236	-161.448	987
98	-	3	94/10/10	0:58	-68.234	-161.416	984
99	-	4	94/10/10	1:41	-68.232	-161.387	988
100	12	5	94/10/10	2:23	-68.230	-161.363	989
101	24	-	94/10/10	21:43	-67.047	-164.030	3978
102	24	-	94/10/11	14:01	-66.985	-166.568	3458
103	-	1	94/10/11	23:14	-66.946	-167.985	987
104	-	2	94/10/12	0:01	-66.946	-167.985	989
105	-	3	94/10/12	0:44	-66.946	-167.994	988
106	-	4	94/10/12	1:30	-66.946	-168.002	1226
107	10	5	94/10/12	2:20	-66.947	-168.017	987
108	23	-	94/10/12	10:01	-66.999	-169.246	3552
109	23	-	94/10/12	21:11	-66.947	-170.586	2969

CTD sensor calibrations and data processing

CTD data were processed using Seasoft software version 4.211, following standard procedures (SeaBird Electronics 1995). Oxygen current and oxygen temperature were advanced by 3 seconds relative to pressure. The records were scanned twice to remove data beyond 2 and 5 standard deviations in 100-point segments and edited to remove pressure reversals due to ship roll or CTD descent during stops for bottle closure. Data obtained during both descent and ascent were processed, with bottle depth files generated from data averaged over 3 seconds around bottle closure time. We retain and report temperature and salinity data taken during both CTD descent and ascent because ship movement during station often results in different but valid data in each mode, bottles are tripped during the ascent, and because the ascent data are valuable on time-series casts, which comprised the majority on this cruise.

The temperature, conductivity, pressure and oxygen sensors were calibrated before and after the cruise by Sea-Bird Electronics, and corrections were applied to the data based on those calibrations. The conductivity was corrected by applying the pre-cruise calibration coefficients and a slope correction (1.000037). Temperatures were corrected by applying the pre-cruise calibration coefficients and a small offset (0.0007). Pressure measurements were adjusted by applying a slope (0.99971) and an offset (-0.0624). After those corrections, the mean rosette-CTD salinity difference is 0.0014 with standard deviation of 0.0016 for all data at pressures greater than 500 dbar.

After pressure, temperature and conductivity corrections had been applied, the CTD oxygen data were processed with post-cruise calibration coefficients. Batches of profiles, descent and ascent, aggregated by similar residual differences between the CTD and water sample oxygen values, were further adjusted toward the bottle data, using polynomial fitting procedures. Due to equilibration problems, the bottle data better fit the CTD-ascent oxygen values, which are thus reported here, except for station 4. It may also be noted that anomalous drifts, offsets and roundings remain in the CTD-O profiles, particularly at shallower levels. Average differences of 0.002 (0.06 standard deviation) were obtained between all rosette bottle oxygen and corrected CTD oxygen below 500 dbar.

The upper few meters of many casts were removed during processing, and a 5-point running mean applied after averaging into 1-dbar bins. UNESCO (1981, 1983) algorithms were used to compute potential temperature, salinity and density.

Water sample analyses

Salinity

To monitor performance of the CTD conductivity sensor and confirm bottle trip depths, ~550 salinity samples were processed on Guildline 8400 and 8400A Autosal salinometers, standardized with IAPSO Standard Seawater batch P122. That batch may have an offset of –0.0009 (Aoyama et al. 1998). Salinity samples drawn into 120 ml bottles were allowed to equilibrate with the laboratory temperature, typically 0-3 degrees below the Autosal bath temperature (24°C). Salinity was calculated according to the Practical Salinity Scale of 1978 (UNESCO, 1981), using three or more conductivity ratio determinations.

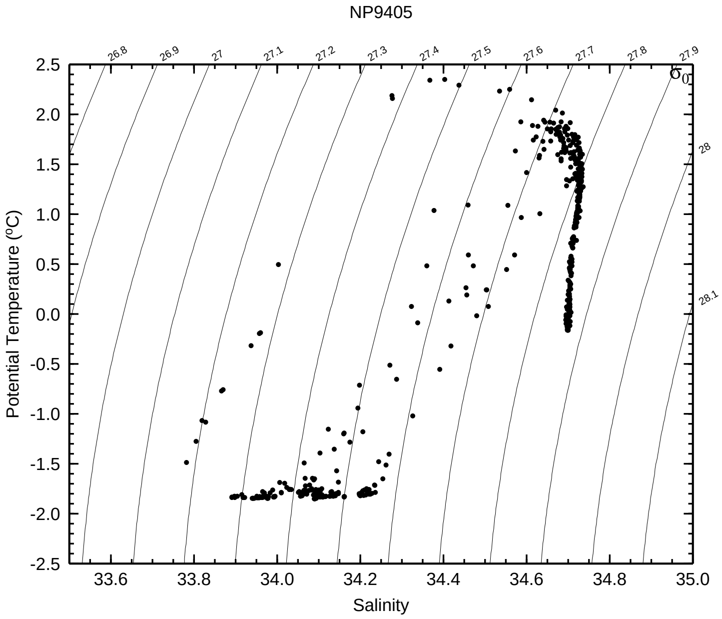

Figure 2. Bottle salinity vs. potential temperature from the CTD, with isopycnals of potential density referenced to the sea surface. The lower-salinity near-surface data and the higher temperatures at the temperature maximum were encountered on the earlier, more northerly stations in the Bellingshausen sector (Fig. 1).

Among the 535 bottle samples reported here, sixteen differ from the corrected CTD salinities by >0.007. The remainder shows a mean bottle minus CTD difference of –0.0006. As this value is small relative to standard seawater offset and related problems (Gouretski & Jancke 2000, and references therein), no bottle-salinity adjustment was made to the sensor-calibrated CTD data. An experiment conducted during the cruise showed that restandardization at the end of a ‘run’ with the (resealed) standard seawater vials opened at the start of that run could introduce apparent drift errors of 0.005.

Dissolved oxygen

Dissolved oxygen measurements were made with an automatic photometric titration system developed and constructed at the Scripps Institution of Oceanography (SIO). Dissolved oxygen samples were either drawn first, or immediately after chlorofluorocarbon samples, and analyzed following the WOCE operations manual (Culberson, 1991). The data were corrected for blank and thiosulfate drift. Measurements using the Scripps titrator were compared with those obtained using an automated amperometric oxygen titrator (Langdon & Bitte 1995). In one set of experiments, eight replicate oxygen samples from the same near-surface bottle were divided between the titrators on stations 68 and 74. Differences between the means of 0.19 and 0.03 uM/kg compared favorably with the 0.13-0.23 uM/kg standard deviation within each set. Another experiment evaluated differences over a range of oxygen concentrations (196-281 uM/kg) using duplicate samples from all water bottles on stations 102 and 109 and obtaining +0.4 and –0.3 uM/kg. This falls within a +/- 2 uM/kg range resulting from an intercomparison of five groups organized by the WOCE program (Joyce et al. 1992).

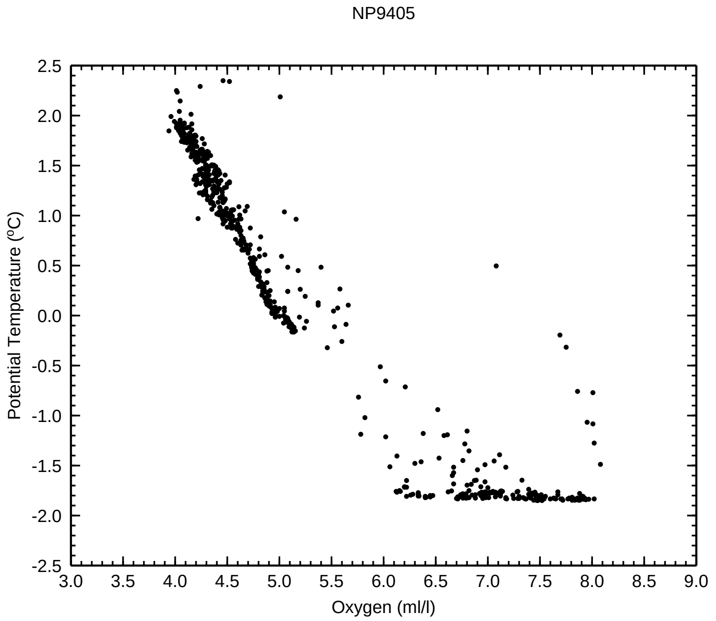

Figure 3. Bottle dissolved oxygen vs. potential temperature from the CTD. The higher oxygen content and warmer temperatures were encountered on the early stations, as in Fig 2.

Nutrients

Phosphate, nitrate (+nitrite) and silicate analyses were made on ~1600 samples, each processed in replicate on the ship's Alpkem Rapid Flow Analyzer (RFA-2). The phosphate analysis procedure was a modification of Bernhardt and Wilhelms (1967). The nitrate and silicate procedures followed or modified techniques in Armstrong et al. (1967). With few exceptions, the RFA software was used for calculations, including baseline corrections, replicate averages and the calibration to working standards. A variety of problems related to the hardware, software, analytical procedures and laboratory temperature compromised the nutrient data quality, as on NP9402 (Giulivi & Jacobs 1997). In general, the 9405 measurements are less noisy than those on 9402, but display more scatter than WOCE nutrient data in the same region (Fig's 4-5).

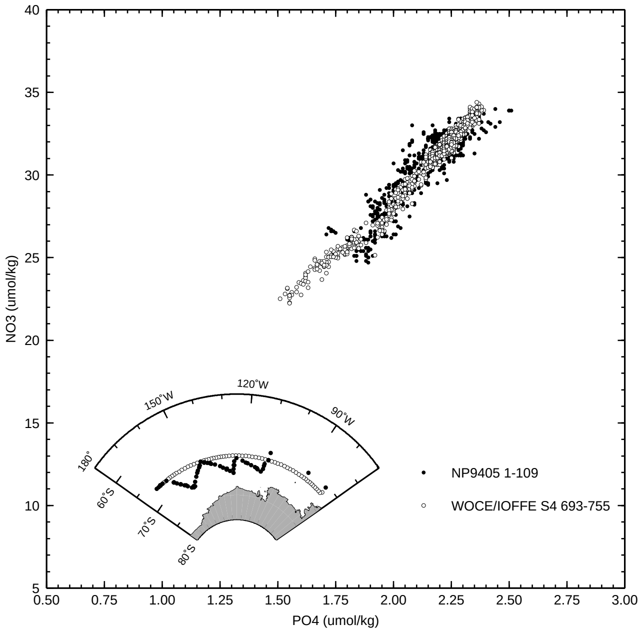

Figure 4. Nitrate vs. phosphate for NP9405 (all data) and for the WOCE/Ioffe S4 stations shown in the inset. The WOCE measurements were made in open water in February - March; the NP 9405 measurements under sea ice in September - October.

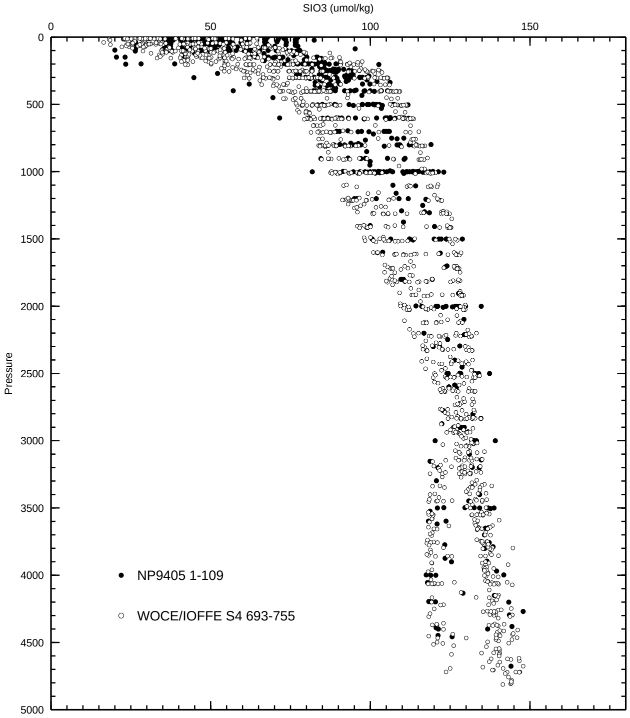

Figure 5. As in Fig. 4, but for silicate vs. depth.

Carbon Dioxide

Total dissolved carbon dioxide (Total CO2) and the partial pressure of CO2 (pCO2) were measured on 651 water samples from the sampled CTD/rosette casts, as on NBP 9402. In addition, quasi-continuous measurements of the surface water pCO2 were made during the transit portions of the cruise outside the area of extensive ice cover.

The total CO2 measurements were made using a Lamont-designed and built extraction and calibration system and a commercial CO2 coulometer. The seawater samples were injected into a stripping chamber using syringes adapted to give constant, reproducible volumes of ~20ml. Calibration of the coulometer was by means of injection of known quantities of pure CO2 into the carrier gas upstream of the extraction system. As a check on the calibration, samples of Calibrated Reference Material (CRM, provided by A Dickson of SIO) were injected and analyzed in the same manner as seawater samples (Fig. 6).

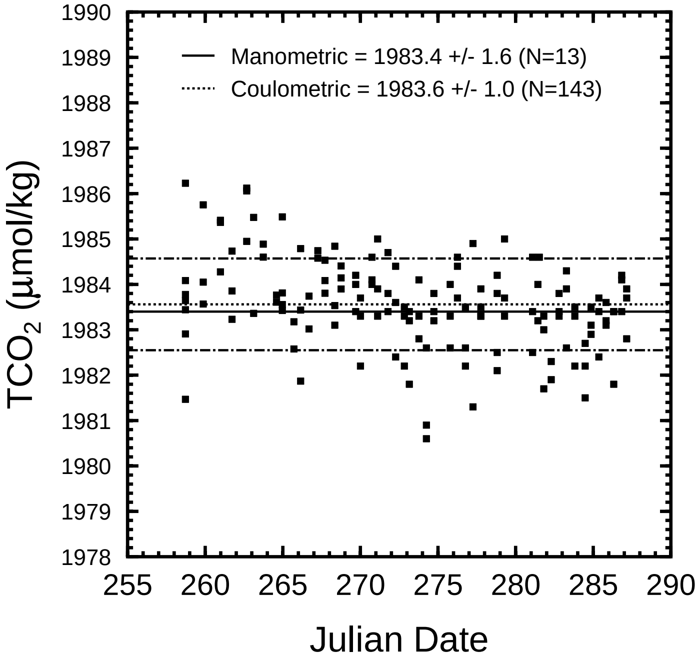

Figure 6. Comparison between the observed mean value of 143 injections of Calibrated Reference Material during the cruise (1983.60 +/- 1.0 umol/kg), and the nominal value for this CRM batch (#20) of 1983.40 +/- 1.6 (13 manometric analyses from the laboratory of CD Keeling of SIO). On the basis of this comparison, the analyses of seawater made during the cruise should be accurate to better than 1 umol/kg, on average.

The pCO2 analyses were also made using a Lamont-designed and built system, based on a Shimadzu gas chromatograph equipped with ruthenium methanization catalyst and flame ionization detector. Pairs of samples were equilibrated at a temperature of 4.00°C with known amounts of air, an aliquot of which was then injected into the carrier gas stream of the chromatograph for analysis. After each sample of the pair had been equilibrated and analyzed twice, three calibration gases (mixtures of CO2 in air) were injected (using the same loop) and analyzed. The areas of the CO2 peaks for the first and second runs of a given sample were compared, and re-equilibrated a 3rd and 4th time if more than 0.25% different from the mean. Since <20% of the samples required re-analysis, precision is estimated to be ~ ±0.15% (1 rms deviation). As there is no reference material for pCO2 analysis, the absolute accuracy of the analyses cannot be demonstrated in the same manner as for TCO2. Shipboard standard gases were calibrated at Lamont against a primary set of standards, which were in turn calibrated in the Keeling laboratory against a set of WMO standards. Equilibration at atmospheric pressure was maintained by means of a vent (with isolation coil) to the laboratory environment, the pressure of which was determined with a high-accuracy electronic barometer. Equilibration bath temperature was determined by means of a thermometer calibrated against one traceable to NIST.

The methods outlined above were taken from a description by D Chipman in Hellmer et al. (1994). See also Chipman et al. (1993). The TCO2 and pCO2 data in this report have appeared previously in Rubin et al. (1997; 1998), but some corrections have been made since that time. The pCO2 values reported here are in units of microatmospheres at 4.00°C, the temperature of measurement. To obtain pCO2 values at other temperatures, see Takahashi et al. (1993).

Chlorofluorocarbons

Chlorofluorocarbon (CFC) samples were drawn into 200 cc precision ground glass syringes from the rosette bottles and then transferred into 60 cc glass ampoules and flame sealed under an ultra high pure nitrogen atmosphere (Busenberg and Plummer 1992). The samples were returned to Lamont and stored in the dark at a temperature of 2-4°C until analysis. The ampoules were opened under an ultra high pure nitrogen atmosphere and a 20 cc aliquot introduced in an automated purge and trap system interfaced to a gas chromatograph with an electron capture detector. The gas chromatography was carried out using a 40 inch x 1/8 inch diameter precolumn of Porasil B, a 60 inch x 1/8 inch diameter main column of Carbograph-1AC and a 4 inch x 1/8 inch diameter post column of molecular sieve 5A, which was valved out of the gas stream after the elution of CFC-12. This procedure provides excellent separation of CFCs 11, 12, and 113 as well as separation of CFC-113 from methyl iodide. The precision of this technique is generally the larger of ± 1% or 0.01 pmol/kg (Mensch et al., 1998).

Other investigations

Ship-mounted ADCP data were logged on all CTD stations, but have not been processed due to problems caused by reflections within the transducer well, software anomalies and the inaccuracy of available GPS data. The ADCP system has since been upgraded, with oversight and post-cruise processing by E Firing and T Chereskin. Sixty-seven expendable bathythermograph casts were made during the cruise, and a portion of the resulting temperature data appear in Hellmer et al. (1995).

Chloroplyll samples were collected in the upper 100m of 35 CTD stations, and additional samples taken at the sea surface and near the tops and bottoms of about a dozen ice cores. Much of the chlorophyll data appear in Belem (1997). Over 400 oxygen isotope samples were obtained, and a subsample of those were processed at another laboratory in conjunction with the sea ice-sampling program (Jeffries et al. 1995; 1998). Those values are not reported here.

Data Presentation and Distribution

The CTD data are presented in tabular and graphical form for each station, on facing pages. The tabular information, from top to bottom, shows standard level observations during CTD descent through the water column, CTD and chemical measurements at bottle trip depths, and standard level data during CTD ascent. Only the last file is truncated if the page length is exceeded.

These data have been reported to the National Oceanographic Data Center, from which copies may be obtained. The data may also be viewed on line at www.ldeo.columbia.edu/physocean/projects.html. Please refer questions or comments to claudiag@ldeo.columbia.edu or sjacobs@ldeo.columbia.edu.

Header fields:

SHCRUS = ship and cruise, NP9405 for *Nathaniel B. Palmer* 1994 leg 5.
STNM = station number (001-109) and cast mode, with D = downcast, and U = upcast, during which the rosette bottles were closed.
YR/MO/DA = date.
GTIME = Greenwich Mean Time, at the start (D), or end (U) of each cast.
LATITUDE and LONGITUDE = coordinates at GTIME, in decimal degrees, negative in the southern and western hemispheres, from GPS navigation.
DPTH = bottom depth in meters (CTD depth plus HT, when available); otherwise corrected sonic depth from the Simrad EK500 or Raytheon 3.5 kHz depth recorders after sound speed corrections from Carter (1980). On many shallow casts no depths were recorded.
HT = distance in meters above bottom at the closest approach of the CTD/rosette to the sea floor. Often missing or not relevant on this cruise.
BARO = barometric pressure, in millibars.
WND = wind direction, degrees true from North.
WNS = wind speed, in meters/second.
AIRTM = air temperature in degrees Celsius.

Atmospheric parameters were taken from CTD logs at the beginning of each station, and are duplicated on the upcast headers.

Data fields:

PRES = pressure at the shallowest, standard and deepest levels, and at bottle trip locations, in decibars.
TEMPCTD = in-situ temperature, Int'l Practical Temperature Scale of 1968, in degrees Celsius, as for the other temperature fields.
POTEMP = potential temperature from UNESCO (1983).
TE>FRZ, TE>FRS = temperature above the in-situ and sea surface freezing points, from UNESCO (1978).
SALCTD, SALBOT = CTD & bottle (rosette) salinity, Practical Salinity Scale of 1978.
OXYUP, OXCTD = CTD dissolved oxygen in milliliters per liter and micromoles per kilogram, with the conversion after Culberson (1991). All CTD oxygen data reported here are from the CTD ascent, with the exception of station 004.
OXBOT = dissolved oxygen titrated from rosette bottle samples, as described above (Water Sample Analyses – Dissolved Oxygen).
SIGMA-0, SIGMA.5, SIGMA-1, SIGMA-2 = potential density anomalies referenced to 0, 500, 1000 and 2000 dbar, in grams per cubic meter.
ANOM = specific volume anomaly, in 10^{-8} cubic meters per kilogram.
GEOPT = dynamic height, in meters, relative to the sea surface.
SVELOC = sound velocity, in meters/second, from Chen & Millero (1977).
DPTH = depth in meters converted from pressure, after Saunders (1981).
SIO3, PO4, NO3 = dissolved silicate, phosphate and nitrate + nitrite, in micromoles per kilogram, converted from micromoles per liter at an assumed density of 1.024 kg/m3.
PCO2 = carbon dioxide partial pressure, in microatmospheres, at the 4° Celsius measurement temperature.
TCO2 = total carbon dioxide, in micromoles per kilogram.
F11, F12, F113 = chlorofluorocarbons, analyzed as above, in picomoles per kg.
BN = bottle number; where more than one bottle was closed at the same depth, values have been merged.

Data plots:

The heavy continuous and dashed lines show vertical profiles of salinity obtained during CTD descent (D) and ascent (U), respectively, with dots indicating bottle salinities. The medium continuous and dashed lines show the corresponding CTD potential temperatures. The light dashed lines show the CTD U dissolved oxygen profiles (D on station 4), with triangles indicating oxygen titrations from water samples. Note the pressure scale change at 1000 dbar. Cast coordinates are given for the start time of the downcast, to the nearest minute. The insert indicates station location.

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