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Technical Data Report:
Oceanic CO₂ Measurements for the WOCE
Hydrographic Survey in the Pacific Ocean, 1990-1991:
Shore Based Analyses

Prepared for the U.S. Department of Energy
Special Research Grant Program 89-7A:
Global Survey of Carbon Dioxide in the Ocean
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1. Introduction

The Office of Health and Environmental Research, of the U.S. Department of Energy (DOE), actively supports global survey investigations of carbon dioxide in the oceans. This large scale study is in conjunction with the hydrographic program of the World Ocean Circulation Experiment (WOCE/HP). On ocean cruises operated by WOCE/HP, carbon dioxide analysis groups, from various oceanographic institutions, perform shipboard chemical measurements of the inorganic carbon system in the ocean. Measurements of total dissolved inorganic carbon (DIC) are of central importance to this carbon survey. Shipboard measurements of DIC were made by employing a coulometric technique developed by Johnson et al. [1985]. The majority of coulometric measurements were made on an integrated automatic device, the Single Operator Multi-Parameter Metabolic Analyzer (SOMMA) [Johnson et al., 1993; DOE, 1994]. In addition to DIC determinations, shipboard analytical groups measured at least one additional parameter of sea water carbon chemistry. This was done to more fully characterize the inorganic carbon system of the sea water sample. This added parameter was one of the following: 1. titration (or "total") alkalinity (ALK) or, 2. the fugacity of carbon dioxide ($f\text{CO}_2$).

In support of DOE's global carbon survey, the CO_2 Research Group (CDRG) at Scripps Institution of Oceanography (SIO), has received "replicate samples" of sea water, collected at sea, and sent to our shore laboratory for precisely calibrated determinations of DIC and ALK. The DIC measurements were produced by vacuum extraction/manometric analysis and the ALK values by potentiometric titration. Both measurements were performed in controlled laboratory conditions using standards. Samples were collected from the same Niskin bottles as were samples for shipboard analyses of DIC using the coulometric technique. The shore laboratory analyses of DIC employed a precise and proven methodology to provide information on the quality of the shipboard analyses done by other investigators.

The WOCE/HP Pacific legs on WOCE lines P16 and P17 were delayed, beginning only in late May 1991 and ending on October 1, 1991. The three legs, named TUNES Expedition Legs 1, 2, and 3 by SIO, were carried out on the SIO R/V *Thomas Washington* as a substitute for the larger R/V *Melville* or *Knorr* research ships because the latter ships were not ready in time. Replicate samples were collected on all three cruise legs. Shipboard analyses of carbon system parameters were conducted by scientists from Woods Hole Oceanographic Institution (WHOI), Lamont Doherty Earth Observatory (LDEO) and SIO. Replicate samples were additionally collected on two legs of the German research ship F/S *Meteor*, Leg Nos. 15 and 18 along WOCE Lines

A9 and A1E. Shipboard personnel of Brookhaven National Laboratory (BNL) measured carbon system parameters.

This technical data report presents DIC and ALK measurements performed in the SIO laboratory on replicate samples collected on the five expedition legs of the WOCE/HP cruises outlined above. A total of 907 replicate samples were collected and 349 of these were successfully analyzed for DIC at SIO. DIC and ALK measurements made on Certified Reference Materials, prepared by Dr. Andrew Dickson, also at SIO, are summarized in this report. Shore based salinity measurements on replicate sea water samples are also presented. Performance on each leg of the replicate sampling program and comparison of shore based to shipboard DIC measurements will be discussed.

2. Methods

2.1 *Sample collection*

2.1a Sample bottles

In preparation for the 1991 WOCE replicate sampling, 1400 (0.5 liter) reagent type borosilicate glass bottles were purchased and prepared for sample collection. Previous sampling was done with 1 liter bottles with greased stoppers closed with custom spring metal clips. New methods, however, for securing the bottle stoppers on the 0.5 liter bottles needed to be devised. Initially, a supply of 700 standard Corning 0.5 liter bottles were purchased. These are equipped with hollow stoppers of approximate standard taper 24/30 size. The bottle joints and stoppers were not of standard taper quality. All of these bottles were therefore hand lapped with carborundum grit and bottles and stoppers were correspondingly labelled. A custom aluminum bale type apparatus was devised to hold each stopper securely shut after the bottle was filled with water. A second approach was to fabricate bottles with standard taper quality joints and stoppers using the Rodaviss greased joint system. The outer joint on this system (a full size 24/40 standard taper joint) has glass threads molded onto the outside of the joint. A plastic knurled nut threads onto the bottle holding the stopper securely shut with an internal O-ring. Solid glass standard taper stoppers were purchased for this system. Bottle blanks were purchased and the glassblower assembled the Rodaviss joints onto the bottles, including a calibrated 5.0 ml air space section in the bottle's neck. These bottles were considerably more expensive than the standard bottles. However, the closure system and joint quality are superior to the standard bottles.

Bottles were packed, 20 to a plastic folding top crate, and equipped with custom made foam inserts to secure them. This proved to be an excellent system for not only protecting the bottles during storage and shipping, but also by providing insulation against short term temperature changes.

Following established procedures, each bottle was labeled with a sequential number and prefix; "S" for standard bottles with a custom closure device, and "R" for the Rodaviss joint bottles. Each sea water sample had a unique number. New labels and numbers were attached to the bottles when reused.

2.1b Sample collection procedure

From any given Niskin bottle, at least one sea water sample was collected for shipboard chemical analyses. Additionally, from the identical bottle, two replicate samples were sent to SIO for shore based comparative sea water analyses. Throughout this report, replicate samples refer to those sea water samples sent to SIO for shore based

analyses. Replicate samples were sequentially collected immediately following collection of the sample for shipboard DIC analysis. Established procedures [DOE, 1994] for DIC sample collection were followed. Mercuric chloride solution (HgCl_2) was added to prevent biological activity from occurring. The accepted quantity of HgCl_2 is approximately 14.0 ppm by weight of the final solution, which corresponds to 100 μl of a saturated aqueous HgCl_2 solution, per 0.5 liter bottle. The bottle stoppers were greased with Apiezon L grease and tightly secured into the bottle joints with the closure system. Samples were stored on the ship in a cool location (not frozen) and promptly air freighted to SIO. Precautions were taken to avoid exposure of the samples to high temperatures, which can cause deterioration of the greased seals (Appendix 6 for procedures).

2.1c Sample inspection and storage

Upon arrival at SIO, the bottles were carefully inspected for leaks of the greased seals and the bottles stored at 5.0°C until analyses are performed.

2.2 *Sample analysis procedure in the laboratory*

2.2a Vacuum extraction of CO_2 gas for total DIC

A 40 gram aliquot of seawater is subsampled into a flow-through pipette upon immediately opening the sample bottle. Procedures to eliminate any loss or gain of CO_2 gas from atmospheric exposure are rigorously observed. The pipette is weighed to 0.001 grams both before and after subsampling, and assembled onto a glass vacuum extraction line. The sample is completely acidified with dilute phosphoric acid and the evolved CO_2 gas quantitatively captured into a trap at liquid nitrogen temperature. CO_2 samples either remain frozen, while awaiting manometric analysis, or are sealed into glass break-off tubes prior to later manometric analysis. The vacuum gas extraction procedure is more fully described in Appendix 7.

2.2b Manometric measurement of extracted CO_2 gas sample

The extracted CO_2 gas sample is cryogenically transferred into a constant volume manometer where pressure and temperature are then measured. These measurements, along with the calibrated sample volume of the manometer provide for calculation of the number of moles of CO_2 gas using a virial equation of state. The number of moles of CO_2 gas analyzed, combined with the weight of the aliquot of sea water, directly yields the DIC in micromoles per kilogram of sea water.

Three different manometric systems are used in the SIO analyses. The primary system is a constant volume mercury manometer with a precision cathetometer which measures mercury height. This instrument provides the calibration standard for atmospheric CO₂ measurements for the network of base line monitoring stations associated with the World Meteorological Organization (WMO). This system and its calibration is detailed by Keeling et al., [1985]. The mercury manometric system is labelled "M" in this report.

The additional two manometers used for analyses at SIO are equipped with a quartz spiral manometer (manufactured by the Ruska Corporation) as the central element. A set of standard CO₂ gas samples are measured on both the mercury manometer and quartz spiral instruments. In this way, the response of the quartz spiral manometer is directly calibrated each day of operation.

The quartz spiral manometer, "S" in this report, was utilized from 1981 until early 1992. Here, samples were cryogenically transferred into a constant volume, comprising also the measurement quartz spiral of a Ruska XR38 manometer. This spiral actually unwinds with pressure and the amount of unwinding is mechanically tracked. In 1991 and 1992, this instrument episodically malfunctioned resulting in some erroneous WOCE sample measurements.

A newly constructed instrument, labelled "E" in this report (Electronic Constant Volume Manometer; ECVM), was first utilized for CO₂ extraction measurements of sea water in July, 1992. Here, the gas sample was cryogenically transferred into a constant volume comprising also one compartment of a Ruska differential pressure gauge. The pressure on the second compartment, separated from the first compartment by a diaphragm, was matched to the sample pressure by supplying pressure from a Ruska DDR6000 quartz spiral manometer configured as a pressure delivery source. The quartz spiral in the DDR6000 manometer is mechanically immobile, held in place by an opposing magnetic field from which the pressure is accurately calculated. The diaphragm position in the differential pressure transducer is additionally electrically detected to very high precision. This instrument was expected, and has proven, to be significantly more linear and precise in its operation than the previous system. It has now replaced the "S" manometer for the measurement of WOCE samples.

For all of the data here reported, the volume of the nominally 4 cc chamber in the mercury manometer was defined as 3.7955 cc, the result of the volume calibration of 1986 [Keeling et al., 1985]. Three manometric volume calibrations, determined in 1988, 1990 and 1993-4, indicate little appreciable drift in the volume. The precision of mercury manometric measurements is established by measurement of duplicate

reference gas samples, sea water gas extractions and volume calibration samples. The precision of a single mercury manometric measurement is consistently at, or less than, one part in 4000, or about 0.5 $\mu\text{mol/kg}$ in DIC. Laboratory results also indicate that the other manometers, particularly the ECVM, have had as good or better precision.

2.2c Alkalinity measurement

After removal of the DIC analysis aliquot from the replicate sample bottle, additional aliquots of sea water are removed and potentiometrically titrated with dilute HCl solution to determine the total alkalinity of the sample. Two titration systems were employed for the data reported: 1. the gravimetric system, identified as system "G" in this report and, 2. the volumetric system, identified as system "V". With the gravimetric system, a weighed aliquot is titrated in a closed cell (Appendix 7). The original sample bottle is equipped with a spout dispenser and weighed before and after filling the cell. The aliquot is quantitatively flowed into the titration cell, using gas pressure. The volumetric system also uses a dispensing system to flow a known volume, from a glass syringe driven by a stepper motor, into the cell. This system was developed for shipboard work and used on two WOCE cruises, TUNES Leg 3 in 1991 and CGC92 in August, September and October of 1992. The volumetric system will be more thoroughly described in a forthcoming shipboard alkalinity report for TUNES Leg 3.

2.2d δC^{13} measurement

After manometric analyses, the CO_2 resulting from sea water extraction is sealed in a glass break off tube and stored for mass spectrometry analysis of the $^{13}\text{C}/^{12}\text{C}$ ratio. Isotopic analyses were run in the laboratory of Dr. Martin Wahlen at SIO. Isotopic values for all samples from TUNES Leg 3 and the majority of samples from Meteor Leg 15 were determined. A report summarizing the isotopic data is in preparation.

2.2e Salinity measurement

After DIC and ALK measurements are completed on each replicate sample, an aliquot of 100 to 250 ml is removed from the sample bottle for salinity determination. The SIO method of sea water collection preserves salinity to within several thousandths per mil. Comparison of shore based salinities at SIO to shipboard salinities helps to demonstrate that the sample was properly collected and stored. Agreement of shipboard and shore based results provide confirmation of salinity values used in the SIO calculations prior to the availability of the final WOCE salinities.

Salinity samples were analyzed to within 0.001 salinity units by the Oceanography Data Facility (ODF) at SIO with an inductive salinometer calibrated with standard sea water.

3. Results

Detailed tables of DIC, ALK, and salinity results and descriptive comments are presented in Appendix Tables 1-5.

3.1. Sample collection

3.1a Sample collection summary

Sample bottles were supplied for the five expedition legs according to the sampling plan originally proposed. The highest priority was given to WOCE legs in the Pacific Ocean on the R/V *Thomas Washington*, TUNES Legs 1, 2, and 3. A total of 1080 bottles were supplied for the three legs with the intention to fill 1044 bottles with collected sea water samples. For Legs 15 and 18 on the German research vessel, *Meteor*, 40 and 58 bottles, respectively, were provided to the Brookhaven National Laboratory CO₂ Analysis Group for replicate sampling. On *Meteor* Leg 15, the scientists also planned to collect additional samples in Dr. Andrew Dickson's Certified Reference Material (CRM) bottles after they had been emptied. For the five legs described (TUNES Legs 1, 2, 3 and *Meteor* Legs 15 and 18), the total number of sample collections was approximately 1200 from a proposed original of 1400.

The replicate sampling plan proposed for the three TUNES legs included collection of a partial depth profile of samples on every third station that was analyzed in full by the shipboard CO₂ analysis group. The following twelve depths (measured in meters) were identified for replicate sample collection: 0, 50, 100, 200, 300, 400, 600, 900, 1200, 1600, 2000, and 3000. Replicate samples were collected at the surface and at approximately 3000 m at the remaining two-thirds of the CO₂ stations on each leg. All replicate samples from Niskins were collected in duplicate.

A series of situations affected the final number of samples actually collected and the number of samples which were actually analyzed at the shore based SIO laboratory (Table 1 summarizes these results). On TUNES Leg 1, sampling was close to satisfying the objective of the sampling plan. Personnel problems on TUNES Leg 2 resulted in approximately 50% of the planned sampling actually being accomplished. On TUNES Leg 3, about 75% of the planned sampling was accomplished. On this leg, the intended percentage of replicate samples were collected but on fewer than originally planned shipboard CO₂ stations.

3.1b Discussion of problems

Personnel restrictions. As a result of utilizing the R/V *Thomas Washington*, which has a smaller capacity, in lieu of the R/V *Knorr* or R/V *Melville*, space was allocated for only two CO₂ scientists on the TUNES legs. On Legs 1 and 3, the CO₂

Table 1. Replicate Sample Collections During 1991

Expedition	WOCE Line Designation	Expedition Date	Number of Samples Planned*	Total Number of Samples Collected	Number of Samples Successfully Analyzed for DIC
TUNES Leg 1	P17C	Jun-Jul 1991	376	354	107
TUNES Leg 2	P16S, P17S	Jul-Aug 1991	384	220	23
TUNES Leg 3	P16C	Sep 1991	284	211	195
Meteor Leg 15	A9	Feb-Mar 1991	40+	66	12
Meteor Leg 18	A1E	Sep 1991	58	56	12
Totals			1142	907	349

* Based upon the proposal to collect replicate samples from approximately 10% of the total number of Niskin samples analyzed at sea for DIC.

scientists were able to complete all of the CO₂ system sampling for shipboard and replicate sampling which, however, resulted in some curtailment of shipboard DIC and ALK analyses, especially on Leg 3. However, on Leg 2, a greater analytical work load by the shipboard CO₂ analysts prevented them from personally sampling for shipboard analyses. Thus, only 57% of the planned number of samples were actually collected.

Replicate sample bottle deficiencies. Upon completion of TUNES Legs 1 and 2, an inspection of the greased bottle seals revealed that those standard Corning bottles, equipped with custom aluminum closures frequently were not sealing. The required careful adjustment of the sample bottle closure device was not always realized by the shipboard samplers, occurring to the time constraints for the reduced staff on these legs. On Leg 3, replicate samples were collected only in bottles equipped with Rodaviss joint closures. (Further use of the standard bottles with custom closures was afterwards abandoned.)

On the first *Meteor* cruise (Leg 15), the experiment of refilling CRM bottles with collected sea water samples failed. These bottles were also standard Corning 0.5 liter bottles with custom rubber band closures, but were not supplied by SIO and were not hand lapped. The bottles invariably fail to seal after filling with water, resulting in gas exchange with the atmosphere.

The bottles with Rodaviss joint closures worked well in general, particularly on TUNES Leg 3. The bottles are fragile and can break at the joint when overtightened. On TUNES Leg 3, some bottle joints broke even though they were not overtightened, possibly indicating faulty joints. Some faulty seals still resulted using these bottles (e.g., those collected on *Meteor* Leg 18). This occurred when water was not entirely cleaned from the joint prior to closure, or if the Rodaviss closure was undertightened.

Bottle storage problems. The greased joints on replicate sample bottles are vulnerable to degradation and eventual leakage if they are exposed to high temperatures, especially greater than 30°C, for extended periods of time. Because of space limitations on the R/V *Thomas Washington*, crates of replicate samples were stored in a non air-conditioned hold. In equatorial regions, temperatures in the storage hold often reach 30°C. This possibly caused some of the leakage problems on the TUNES legs. After TUNES Leg 1, the sample crates were accidentally stored in a warehouse in Papeete, Tahiti for two weeks prior to air shipment to San Diego. Shipment was made promptly following TUNES Legs 2 and 3. There were also possible problems with prompt shipping after the F/S *Meteor* Legs 15 and 18 and unknown storage conditions

on the F/S *Meteor*.

(Since the 1991 expedition legs, steps have been taken which have resulted in more appropriate storage of samples on the ship and prompt air shipment back to SIO following each leg.)

Bottle condition summary. Figure 1 is a bar graph displaying results of inspection of the sample bottles upon return to SIO. Those bottles which upon visible inspection appeared to be faulty (i.e., evidence of a leaked greased seal) were not usually analyzed. Serious problems were observed on four of the five legs. The sole exception was TUNES Leg 3. For comparison, inspection results from three previous collections of 1 liter shore replicate samples (which included profiles with depth) are also displayed in in Figure 1.

Evidence for lack of HgCl_2 treatment on replicate samples. A number of samples from TUNES Leg 3 indicated high bottle pair disagreement, greater than 10 $\mu\text{mol/kg}$. Since the greased seals were intact on these samples, it was suggested that the only likely explanation could be that the process of HgCl_2 sample treatment had been omitted. A chemical indicator test for the presence of HgCl_2 in these samples was then implemented. Small aliquots of sea water from each bottle, of a suspected bottle pair, were tested for HgCl_2 . After precipitating excess chloride from the water by adding silver nitrate, a dilute solution of an azo dye (phenylazoformic acid 2-phenylhydrazide), was added and the development of a purple color observed. In some cases, a definite difference in color was noted, in which bottles with high DIC values showed little color development. These samples have been flagged with an "F" in the data summaries. As this test was used more frequently in the course of analyses, it became obvious that it was not entirely reliable. With enough time, color development intensified on all samples. Little positive difference was observed on some tests. Use of this test was then terminated. The flagged samples thus reflect erroneous values for which the cause would not be decisively established.

The alkalinity values in the suspected bottle pairs, in most cases, also showed poor agreement, although the differences were not always unidirectional. In these instances, it appeared as if the sea water sample was contaminated. In one case, the alkalinity bottle pair difference was good. Here, the incorrect DIC value was possibly attributed to an analytical mistake. The $^{13}\text{C}/^{12}\text{C}$ ratios measured on the CO_2 gas extractions from the suspected bottle pairs from TUNES Leg 3 provide yet another clue. In the majority of examples, the sample with the high DIC value had a correspondingly negative (light) $^{13}\text{C}/^{12}\text{C}$ result. This appeared erroneous when

Figure 1. Replicate sampling quality summary. The quality of sample bottles is divided into four categories and is based upon visual inspection at SIO of the greased seals. Imperfect bottle joint seals are noted in the figure as *possible* or *definite* problem. As a basis for comparison, the quality of replicate samples from three prior expeditions are also represented. These three expeditions are: TTNA, Transient Tracers in the North Atlantic, 1980-1981; TTTA, Transient Tracers in the Tropical Atlantic, 1982-1983; and INDIGO, Indien Gaz Ocean 1 expedition on the French vessel Marion Dufresne in 1985.

compared to adjacent data sets. The contamination may have resulted from biological oxidation of organic carbon in the absence of mercury. A similar result may have been caused by contamination of the sample with atmospheric CO_2 , either during sampling, storage (leaking), or due to an extraction error.

An explanation is lacking for the possible omission of HgCl_2 treatment in such a large number of samples as those collected on TUNES Leg 3, where the sampling was supervised by the senior author of this report. The micropipette used during this expedition leg specifically for the addition of HgCl_2 was detected sometimes to have failed to fill properly. It is possible that an air bubble line in the pipette tip made the tip appear as if it was actually filled with the HgCl_2 solution, and the improper fill was not noticed.

Other possible problems with samples. The possibility that poor results on TUNES Leg 3 were in some way due to the use of smaller bottles than those in previous sampling by the CDRG (0.5 liter instead of 1 liter), was also considered. Excellent results for samples collected with the smaller bottles on later expeditions has ruled out that possibility.

An explanation for inaccurate results on TUNES Legs 1 and 2 and both *Meteor* legs is incorrect sampling from the Niskin bottles. Examples of this type of problem include: 1) long periods of elapsed time after opening the Niskin bottle prior to sampling, 2) long periods of elapsed time after the shipboard sample was collected and prior to the replicate sample collection, and 3) sampling at the bottom of the Niskin bottle. Thus, lack of prompt sampling perhaps contributed to inaccurate results due to gas exchange with the atmosphere.

Analytical problems. Some of the inconsistent bottle pair agreement observed was perhaps a result of a malfunction in the quartz spiral manometer ("S"). Occasionally, this device produced an identified incorrect count. For example, an erroneous value was occasionally noted on standard CO_2 gas samples where the correct value is known. Such misreadings were sporadic and possibly undetected malfunctions occurred on some sea water extractions. In cases where evidence existed for this occurrence, the datum was flagged in the data set (the most common reason for the "EX" flag). After attempts to eliminate the malfunctioning proved unsuccessful, the quartz spiral manometer was abandoned and replaced (after a delay) by the electronic constant volume manometer ("E").

3.2 *Measurements of total dissolved inorganic carbon on Certified Reference*

Materials

Appendix Tables 1A-1L present all of the measurements of DIC by vacuum/extraction on Certified Reference Materials (CRM's) prepared in the laboratory of Dr. Andrew Dickson of SIO. These measurements constitute the certification of the DIC concentrations of the various batches of CRM's (Batches 1-13).

In any given batch of CRM, approximately 600 bottles were filled with homogeneous sea water. The majority of bottles in a batch were sent to sea for quality control measurements by shipboard CO₂ analysis groups. Approximately 10 bottles of each batch were reserved for certification of DIC at SIO.

Serious problems with biological contamination were encountered in the preparation of the natural sea water reference materials beginning with CRM Batches 4 and 5. DIC concentrations drifted upward with increasing storage time. As a temporary measure to produce stable batches, several (6, 7 and 11) were prepared in sodium chloride solution (artificial sea water). Stable DIC results for CRM's in natural sea water were obtained beginning with CRM Batch 10, following extensive cleaning of the preparation apparatus.

3.3 Measurements of total alkalinity on Certified Reference Materials

Appendix Tables 2A-2M present all of the measurements of ALK by potentiometric titration on Certified Reference Materials (CRM's) prepared in the laboratory of Dr. Andrew Dickson at SIO.

The measurements, in most cases, were made on the same bottles of CRM's measured for DIC and reported in Table 1. Although the CRM's have been titrated at sea as reference materials for quality control of shipboard ALK measurements, there is currently no certification of ALK for the CRM's.

ALK results were unstable for the biologically contaminated batches, beginning with CRM Batch 4. Typically, the ALK drifted downward with time as the DIC drifted upward. Very poor least squares fits to the titration data were also observed, as if proton donors, such as organic acids, were produced in the water by biological reactions. Stable ALK results for natural sea water batches were not obtained until CRM Batch 13. Several measurements made in 1993 on CRM Batch 13 are not listed in Appendix Table 2M. Complete results for CRM Batch 13 will be presented in the next report.

3.4 *Measurements of total dissolved inorganic carbon in replicate sea water samples*

Appendix Tables 3A-3E present all of the measurements of DIC by vacuum extraction/manometry on replicate sea water samples collected on the five expedition legs of 1991. Flags indicate measurements omitted from further consideration for experimental reasons. DIC results for bottle pairs collected from individual Niskin bottles are averaged and compared with shipboard DIC results. The shipboard DIC results are considered final (as reported to the Carbon Dioxide Information and Analysis Center) except for possible data adjustments to the *Meteor* Leg 18 expedition by the group at Brookhaven National Laboratory. The shipboard data are listed as reported by the shipboard analysis groups, to 0.1 $\mu\text{mol/kg}$ for the three TUNES legs and to 0.01 $\mu\text{mol/kg}$ for the two *Meteor* legs. Inference should not be made regarding the precision of the shipboard data from the number of figures listed. Dr. Takahashi at Lamont Doherty Earth Observatory (LDEO) estimates that for TUNES Leg 2, the overall precision of the shipboard DIC data is $\pm 2 \mu\text{mol/kg}$ (one sigma for a single measurement). He has kindly allowed the LDEO data to be listed to one more significant figure for comparison purposes.

3.5 *Measurements of total alkalinity in replicate sea water samples*

Appendix Tables 4A-4E present all of the measurements of ALK by potentiometric titration on replicate sea water samples collected on the five expedition legs of 1991. Flags are indicated for measurements omitted from further consideration for experimental reasons. ALK results for bottle pairs collected from individual Niskin bottles are averaged and compared with shipboard ALK results when available. The shipboard ALK results listed for TUNES Leg 1, are considered to be final (as reported to the Carbon Dioxide Information and Analysis Center by Dr. C. Goyet and co-workers at Woods Hole Oceanographic Institution). The shipboard ALK results for TUNES Leg 3 are not final, pending a report by Dr. C. D. Keeling and co-workers at SIO. Shipboard data for both legs are listed as reported to 0.01 $\mu\text{mol/kg}$ of hydrogen ion equivalent (approximately two decimal figures beyond the accuracy of the measurements).

3.6 *Measurements of salinity in replicate sea water samples*

Appendix Tables 5A-5E present all of the measurements of salinity on replicate sea water samples collected on the expedition legs of 1991. These measurements were made by scientists of the Oceanographic Data Facility at SIO on subsamples of water from the same bottles analyzed for DIC and ALK. Measurements were made on an

inductive salinometer calibrated with standard sea water. Salinity results for bottle pairs collected from individual Niskin bottles are averaged and compared with preliminary shipboard salinity results as reported by the shipboard samplers. These preliminary shipboard salinities are, in some instances, obtained from the conductivity-temperature-depth profiler and in other instances from discrete shipboard salinometers. The shore based laboratory data will eventually be compared to the final shipboard salinometer results when they are released by the WOCE/HP. Shore based salinity data are lacking for the *Meteor* Leg 18 samples (in Table 5E, only the shipboard analyses are presented). Table 5E is included to identify preliminary salinities used in the determination of ALK for those samples.

4. Shipboard and shore based results

The performance of the replicate sampling program is appraised by estimating the precision of an SIO laboratory result, the average difference, and precision of the difference between the laboratory result and the shipboard result. Since samples are always collected in duplicate, the overall agreement of the pairs of measurements provides an estimate of the laboratory and sampling precisions. The overall average difference between the average SIO laboratory results and the shipboard results, for each cruise, is an estimate of the systematic difference between shipboard and shore based analyses. The variation in this difference provides an independent estimate of the combination of the shipboard and shore based precisions.

Bottle pair agreement. A replicate sample standard deviation (s) is calculated from the set of analyses on duplicate samples. The general equation for calculating the variance of a series of observations, divided into subgroups, is the following [Laitinen, 1969, p. 548]:

$$s^2 = \frac{1}{N-k} \sum_k \sum_i (x_i - \bar{x}_i)^2 \quad (1)$$

where there are N observations, k subgroups and $x_i - \bar{x}_i$ is the deviation of each observation from the average of its subgroup. For a series of *duplicate* observations, this equation reduces to:

$$s^2 = \frac{\sum \Delta_i^2}{2n} \quad (2)$$

where Δ_i (delta) is an individual duplicate observational *difference*, n is the total number of pairs of observations, and s is the sample standard deviation of an individual observation.

Comparison of shipboard and shore based measurements. The overall bias between shore based and shipboard measurements of DIC for an individual expedition leg is estimated by calculating the average difference between the shipboard results and the shore based results. The precision of an individual difference is estimated by calculating the sample standard deviation of the set of ship minus shore differences for a particular cruise. This is represented by:

$$s^2 = \frac{\sum d_i^2}{n-1} \quad (3)$$

where d_i is an individual deviation from the average difference for a cruise, n is the total number of ship minus shore comparisons, and s in this case is the sample standard deviation of an individual difference between shipboard and shore based measurements. In the following discussion, this s is expressed as a $\pm$, following a calculated average difference. A *negative* difference means that the shipboard data is *lower* than the shore based.

Average DIC results: Tables 2 and 3. To calculate meaningful overall averages and statistical quantities for the individual cruise legs, some data are omitted. First, all data with specific experimental reasons for error are omitted. These are flagged in Appendix Tables 3a to 3e. Secondly, the "three sigma" criterion is used to omit possible outliers. For data described by a normal error curve, this criterion is the 99.7% confidence level. At SIO, the overall sample standard deviation s is calculated and bottle pair differences with delta's greater than $3s$ are omitted. The s is then recalculated.

Details of the calculations are discussed for each of the five expedition legs and presented in Tables 2 and 3 and Figures 2-8. Averages and statistics are first calculated for all available data from each leg. Additionally, for the TUNES legs, results are calculated and discussed for the following subsets of the data: 1. near surface (0-10 m) and deep (approx. 3000 m) data (this subset represents the replicate sampling plan adopted after 1991), and 2. profile data (this subset represents the originally proposed replicate sampling plan for 1991). Separate calculations are made for each station where replicate samples were collected from 12 depths.

4.1 TUNES Leg 1

All data. When all 50 unflagged bottle pair data sets are used in calculating the sample standard deviation (s , Equation 2) of an individual replicate DIC value, a result of $1.9 \mu\text{mol/kg}$ is calculated. If three pairs with delta's greater than three times the sample standard deviation (s) are omitted, then the resultant s is reduced to $1.34 \mu\text{mol/kg}$. Table 2 presents the results with details of omitted data.

In Table 3, the comparison between the shipboard and shore based replicate results indicates a high sample standard deviation as calculated by Equation 3 and a significant systematic bias with shipboard values lower by $3\text{-}5 \mu\text{mol/kg}$. The most reliable and best result is obtained by considering only unflagged comparisons with good replicate deltas (i.e., those not omitted in Table 2 for being greater than $3s$), and also by omitting one difference of -30.6 , more than $3s$ from the average. The systematic bias then is $-3.4 \pm 4.0 \mu\text{mol/kg}$ for 40 comparisons.

Table 2. Replicate Sample Statistics (Shore Based DIC Results)

Expedition	All Unflagged Pairs		Omitting Δ 's > 3s	
	s ($\mu\text{mol/kg}$)	No. of Pairs	s ($\mu\text{mol/kg}$)	No. of Pairs*
TUNES Leg 1	1.90	50	1.34	47(1)
TUNES Leg 2	1.43	11	-	-
TUNES Leg 3	1.25	74	1.01	71(2)
Meteor Leg 15	2.45	5	-	-
Meteor Leg 18	1.12	5	-	-

* Notes

"s" is the sample standard deviation of an individual replicate sample DIC, as calculated with Equation 2 for a single leg. "No. of Pairs" is the number of replicate pair data in the calculation of "s". " Δ " is the absolute difference between the DIC's of each sample of a bottle pair.

1. TUNES Leg 1: Three unflagged pairs with Δ 's > 3s are omitted (7.04, 8.11, 8.64 $\mu\text{mol/kg}$).
2. TUNES Leg 3: Three unflagged pairs with Δ 's > 3s are omitted (4.66, 4.89, 6.35 $\mu\text{mol/kg}$).

Table 3. DIC Comparisons (Shipboard Minus Shore Based Results)

Expedition	Shipboard Anal. Group	All Unflagged Comparisons			Omitting Singlets and Replicates > 3s			Omitting Diff's > 3s		
		Av. Diff. $\mu\text{mol/kg}$	s $\mu\text{mol/kg}$	No. of Comp.	Av. Diff. $\mu\text{mol/kg}$	s $\mu\text{mol/kg}$	No. of Comp.*	Av. Diff. $\mu\text{mol/kg}$	s $\mu\text{mol/kg}$	No. of Comp.*
TUNES Leg 1	WHOI	-4.87	6.33	47	-4.07	5.80	41(1)	-3.41	4.00	40(2)
TUNES Leg 2	LDEO	-2.85	2.88	12	-3.47	1.97	11(3)	-	-	-
TUNES Leg 3	WHOI	-2.86	4.02	95	-2.36	2.90	68(4)	-2.08	2.41	66(5)
Meteor Leg 15	BNL	-3.16	5.68	7	-	-	-	-1.78	4.76	6(6)
Meteor Leg 18	BNL	-3.46	3.41	7	-	-	-	-2.32	1.74	6(7)

* Notes

"Av. Diff." is the average shipboard minus shore based DIC for a single leg. "s" is the sample standard deviation of an individual comparison difference. "No. of Comp." is the number of comparisons averaged.

1. Tunes Leg 1 omissions: 5 comparisons with "singlet" replicate samples (including one with flagged pair) and another with replicate Δ (8.64) greater than 3s (comparison = -6.12)
2. TUNES Leg 1 omissions: one additional comparison with difference greater than 3s (-30.6)
3. TUNES Leg 2 omissions: one comparison with "singlet" replicate sample
4. TUNES Leg 3 omissions: 24 comparisons with "singlet" replicate samples and 3 with replicate Δ 's (4.89, 4.66, 6.35) greater than 3s (comparisons: +2.86, -6.71, -2.69)
5. TUNES Leg 3 omissions: 2 additional comparisons with differences greater than 3s (-12.12, -11.51)
6. Meteor Leg 15 omissions: one comparison with largest difference (-11.46); 2 "singlets" included
7. Meteor Leg 18 omissions: one comparison with difference greater than 3s (-10.31); 2 "singlets" included

Surface and deep data. Figure 2 displays, for TUNES Leg 1, the performance of the replicate sampling program for a subset of all data including only near surface (0-10 m) and deep (approx. 3000 m) data. The same data omissions are made as above and detailed in Table 3. Two data points with replicate sample singlets are omitted, as well as one with a ship minus shore difference of $-30.6 \mu\text{mol/kg}$, and one with a replicate delta greater than $4.0 \mu\text{mol/kg}$.

For the 17 comparisons, the replicate s is $0.9 \mu\text{mol/kg}$, similar to the s calculated for the entire data set. However, the average ship minus shore difference of $-1.4 \pm 3.2 \mu\text{mol/kg}$ is considerably less negative than that calculated for the entire data set. Figure 2 illustrates that the near surface data is in better agreement than the deep data. As 12 of the 17 comparisons are between surface data values, their better agreement weighs the subset such that there is lack of agreement with the entire data set.

Figure 2 illustrates better performance of the replicate sampling program at the onset of TUNES Leg 1, with more scatter of the data evident towards the end of the leg.

Profile data. Figure 3 displays three sets of profile differences from TUNES Leg 1. For Station 17, if three data points with ship minus shore differences greater than $3s$ are omitted as in Table 3 (next to last column), the average ship minus shore difference, for the remaining five comparisons (Fig. 3), is $-4.4 \pm 3.9 \mu\text{mol/kg}$. Similarly for Station 26, with one singlet omitted, the average ship minus shore difference for the remaining 11 depths is $-3.5 \pm 3.4 \mu\text{mol/kg}$. For Station 53, the difference for all eleven possible comparisons with no omissions is $-4.4 \pm 3.7 \mu\text{mol/kg}$. The average ship minus shore result for the three profiles is essentially the same as that calculated above for the entire data set. Figure 3 also indicates that the ship minus shore difference is smaller for surface data and larger (i.e., shipboard measurements relatively lower) for deeper samples.

4.2 TUNES Leg 2

All data. For this small data set, a replicate s of $1.43 \mu\text{mol/kg}$ for eleven unflagged pairs, is calculated, with no delta's greater than $3s$.

The average ship minus shore difference is $-3.5 \pm 2.0 \mu\text{mol/kg}$ for eleven comparisons, omitting comparisons of singlet replicate samples.

Figure 2. TUNES Leg 1: WHOI shipboard DIC minus shore based DIC versus date for surface and deep samples. Open circles represent shipboard minus average shore based DIC for near surface samples. Shaded triangles represent shipboard minus average shore based DIC for deep samples. Vertical bracketed lines represent replicate pair deltas. Arrows indicate dates when replicate samples were collected.

Figure 3. TUNES Leg 1: WHOI shipboard DIC minus shore based DIC versus depth for Stations 17, 26, and 53. Open squares indicate shipboard minus average shore based DIC. Horizontal bracketed lines represent replicate pair deltas.

Surface/deep data. Only two surface water and two deep water comparisons exist for TUNES Leg 2. This represents too few data points for meaningful comparative analysis.

Profile data. Figure 4 displays the one set of profile differences from TUNES Leg 2. There are eight comparisons from Niskins at 300 m and deeper. After omitting the one shallowest comparison (a replicate singlet), the remaining seven are characterized by an average difference of $-4.3 \pm 1.6 \mu\text{mol/kg}$. The consistency of the four deeper comparisons, all with excellent bottle pair agreement, is striking.

4.3 TUNES Leg 3

All data. The replicate sample standard deviation for this large data set of 71 unflagged pairs is $1.0 \mu\text{mol/kg}$, after omitting the three replicate pairs with delta's greater than $3s$ (Table 2).

Substantial reduction in the calculated s of the ship minus shore comparison is made (Table 3) by omitting 24 comparisons of singlet replicate samples, plus five more that are greater than $3s$ for either the replicate pairs or the comparison difference. For the 66 remaining comparisons, the average ship minus shore difference is $-2.1 \pm 2.4 \mu\text{mol/kg}$.

Surface and deep data. Figure 5 displays the ship minus shore differences for all available surface and deep data from TUNES Leg 3. After omission of ten replicate singlet data points and two by the $3s$ criterion as shown in Table 2, the replicate s for eighteen bottle pairs is $1.1 \mu\text{mol/kg}$. Two additional comparative differences are omitted in the calculation of the average difference as they are greater than $3s$ of the whole data set (Table 3). The remaining 16 comparisons (ten surface, six deep) are characterized by an average difference of $-1.8 \pm 2.3 \mu\text{mol/kg}$. This result is in close approximation to the result for the entire data set (Table 3). Figure 5 illustrates an improvement in performance during the latter half of this leg. The plotted data in this figure indicates some surface relative to deep bias. Surface data are characterized by better agreement between the shipboard and shore based data.

Profile data. Figures 6, 7, and 8 are difference plots for the seven profile data sets from TUNES Leg 3. The average difference calculated for each station is sensitive to inclusion of replicate singlet comparisons. Details of the calculations are noted in the following table (omitted data are presented in Table 3).

Figure 4. TUNES Leg 2: LDEO shipboard DIC minus shore based DIC versus depth for Station 180. Open squares represent shipboard minus average shore based DIC. Horizontal bracketed lines indicate replicate pair deltas.

Figure 5. TUNES Leg 3: WHOI shipboard DIC minus shore based DIC versus date for surface and deep samples. Open circles represent shipboard minus average shore based DIC for near surface samples. Shaded triangles represent shipboard minus average shore based DIC for deep samples. Vertical bracketed lines represent replicate pair deltas. Arrows indicate dates when replicate samples were collected.

Figure 6: TUNES Leg 3: WHOI shipboard DIC minus shore based DIC versus depth for Stations 226, 238, and 246. Open squares represent shipboard minus average shore based DIC. Horizontal bracketed lines represent replicate pair deltas.

Figure 7. TUNES Leg 3: WHOI shipboard DIC minus shore based DIC versus depth for Stations 274, 290, and 302. Open squares represent shipboard minus average shore based DIC. Horizontal bracketed lines represent replicate pair deltas.

Figure 8. TUNES Leg 3: WHOI shipboard DIC minus shore based DIC versus depth for Station 314. Open squares represent shipboard minus average shore based DIC. Horizontal bracketed lines represent replicate pair deltas.

Station	Average Ship-Shore Difference ($\mu\text{mol/kg}$)	s ($\mu\text{mol/kg}$)	No. of Comparisons	Notes
226	-2.0	2.9	11	one bad comparison omitted four singlets included
238 (a)	-2.8	3.1	10	one bad singlet omitted
(b)	+1.4	2.0	5	five more singlets omitted
246 (a)	-5.3	1.3	10	one bad singlet omitted
(b)	-5.7	1.0	7	remaining two singlets and one bad replicate pair omitted
274 (a)	-1.6	2.4	9	two singlets included
(b)	-2.1	2.5	7	two singlets omitted
290	-0.8	1.6	12	one singlet included
302	-2.5	1.5	10	two singlets included
314	-2.4	0.7	11	one singlet included

Variation in performance of the replicate sampling program, from station to station, is evident. For five of the seven stations, the average difference is -2.0 to -3.0 $\mu\text{mol/kg}$. The precision improves toward the end of this leg. The shipboard data for Station 246 are much lower (less than -5.0 $\mu\text{mol/kg}$), yet the ship minus shore difference has a very low scatter. The data for Station 290 also have a low scatter but the average difference of the shipboard data with respect to the replicate shore data is -0.8 $\mu\text{mol/kg}$. As evidence is lacking for variation in the performance of the replicate sample data, these station to station differences must therefore represent differences in the performance of the shipboard SOMMA analysis system, perhaps attributed to daily calibration differences.

4.4 Meteor Leg 15

In this small data set, three of the five replicate pair delta's are greater than 4.00 $\mu\text{mol/kg}$. The calculated s is over 2.0 $\mu\text{mol/kg}$, with no omissions.

Scrutiny of the ship minus shore differences is not meaningful for such a small data set. If the two comparisons with replicate sample singlets are included and one ship minus shore difference of -11.46 is omitted, (although less than $3s$), an average difference of $-1.8 \pm 4.8 \mu\text{mol/kg}$ is obtained for six comparisons. There are insufficient data to allow separate considerations of surface/deep and profile data from this leg.

4.5 Meteor Leg 18

In this small data set of 5 replicate pairs, the calculated s is similar to that of the larger data sets, at $1.1 \mu\text{mol/kg}$. As for the *Meteor* 15 data set, two comparisons, with replicate sample singlets, are included and one large comparison difference, -10.31 , (about $3s$) is omitted to obtain an average difference of $-2.3 \pm 1.7 \mu\text{mol/kg}$ for six comparisons. There are insufficient data to allow separate considerations of surface/deep and profile data for this leg.

5. Conclusions

The replicate sampling program for the 1991 expedition legs was a mixed success. There were many unsatisfactory samples collected on which shore based analyses could not be done. Problems in the laboratory resulted in additional bad results that have to be omitted from statistical analyses and comparisons of the data. Most severely affected was TUNES Leg 2, where of 220 collected samples only 23 could be successfully analyzed. The smaller sample collections on the two *Meteor* cruises were also unsatisfactory, with only 5 good replicate pairs per leg obtained.

The replicate sampling programs on TUNES Legs 1 and 3 were more successful than on the other legs. After possibly outlying data are omitted, substantial data sets remain with replicate DIC sample precisions of 1.0 to $1.3 \mu\text{mol/kg}$. The two cruises have substantially different results for the comparison between ship and shore results, even though the shipboard DIC analyses were carried out by the same shipboard CO_2 group with the same instrument. On Leg 1, the s of the ship minus shore difference, $4.0 \mu\text{mol/kg}$, is higher than expected from the stated precisions of shore based and shipboard data, $1.3 \mu\text{mol/kg}$ and $2 \mu\text{mol/kg}$, respectively. On Leg 3 the s of the ship minus shore difference, $2.4 \mu\text{mol/kg}$, approaches what is expected. Viewing all three TUNES legs, the shipboard DIC data were on average 2.0 to $3.5 \mu\text{mol/kg}$ lower than the shore based data.

The sets of profile data comparisons shown for the TUNES legs (Figs. 3, 5, 6, 7, and 8) illustrate that collections of a number of samples through the water column at individual stations provides information on the station to station performance of the shipboard analyses. The surface and deep sample strategy now adopted for replicate sampling may not define the station to station performance clearly. For TUNES Leg 1 an overall bias in the results between near surface versus deeper samples is shown more clearly on the profile data. For TUNES Leg 3, data from the seven profile stations clearly show station to station differences in the shipboard analysis results.

These results indicate that for a given station (i.e., on a given analysis day at sea) the SOMMA can reach a precision of $1.5 \mu\text{mol/kg}$ or better. Averaged surface and deep data from the leg would indicate a precision of more than $2 \mu\text{mol/kg}$.

It should be noted that the results of comparison of the shipboard and shore based DIC results are an improvement over previous efforts during the GEOSECS and Transect Tracers studies. For a limited set of replicate samples from the GEOSECS Indian Ocean Expedition in 1979-1980, the average difference between shipboard DIC by potentiometric titration and shore based DIC by vacuum extraction manometry was determined to be $17 \pm 4.2 \mu\text{mol/kg}$ (reported at 1980 fall AGU meeting). For the Transient Tracers North Atlantic Study in 1981, improvements in the titration system had been made and a difference of $-4.0 \pm 2.9 \mu\text{mol/kg}$ was found for deep water comparisons [Brewer et al., 1986]. A considerably greater difference of $-7.2 \pm 5.9 \mu\text{mol/kg}$ was found for comparisons of upper water column data (surface to 1000m). The recent data strongly support that the coulometric method for shipboard DIC is a substantial improvement over the potentiometric titration method used formerly.

The shore replicate sampling program has continued beyond 1991 with changes in sampling strategy discussed above and with general improvement in the sample collections. The number of WOCE cruises with shipboard DIC analyses carried out by U.S. analytical groups has increased and replicate sample collections have been obtained from all of them. In summary, the results of the first year of the replicate sampling program demonstrate that this program provided valuable information on the performance of the shipboard DIC measurements and additionally for a better understanding of the inorganic carbon system in the central Pacific Ocean.

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Appendix Table 1. Summaries of Total Dissolved Inorganic Carbon Data for Certified Reference Materials

Tables 1A to 1L summarize DIC measurements on water from bottles of Certified Reference Materials (CRM's) prepared in the laboratory of Dr. Andrew Dickson of SIO. These measurements constitute the certification of the 12 batches of CRM's, numbered Batch 1 to Batch 13 (DIC measurements were not made on Batch 9). Not all of these batches were used as CRM's for shipboard DIC measurements. Natural sea water Batches 4 and 5 proved to be contaminated biologically. During solution of the contamination problem, Batches 6, 7 and later 11 were made of "artificial sea water", mixtures of sodium bicarbonate in a sodium chloride solution matrix. With Batch 10, uncontaminated batches of natural sea water stable for DIC were again produced.

Comments on each column in the table follow:

ANAL DATE	The date of manometric analysis of the CO ₂ gas extraction.
ANAL SYST	The manometric analysis system used to measure the CO ₂ gas extraction: M, the mercury manometer; and S, the Ruska XR38 quartz spiral manometric system. A number of samples were analyzed on both systems, first on the mercury and then on the quartz spiral. Beginning with Batch 11, CRM's were measured only on the mercury system.
SAMPLE BOTTLE	The number refers to the bottle number assigned by the Dickson laboratory: it corresponds to the order of filling of that bottle in its batch. The "P" and the following letter are codes for SIO laboratory use.
RUN	This refers to multiple manometric analyses of the same gas extraction. There are none in this data set. On the page with CRM Batch 2, bottle 143PB has two runs labelled 001B and 001A. These are "subruns", where the sample was measured twice but not transferred out of the mercury manometer between measurements.
FLAG	Very bad results are flagged with "EX" and omitted from consideration in calculation of averages, etc.
INDIV	The individual DIC result for each bottle.
AV(M)	The average DIC of all unflagged mercury manometric measurements.
STDEV(M)	The sample standard deviation calculated from the mercury manometric results, along with the number of mercury manometric results averaged.
AV(S)	The average DIC of all unflagged quartz spiral manometric measurements.
STDEV(S)	The sample standard deviation calculated from the quartz spiral manometric results, along with the number of quartz spiral manometric results averaged.

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 1 (Natural Sea Water)

TABLE 1A
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN	FLAG	INDIV	AV(M)	DIC(uM/kg) STDEV(M)	AV(S)	STDEV(S)
900202	S	31PA	001		2021.20				
900202	S	41PA	001		2018.65				
900202	S	73PA	001		2019.83				
900202	S	78PA	001		2019.84				
900604	S	39PA	001		2021.67				
900604	S	40PA	001		2021.03				
900604	S	75PA	001		2019.62				
900604	S	81PA	001		2020.50				
900906	S	38PA	001		2019.88				
900906	S	34PA	001		2020.03				
900906	S	74PA	001		2019.29				
901121	S	32PA	001		2020.31				
901121	S	82PA	001	EX	2015.84			2020.15	0.85(of 12)

ANAL SYST:
 S = QUARTZ SPIRAL MANOMETER

FLAGS:
 EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 2 (Natural Sea Water)

TABLE 1B
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	DIC (uM/kg)		AV (S)	STDEV (S)
					AV (M)	STDEV (M)		
901102	M	282PB	001	1977.67				
901102	M	21PB	001	1977.98				
901102	M	74PB	001	1977.29				
901107	S	282PB	001	1976.49				
901107	S	21PB	001	1977.71				
901107	S	74PB	001	1976.62				
910118	M	264PB	001	1978.60				
910118	M	143PB	001B	1979.99				
910118	M	143PB	001A	1978.96				
910123	S	264PB	001	1978.01				
910123	S	143PB	001	1979.28				
910131	M	125PB	001	1979.14				
910131	S	125PB	001	1979.43				
910201	M	22PB	001	1979.33				
910201	M	25PB	001	EX 2001.79				
910201	M	84PB	001	1979.54				
910201	M	73PB	001	1979.95				
910215	S	22PB	001	1978.18				
910215	S	25PB	001	EX 2001.36				
910215	S	84PB	001	1978.93				
910313	M	9PB	001	1980.07				
910314	M	152PB	001	1979.95				
910314	S	152PB	001	1979.90	1979.00	0.96(of 11)	1978.28	1.21(of 9)

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER
 S = QUARTZ SPIRAL MANOMETER

FLAGS:

EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 3 (Natural Sea Water)

TABLE 1C
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV (M)	DIC (uM/kg) STDEV (M)	AV (S)	STDEV (S)
910115	M	73PC	001	2049.41				
910115	M	158PC	001	2049.22				
910116	M	273PC	001	2049.28				
910307	M	34PC	001	2052.66				
910308	M	150PC	001	2054.15				
910308	M	166PC	001	2054.03				
910314	S	150PC	001	2054.09				
910314	S	166PC	001	2053.67				
910314	S	34PC	001	2053.11	2051.46	2.42 (of 6)	2053.62	0.49 (of 3)

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

S = QUARTZ SPIRAL MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 4 (Natural Sea Water)

TABLE 1D
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV (M)	DIC (uM/kg) STDEV (M)	AV (S)	STDEV (S)
910404	M	363PD	001	1994.20				
910404	S	363PD	001	1994.54				
910405	M	463PD	001	1994.56				
910405	M	467PD	001	1993.67				
910411	S	463PD	001	1993.65				
910411	S	467PD	001	1993.40				
910419	M	297PD	001	1998.33				
910419	M	481PD	001	1997.85				
910425	S	297PD	001	1996.79				
910502	M	4PD	001	2001.81				
910503	M	166PD	001	1996.82	1996.75	2.88(of 7)	1994.60	1.53(of 4)

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

S = QUARTZ SPIRAL MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material Batch 5 (Natural Sea Water)

TABLE 1E
SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV(M)	DIC (uM/kg) STDEV(M)	AV(S)	STDEV(S)
910510	M	7PE	001	1985.62				
910511	M	9PE	001	1984.74				
910517	M	5PE	001	1994.46				
910517	M	10PE	001	1994.13	1989.74	5.28 (of 4)		

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 6 (Bicarbonate/NaCl solution)

TABLE 1F
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN	FLAG	INDIV	AV(M)	DIC(μ M/kg) STDEV(M)	AV(S)	STDEV(S)
910605	M	403PF	001			2303.99			
910605	M	58PF	001			2304.52			
910628	M	116PF	001			2305.82			
910702	S	206PF	001			2304.41			
910702	S	116PF	001			2303.95			
910709	M	8PF	001			2307.99			
910709	M	349PF	001			2304.44			
910719	S	8PF	001	EX		2311.19			
910719	S	349PF	001			2301.93			
910803	M	97PF	001			2304.53			
910803	M	184PF	001			2303.53			
910906	S	220PF	001			2305.26			
910906	S	39PF	001			2305.02			
911010	M	121PF	001			2304.67			
911010	M	350PF	001			2302.25			
911010	S	121PF	001			2303.71			
911010	S	350PF	001			2303.45	2304.64 1.58(of9)	2303.96	1.11(of 7)

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER
 S = QUARTZ SPIRAL MANOMETER

FLAGS:

EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 7 (Bicarbonate/NaCl solution)

TABLE 1G
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV(M)	DIC(μ M/kg) STDEV(M)	AV(S)	STDEV(S)
910815	S	247PG	001		1925.07			
910815	S	73PG	001		1926.07			
910815	S	144PG	001	EX	1930.23			
910906	S	351PG	001		1925.62			
910906	S	202PG	001		1925.73			
910906	S	168PG	001		1927.00			
911010	S	8PG	001		1926.34			
911010	S	108PG	001		1927.75			
920123	M	82PG	001		1925.84			
920123	M	305PG	001		1925.92			
920212	S	305PG	001		1926.21			
920528	M	95PG	001		1927.80			
920528	M	352PG	001		1926.57			
920701	M	100PG	001		1926.85			
920701	M	317PG	001		1926.82	1926.85 0.72(of 6)	1926.19	0.84(of 8)

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

S = QUARTZ SPIRAL MANOMETER

FLAGS:

EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material Batch 8 (Natural Sea Water)

TABLE 1H
SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV(M)	DIC (uM/kg) STDEV(M)	AV(S)	STDEV(S)
910906	S	287PH	001	1920.37				
910906	S	227PH	001	1919.78				
910906	S	371PH	001	1920.01			1920.05	0.30(of 3)

ANAL SYST:
S = QUARTZ SPIRAL MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material Batch 10 (Natural Sea Water)

TABLE 1I
 SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV(M)	DIC (uM/kg) STDEV(M)	AV(S)	STDEV(S)
920108	M	18PJ	001	1960.08				
920110	M	505PJ	001	1960.70				
920110	S	18PJ	001	1960.06				
920110	S	505PJ	001	1960.85				
920114	M	509PJ	001	1960.57				
920317	M	171PJ	001	1960.97				
920317	M	464PJ	001	1961.02				
920318	S	171PJ	001	1961.45				
920318	S	464PJ	001	1961.65				
920603	M	60PJ	001	1960.11				
920603	M	538PJ	001	1960.84	1960.61	0.38(of 7)	1961.03	0.72(of 4)

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

S = QUARTZ SPIRAL MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material Batch 11 (Bicarbonate/NaCl solution)

TABLE 1J

SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN	FLAG	INDIV	AV (M)	DIC (uM/kg) STDEV (M)	AV (S)	STDEV (S)
920123	M	175PK	001		2188.25				
920124	M	202PK	001		2189.09				
920124	M	397PK	001		2188.30				
920317	M	10PK	001		2189.56				
920317	M	379PK	001		2188.63				
920617	M	86PK	001		2188.89				
920617	M	326PK	001		2189.48	2188.87	0.52 (of 7)		

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material Batch 12 (Natural Sea Water)

TABLE 1K
SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	INDIV	AV(M)	DIC(μ M/kg) STDEV(M)	AV(S)	STDEV(S)
920317	M	11PL	001	1984.48				
920318	M	314PL	001	1983.91				
920318	M	583PL	001	1983.31				
920528	M	176PL	001	1983.80				
920528	M	194PL	001	1984.74				
920804	M	56PL	001	1985.55				
920804	M	557PL	001	1984.02	1984.26	0.73(of 7)		

ANAL SYST:
M = CONSTANT VOLUME MERCURY MANOMETER

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material Batch 13 (Natural Sea Water)

TABLE 1L
SUMMARY OF DISSOLVED INORGANIC CARBON DATA

ANAL DATE	ANAL SYST	SAMPLE BOTTLE	RUN FLAG	DIC(μ M/kg) INDIV	AV(M)	STDEV(M)	AV(S)	STDEV(S)
920701	M	3PM	001	2014.50				
920702	M	241PM	001	2015.39				
920702	M	489PM	001	2014.94				
920805	M	18PM	001	2014.78				
920805	M	466PM	001	2014.78	2014.87	0.34(of 5)		

ANAL SYST:

M = CONSTANT VOLUME MERCURY MANOMETER

Appendix Table 2. Summaries of Total Alkalinity Data
for Certified Reference Materials

Tables 2A to 2M summarize ALK measurements on water from bottles of Certified Reference Materials (CRM's) prepared in the laboratory of Dr. Andrew Dickson of SIO. These measurements in most cases were made on the same bottles measured for DIC and reported in Table 1, but DO NOT constitute a certification of the 13 batches of CRM's. Natural sea water Batches 4 and 5 proved to be contaminated biologically. During solution of the contamination problem, Batches 6, 7 and later 11 were made of "artificial sea water", mixtures of sodium bicarbonate in a sodium chloride solution matrix. With Batch 13, natural sea water batches stable for ALK were again produced. Several measurements made in 1993 on batch number 13 are not listed in Table 2M. Complete results for CRM batch 13 will be presented in the next report.

Comments on each column in the table follow:

ANAL DATE	The date of potentiometric titration of the CRM sample.
TITR SYST	The titration system used to measure the ALK: G, the gravimetric system, and V, the volumetric system.
SAMPLE BOTTLE	The number refers to the bottle number assigned by the Dickson laboratory: it corresponds to the order of filling of that bottle in its batch. The "P" and the following letter are codes for SIO laboratory use.
TRIAL	This number refers to multiple titrations on the same CRM bottle. In this table, all trials are given equal weight, meaning that all bottles of the batch are considered to contain the same water.
FLAG	Very bad results are flagged with "EX" and omitted from consideration in the calculation of averages.
INDIV	The individual ALK result for each titration trial.
AV(G)	The average ALK of all unflagged gravimetric titrator system measurements.
STDEV(G)	The sample standard deviation calculated from the gravimetric system results, along with the number of gravimetric trials averaged. No listing appears for batches 11 and 12 because only two gravimetric measurements were made.
AV(V)	The average ALK of all unflagged volumetric titrator system measurements.
STDEV(V)	The sample standard deviation calculated from the volumetric system results, along with the number of volumetric trials averaged. No listing appears for batch 13 because only two unflagged volumetric measurements were made.

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 1 (Natural Sea Water)

TABLE 2A
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
26FEB90	G	31PA	1			2296.11			
27FEB90	G	31PA	2			2298.23			
27FEB90	G	41PA	1			2295.30			
27FEB90	G	41PA	2			2297.00			
27FEB90	G	73PA	1			2299.20			
27FEB90	G	73PA	2			2299.66			
27FEB90	G	78PA	1			2299.95			
28FEB90	G	78PA	2			2298.79			
25MAY90	G	39PA	1			2300.59			
25MAY90	G	75PA	1			2301.45			
29MAY90	G	41PA	3			2292.26			
01JUN90	G	81PA	1			2298.95			
04JUN90	G	41PA	4			2296.58			
04JUN90	G	40PA	1			2300.04			
16JUL90	G	40PA	2	EX		2311.45			
06SEP90	G	38PA	1			2298.30			
07SEP90	G	34PA	1			2297.76			
07SEP90	G	74PA	1			2295.83			
03OCT90	G	73PA	3			2296.19			
03OCT90	G	73PA	4			2302.34			
03OCT90	G	78PA	3			2300.13			
04OCT90	G	78PA	4			2294.95			
29OCT90	G	34PA	3			2295.86			
30OCT90	G	34PA	4			2290.07			
14NOV90	G	38PA	3	EX		2305.84			
19NOV90	G	32PA	1			2297.69			
20NOV90	G	82PA	1			2305.84			
20NOV90	G	82PA	2			2297.67			
20NOV90	G	82PA	3			2298.78	2297.98 3.10(of 27)		

TITRATION SYSTEM:
 G = GRAVIMETRIC

FLAGS:
 EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 2 (Natural Sea Water)

TABLE 2B
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV (G)	ALK (uEQ/KG) STDEV (G)	AV (V)	STDEV (V)
14FEB90	G	22PB	3		2242.18				
19NOV90	G	282PB	1		2243.38				
20NOV90	G	21PB	1		2242.37				
21NOV90	G	74PB	1		2245.34				
21NOV90	G	74PB	2		2243.87				
16JAN91	V	143PB	1		2239.68				
17JAN91	V	264PB	1		2243.17				
17JAN91	V	151PB	1		2244.64				
17JAN91	V	250PB	1		2244.99				
30JAN91	V	30PB	1		2243.76				
30JAN91	V	164PB	1		2244.54				
01FEB91	V	25PB	1		2243.02				
01FEB91	V	84PB	1		2246.24				
01FEB91	V	72PB	1		2246.68				
05FEB91	G	73PB	1		2245.99				
07FEB91	V	125PB	1		2248.66				
07FEB91	G	125PB	2		2241.21				
07FEB91	G	125PB	3		2236.45				
07FEB91	V	125PB	4		2243.56				
07FEB91	V	22PB	1	EX	2263.26				
07FEB91	G	22PB	2		2243.23				
01MAR91	G	223PB	1		2244.35				
01MAR91	G	245PB	1		2244.86				
04MAR91	G	55PB	1		2244.45				
04MAR91	G	209PB	1		2244.65				
11MAR91	G	152PB	1		2243.72				
11MAR91	G	9PB	1		2242.59				
02APR91	G	192PB	1		2247.02				
02APR91	G	192PB	2		2246.59				
08MAY91	G	135PB	1		2243.37	2243.66	2.38(of 18)	2244.43	2.30(of 11)

TITRATION SYSTEM:

G = GRAVIMETRIC
 V = VOLUMETRIC

FLAGS:

EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 3 (Natural Sea Water)

TABLE 2C
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
15JAN91	V	73PC	1		2221.01				
15JAN91	V	73PC	2		2219.15				
15JAN91	V	158PC	1		2223.41				
15JAN91	V	158PC	2		2225.35				
16JAN91	V	273PC	1		2222.95				
16JAN91	V	273PC	2		2219.58				
07MAR91	G	150PC	1		2210.19				
07MAR91	G	34PC	1		2214.76				
07MAR91	G	34PC	2		2212.74				
08MAR91	G	150PC	2		2211.07				
08MAR91	G	166PC	1		2214.94				
08MAR91	G	166PC	2		2213.46	2212.86	1.93(of 6)	2221.91	2.41(of 6)

TITRATION SYSTEM:

G = GRAVIMETRIC

V = VOLUMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material, Batch 4 (Natural Sea Water)

TABLE 2D
SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
04APR91	G	363PD	1		2247.81				
05APR91	G	463PD	1		2245.96				
05APR91	G	467PD	1		2248.20				
22APR91	G	481PD	2		2235.29				
23APR91	G	297PD	1		2240.23				
02MAY91	G	4PD	1		2240.22				
03MAY91	G	4PD	2		2227.78				
03MAY91	G	166PD	1		2239.47	2240.62	6.89(of 8)		

TITRATION SYSTEM:
G = GRAVIMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material, Batch 5 (Natural Sea Water)

TABLE 2E
SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
09MAY91	G	7PE	1		2215.53				
09MAY91	G	9PE	1		2214.32				
10MAY91	G	9PE	2		2211.33				
17MAY91	G	5PE	1		2189.70				
17MAY91	G	10PE	1		2194.31	2205.04	12.10(of 5)		

TITRATION SYSTEM:
G = GRAVIMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 6 (Bicarbonate/NaCl solution)

TABLE 2F, PAGE 1
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
23MAY91	G	401PF	1		2379.37				
24MAY91	G	401PF	2		2378.96				
24MAY91	G	402PF	1		2379.19				
30MAY91	G	207PF	1		2376.41				
12JUN91	G	58PF	1		2376.84				
12JUN91	G	234PF	1		2379.10				
01JUL91	G	116PF	1		2382.07				
02JUL91	G	206PF	1		2376.67				
08JUL91	G	8PF	1		2380.17				
08JUL91	G	349PF	1		2383.14				
09JUL91	G	403PF	1		2383.87				
05AUG91	G	97PF	1		2382.28				
05AUG91	G	184PF	1		2381.98				
03SEP91	G	39PF	1		2380.94				
28OCT91	G	350PF	1		2375.43				
28OCT91	G	121PF	1		2381.45				
31OCT91	G	155PF	2		2385.09				
31OCT91	G	155PF	1		2383.31				
01NOV91	G	155PF	3		2377.60				
01NOV91	G	350PF	2		2379.59				
04NOV91	G	138PF	2		2381.67				
04NOV91	G	138PF	1		2379.80				
18NOV91	G	400PF	2		2384.21				
18NOV91	G	400PF	1		2380.17				
16DEC91	V	376PF	4		2382.07				
16DEC91	V	376PF	3		2384.98				
16DEC91	V	376PF	2		2383.19				
16DEC91	V	376PF	1		2385.08				
16DEC91	V	205PF	1	EX	2402.31				
16DEC91	V	205PF	4		2387.19				
16DEC91	V	205PF	3		2385.23				
16DEC91	V	205PF	2		2385.51				
17DEC91	V	291PF	3		2382.41				
17DEC91	V	291PF	2		2383.74				
17DEC91	V	291PF	1		2381.86				
17DEC91	V	307PF	3		2383.59				
17DEC91	V	307PF	2		2380.50				
17DEC91	V	307PF	1		2390.98				
26DEC91	V	351PF	4		2384.97				
26DEC91	V	351PF	3		2386.41				
26DEC91	V	351PF	2		2384.22				
26DEC91	V	351PF	1		2386.54				
07JAN92	V	333PF	4		2385.49				
07JAN92	V	333PF	3		2383.23				

TITRATION SYSTEM:
 G = GRAVIMETRIC
 V = VOLUMETRIC

FLAGS:
 EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 6 (Bicarbonate/NaCl solution)

TABLE 2F, PAGE 2
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
07JAN92	V	333PF	2		2382.51				
07JAN92	V	391PF	4		2376.32				
07JAN92	V	391PF	3		2386.97				
07JAN92	V	391PF	2		2395.21				
09JAN92	V	28PF	2		2387.05				
09JAN92	V	28PF	1		2384.94				
13JAN92	V	132PF	3		2385.34				
13JAN92	V	132PF	2		2378.72				
13JAN92	V	132PF	1		2383.47				
13JAN92	V	509PF	1	EX	2247.25				
17JAN92	V	505PF	1	EX	2248.63				
27FEB92	V	139PF	3		2381.47				
27FEB92	V	139PF	2		2381.73				
27FEB92	V	139PF	1		2379.82				
27FEB92	V	387PF	3		2384.29				
27FEB92	V	387PF	2		2383.16				
27FEB92	V	387PF	1		2381.09				
19MAR92	V	232PF	2	EX	2407.16				
19MAR92	V	232PF	1		2384.47				
25MAR92	V	328PF	1		2396.99				
26MAR92	V	189PF	4		2381.18				
26MAR92	V	189PF	3		2382.05				
26MAR92	V	189PF	2		2380.39				
26MAR92	V	189PF	1		2376.76				
31MAR92	V	226PF	4		2383.83				
31MAR92	V	226PF	3		2382.82				
31MAR92	V	226PF	2		2398.94				
31MAR92	V	226PF	1		2386.55				
07APR92	V	23PF	4		2383.83				
07APR92	V	23PF	3		2384.18				
07APR92	V	23PF	2		2382.29				
07APR92	V	23PF	1		2382.39	2380.39 2.63(of 24)	2384.29 4.27(of 48)		

TITRATION SYSTEM:

G = GRAVIMETRIC
 V = VOLUMETRIC

FLAGS:

EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 7 (Bicarbonate/NaCl solution)

TABLE 2G
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
13AUG91	G	247PG	1	1978.44				
13AUG91	G	73PG	1	1981.38				
13AUG91	G	144PG	2	1981.94				
13AUG91	G	144PG	1	1982.78				
03SEP91	G	351PG	1	1981.34				
04SEP91	G	202PG	2	1982.36				
04SEP91	G	168PG	1	1979.74				
09SEP91	G	168PG	2	1981.53				
23JAN92	V	82PG	1	1978.44				
23JAN92	V	305PG	1	1984.66				
08JUN92	V	95PG	1	1979.63				
08JUN92	V	352PG	1	1989.16				
09JUN92	V	352PG	2	1985.23				
06AUG92	G	100PG	1	1981.89				
07AUG92	G	317PG	1	1981.50	1981.29	1.28(of 10)	1983.42	4.39(of 5)

TITRATION SYSTEM:

G = GRAVIMETRIC

V = VOLUMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material, Batch 8 (Natural Sea Water)

TABLE 2H
SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL FLAG	INDIV	AV (G)	ALK (μ EQ/KG) STDEV (G)	AV (V)	STDEV (V)
03SEP91	G	371PH	1	2175.72				
04SEP91	G	227PH	1	2162.20				
05SEP91	G	287PH	1	2178.37	2172.10	8.67 (of 3)		

TITRATION SYSTEM:
G = GRAVIMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 9 (Natural Sea Water)

TABLE 2I
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
24SEP91	G	6PI	1	2223.39				
24SEP91	G	13PI	1	1858.72				
25SEP91	G	4PI	1	2224.25				
25SEP91	G	11PI	1	2218.11				
25SEP91	G	13PI	2	1861.82				
08OCT91	G	20PI	1	2210.48				
18OCT91	G	43PI	1	2135.46				
31OCT91	G	32PI	2	2205.19				
31OCT91	G	32PI	1	2235.96	2130.38	155.83(of 9)		

TITRATION SYSTEM:
 G = GRAVIMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 10 (Natural Sea Water)

TABLE 2J
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
20DEC91	V	380PJ	2		2258.57				
20DEC91	V	380PJ	4		2262.49				
13JAN92	V	509PJ	1		2258.98				
14JAN92	V	18PJ	1		2262.44				
17JAN92	V	505PJ	1		2261.09				
17JAN92	V	505PJ	2		2262.71				
17MAR92	V	464PJ	1		2267.51				
19MAR92	V	171PJ	1		2261.19				
26MAR92	V	464PJ	2		2242.14				
26MAR92	V	18PJ	2		2242.56				
31MAR92	V	171PJ	2		2257.26				
17JUN92	V	60PJ	1		2244.10				
17JUN92	V	538PJ	1		2247.12			2258.01	8.78(of 13)

TITRATION SYSTEM:
 V = VOLUMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
Certified Reference Material, Batch 11 (Bicarbonate/NaCl Solution)

TABLE 2K
SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL FLAG	INDIV	AV(G)	ALK(μ EQ/KG) STDEV(G)	AV(V)	STDEV(V)
23JAN92	V	175PK	1	2357.95				
23JAN92	V	202PK	1	2365.33				
23JAN92	V	397PK	1	2366.07				
19MAR92	V	10PK	1	2365.26				
19MAR92	V	379PK	1	2358.77				
26MAR92	V	379PK	2	2361.61				
31MAR92	V	10PK	2	2366.62				
07AUG92	G	86PK	1	2368.03				
10AUG92	G	326PK	1	2370.35	2369.19		2363.09	3.61(of 7)

TITRATION SYSTEM:

G = GRAVIMETRIC

V = VOLUMETRIC

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 12 (Natural Sea Water)

TABLE 2L
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(Q)	ALK (uEQ/KQ) STDEV(Q)	AV(V)	STDEV(V)
19MAR92	V	11PL	1		2225.40				
19MAR92	V	314PL	1		2210.42				
19MAR92	V	583PL	1	EX	2278.11				
23APR92	V	11PL	2	EX	2239.22				
23APR92	V	314PL	2		2227.46				
17JUN92	V	176PL	1		2207.25				
17JUN92	V	194PL	1		2210.44				
07AUG92	Q	56PL	1		2226.64				
10AUG92	Q	557PL	1		2226.31	2226.48		2216.19	9.46 (of 5)

TITRATION SYSTEM:

Q = GRAVIMETRIC
 V = VOLUMETRIC

FLAGS:

EX: Excluded from analysis

THE CARBON DIOXIDE PROJECT, SCRIPPS INSTITUTION OF OCEANOGRAPHY
 Certified Reference Material, Batch 13 (Natural Sea Water)

TABLE 2M
 SUMMARY OF ALKALINITY DATA

ANAL DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	INDIV	AV(Q)	ALK(μ EQ/KG) STDEV(Q)	AV(V)	STDEV(V)
10MAR92	V	1PM	1		2206.56				
12MAR92	V	600PM	3		2205.78				
12MAR92	V	600PM	4	EX	2163.61				
07AUG92	G	3PM	1		2200.01				
07AUG92	G	18PM	1	EX	2223.18				
10AUG92	G	3PM	2		2195.55				
10AUG92	G	241PM	1		2198.06				
10AUG92	G	466PM	1		2204.61				
11AUG92	G	489PM	1		2195.11	2198.67	3.86(of 5)	2206.17	

TITRATION SYSTEM:

G = GRAVIMETRIC

V = VOLUMETRIC

FLAGS:

EX: Excluded from analysis

**Appendix Table 3. Summaries of Total Dissolved Inorganic Carbon Data
for Replicate Sea Water Samples**

Tables 3a to 3e summarize the laboratory DIC measurements by vacuum extraction/manometry on replicate samples of sea water collected on the five expedition legs of 1991, presented in the following order:

Table 3a.	TUNES Leg 1	WOCE Line	P17C
Table 3b.	TUNES Leg 2	WOCE Lines	P17S,P16S
Table 3c.	TUNES Leg 3	WOCE Line	P16C
Table 3d.	Meteor 15	WOCE Line	A9
Table 3e.	Meteor 18	WOCE Line	A1E

Comments on each column in the table follow:

LEG to SAMPLE STN DATE	The identifying information for each Niskin bottle sampled at sea.
EXTRAC DATE	The date of extraction of CO ₂ gas from an aliquot of sea water taken from a given sample bottle is listed.
ANALYSIS DATE	The date of manometric analysis of the extracted CO ₂ gas sample is listed. Usually, the date is within one week of the date of extraction. In a few case the intervening time period is longer. See, for example, several stations on TUNES Leg 3, such as Station 238. In April 1992, the quartz spiral manometer was malfunctioning and the new instrument was still under development. Gas extractions were stored for 2 to 3 months sealed in glass tubes before manometric analysis.
MANO TYPE	The manometric system used to analyze the CO ₂ gas extraction is identified: M, the mercury manometer; S, the Ruska XR38 quartz spiral manometric system; E, the electronic manometric system using the Ruska DDR6000 quartz spiral pressure source and differential pressure transducer.
SAMPLE BOTTLE	The label number for the individual replicate sample bottle filled at sea is listed. The prefix "S" indicates a standard 500 ml Corning borosilicate glass bottle with a hollow stopper (individually lapped to the bottle joint with carborundum grit) equipped with an aluminum bale type fixture for holding the stopper in its sealed position. The prefix "R" indicates a 500 ml borosilicate glass bottle equipped with a standard taper (24/40 size) joint and solid stopper with a Rodawiss plastic knurled nut system for holding the stopper.
RUN	This number indicates whether more than one manometric measurement of a given gas sample was made on each manometer. See, for example, TUNES Leg 2, Station 180, where two measurements on the electronic (E) manometer were made during its initial period of use.

Appendix Table 3. Summaries of Total Dissolved Inorganic Carbon Data for Replicate Sea Water Samples (cont.)

FLAG	The flag code identifies runs that are rejected from further consideration due to identifiable experimental reasons. The flags used have the following meanings: F, evidence indicated that the sample had no mercuric chloride added (see text for further discussion); G, the greased bottle seal showed signs of a severe bottle leak (usually, such bottles were not analyzed); EX, a general flag for some other experimental rejection, such as a procedural extraction error or an equipment malfunction.
S.I.O. RUN	The DIC in micromoles per kilogram of sea water is listed for an individual manometric run of a CO ₂ gas extraction.
RUN DELTA	The run difference for two runs as discussed above, if both runs are unflagged.
BOTTLE DIC	The average bottle DIC for unflagged runs. In most cases (single runs), the S.I.O. RUN and the BOTTLE DIC are identical. In cases where gas extractions were analyzed on both the mercury manometer (first) and one of the other manometers, both DIC's are listed (see, for example, the data from TUNES Leg 1 on Table 3a from Station 74 on).
BOTTLE DELTA	The difference between two bottles collected from a single Niskin bottle is listed. As noted above for cases of measurement on two manometers, the differences for both manometers are listed. For further analysis and comparisons of data, the mercury manometer data are selected.
"NISKIN" AVG	Here is listed the average S.I.O. laboratory DIC result for water from a particular Niskin bottle sampled at sea. Again, as discussed above, the averages for both manometers are listed for those cases where gas samples were measured on two manometers.
{INSTITUTION} DIC	This column lists the shipboard DIC result from a SOMMA or other coulometric system. The institution abbreviations indicate the shipboard CO₂ analytical group operating on that expedition leg, as follows: WHOI, the group of Dr. Catherine Goyet, P.I., and Dr. Edward Peltzer of Woods Hole Oceanographic Institution; LDEO, the group of Drs. Taro Takahashi, P. I., and David Chipman of Lamont Doherty Earth Observatory; BNL, the group of Dr. Douglas Wallace, P.I., and Mr. Ken Johnson, of Brookhaven National Laboratory. No inference should be made from the listed data as to the imprecision of the data. Dr. Takahashi estimates the overall imprecision of the LDEO shipboard DIC data as +/- 2. umol/kg (one sigma for a single measurement). Here we choose to list data to one more place than is significant, and thank Dr. Takahashi for his indulgence.
{INSTITUTION} - S.I.O.	The difference between the shipboard DIC result and the laboratory replicate sample average is listed. Note again that for cases where gas samples are measured on two manometers, the differences for both manometers are listed.

**Appendix Table 3. Summaries of Total Dissolved Inorganic Carbon Data
for Replicate Sea Water Samples (cont.)**

NOTE: At the end of the Table 3 section for each leg is a note
Dilution Factor detailing the multiplicative dilution factor applied to account
for the addition of the HgCl_2 poison solution to the S.I.O.
replicate sample bottles. The nominally 500 ml bottles actually
hold about 585 ml. Thus for the addition of 0.1 ml of saturated
aqueous HgCl_2 , a dilution factor of 1.00017 is calculated. The
shipboard data listed in the last two columns have also been
appropriately corrected for dilution by each shipboard analysis
group.

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
TUNES Leg 1 1991 Pacific WOCE Line P17C

Table 3a, Page 1

SUMMARY OF DISSOLVED INORGANIC CARBON DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC (UMOL/KG SW)	BOTTLE "NISKIN" DELTA AVG	WHOI DIC	WHOI -S.I.O.
1	35-33N	1 1	1	03 JUN 91	20 AUG 91	22 AUG 91	S	S3750	001		1982.51		1982.51			
5	122-52W				21 AUG 91	22 AUG 91	S	S3751	001		1983.22		1983.22	+0.71	1982.86	
1	34-49N	1 1	1	04 JUN 91	21 AUG 91	22 AUG 91	S	S3772	001		1984.63		1984.63			
8	124-35W				22 AUG 91	22 AUG 91	S	S3773	001		1982.71		1982.71	-1.92	1983.67	
		1 3	66		21 AUG 91	22 AUG 91	S	S3770	001		2027.65		2027.65			
					21 AUG 91	22 AUG 91	S	S3771	001		2028.92		2028.92	+1.27	2028.29	
1	34-35N	1 29	2896	05 JUN 91	22 AUG 91	28 AUG 91	S	S3774	001		2377.63		2377.63		2377.63	
11	127-38W															
1	34-35N	1 1	2	07 JUN 91	22 AUG 91	28 AUG 91	S	S3781	001		1993.44		1993.44			
14	131-19W				23 AUG 91	28 AUG 91	S	S3782	001		1986.40		1986.40	-7.04	1989.92	
1	34-36N	2 1	1	08 JUN 91	09 SEP 91	12 SEP 91	S	S3806	001		1988.39		1988.39			
17	134-58W				10 SEP 91	12 SEP 91	S	S3807	001		1988.47		1988.47	+0.08	1988.43	1987.4 -1.03
		2 2	52		10 SEP 91	12 SEP 91	S	S3804	001		1982.28		1982.28			
					09 SEP 91	12 SEP 91	S	S3805	001		1984.65		1984.65	+2.37	1983.47	1982.5 -0.97
		2 4	98		09 SEP 91	12 SEP 91	S	S3802	001		1993.50		1993.50		1993.50	1975.9 -17.60
		2 8	201		29 AUG 91	29 AUG 91	S	S3800	001		2098.60		2098.60			
					29 AUG 91	29 AUG 91	S	S3801	001		2107.24		2107.24	+8.64	2102.92	2096.8 -6.12
		2 10	300		28 AUG 91	29 AUG 91	S	S3798	001		2179.95		2179.95			
					28 AUG 91	29 AUG 91	S	S3799	001		2180.55		2180.55	+0.60	2180.25	2177.6 -2.65
		2 12	401		26 AUG 91	29 AUG 91	S	S3796	001		2235.29		2235.29			
					26 AUG 91	29 AUG 91	S	S3797	001		2234.32		2234.32	-0.97	2234.81	2225.6 -9.21
		2 14	601		26 AUG 91	28 AUG 91	S	S3794	001		2309.78		2309.78			
					26 AUG 91	29 AUG 91	S	S3795	001		2311.76		2311.76	+1.98	2310.77	2302.8 -7.97
		2 17	899		26 AUG 91	28 AUG 91	S	S3792	001		2365.29		2365.29			
					26 AUG 91	28 AUG 91	S	S3793	001		2367.90		2367.90	+2.61	2366.59	2351.1 -15.49
		2 19	1200		23 AUG 91	28 AUG 91	S	S3790	001		2373.67		2373.67			
					23 AUG 91	28 AUG 91	S	S3791	001		2373.97		2373.97	+0.30	2373.82	
		2 21	1800		23 AUG 91	28 AUG 91	S	S3788	001		2377.93		2377.93			
					23 AUG 91	28 AUG 91	S	S3789	001		2386.04		2386.04	+8.11	2381.99	

MANOMETER TYPE:

S = QUARTZ SPIRAL MANOMETER DATUM

M = CONSTANT VOLUME MERCURY MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

G: Severe bottle leak

EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC (UMOL/KG SW)	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
1	33- 4N	1 1	1	09JUN91	20SEP91	20SEP91	S	S3810	001		2002.42		2002.42				
20	135-00W				20SEP91	20SEP91	S	S3811	001		2002.10		2002.10	-0.32	2002.26	2001.0	-1.26
		1 20	2798		17SEP91	20SEP91	S	S3808	001		2362.05		2362.05				
					19SEP91	20SEP91	S	S3809	001		2362.85		2362.85	+0.20	2362.75	2359.1	-3.65
1	31-32N	1 1	0	10JUN91	24SEP91	20SEP91	S	S3814	001		2007.87		2007.87				
23	135- 0W				24SEP91	20SEP91	S	S3815	001		2010.70		2010.70	+2.83	2009.29	2012.5	3.21
		1 20	3003		24SEP91	20SEP91	S	S3813	001		2356.61		2356.61		2356.61	2353.5	-3.11
1	30- 2N	2 1	1	11JUN91	19AUG91	22AUG91	S	R4478	001		2021.92		2021.92				
26	134-57W				19AUG91	22AUG91	S	R4479	001		2020.63		2020.63	-1.29	2021.28	2022.3	1.02
		2 2	64		09AUG91	12AUG91	S	R4476	001		2031.34		2031.34				
					09AUG91	12AUG91	S	R4477	001		2027.18		2027.18	-4.16	2029.26	2020.8	-8.46
		2 4	109		08AUG91	12AUG91	S	R4474	001		2032.43		2032.43				
					08AUG91	12AUG91	S	R4475	001		2030.79		2030.79	-1.64	2031.61	2021.7	-9.91
		2 7	206		06AUG91	07AUG91	S	R4472	001		2044.07		2044.07				
					08AUG91	12AUG91	S	R4473	001		2043.64		2043.64	-0.43	2043.85	2041.7	-2.15
		2 10	324		06AUG91	07AUG91	S	R4470	001		2099.91		2099.91				
					06AUG91	07AUG91	S	R4471	001		2099.87		2099.87	-0.04	2099.89	2099.3	-0.59
		2 11	400		05AUG91	07AUG91	S	R4468	001	EX	2166.40						
					05AUG91	07AUG91	S	R4469	001		2149.91		2149.91		2149.91	2146.1	-3.81
		2 13	606		05AUG91	07AUG91	S	R4466	001		2283.85		2283.85				
					05AUG91	07AUG91	S	R4467	001		2284.53		2284.53	+0.68	2284.19	2282.1	-2.09
		2 16	909		20SEP91	20SEP91	S	S3824	001		2354.87		2354.87				
					20SEP91	20SEP91	S	S3825	001		2354.57		2354.57	-0.30	2354.72	2351.5	-3.22
		2 18	1202		27SEP91	020CT91	S	S3822	001		2374.15		2374.15				
					27SEP91	020CT91	S	S3823	001		2370.18		2370.18	-3.97	2372.17	2365.6	-6.57
		2 20	1605		25SEP91	20SEP91	S	S3820	001		2372.06		2372.06				
					27SEP91	020CT91	S	S3821	001		2371.81		2371.81	-0.25	2371.94	2368.7	-3.24

MANOMETER TYPE:

S = QUARTZ SPIRAL MANOMETER DATUM

M = CONSTANT VOLUME MERCURY MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

G: Severe bottle leak

EX: Data excluded from analysis

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
TUNES Leg 1 1991 Pacific WOCE Line P17C

Table 3a, Page 3

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
1 26	30-2N 134-57W	2 22	2007	11JUN91	25SEP91	26SEP91	S	S3818	001		2366.87		2366.87				
								S3819	001		2372.19		2372.19	+5.32	2369.53	2366.7	-2.83
		2 27	3000		25SEP91	26SEP91	S	S3816	001		2356.27		2356.27				
								S3817	001		2356.34		2356.34	+0.07	2356.31	2355.6	-0.71
1 29	28-30N 135-00W	1 1	1	12JUN91	20AUG91	22AUG91	S	R4482	001		2021.52		2021.52				
								R4483	001		2022.63		2022.63	+1.11	2022.08	2020.5	-1.58
		1 31	2951		20AUG91	22AUG91	S	R4480	001		2382.18		2382.18				
								R4481	001		2378.02		2378.02	-4.16	2380.10	2349.5	-30.60
1 47	19-30N 135-00W	1 1	0	18JUN91	10SEP91	12SEP91	S	R4486	001		1979.78		1979.78				
								R4487	001		1979.01		1979.01	-0.77	1979.40	1976.7	-2.70
		1 27	3005		10SEP91	12SEP91	S	S3884	001		2350.86		2350.86				
								S3885	001		2351.54		2351.54	+0.68	2351.20	2342.6	-8.60
1 50	18-00N 135-00W	1 1	0	19JUN91	11SEP91	13SEP91	S	R4490	001		1950.81		1950.81				
								R4491	001		1951.11		1951.11	+0.30	1950.96	1947.8	-3.16
		1 27	2999		11SEP91	13SEP91	S	R4488	001		2368.76		2368.76		2368.76	2347.1	-21.66
1 53	16-30N 135-00W	1 1	0	20JUN91	020CT91	020CT91	S	S3894	001		1944.28		1944.28				
								S3895	001		1946.88		1946.88	+2.60	1945.58	1945.0	-0.58
		1 2	50		010CT91	020CT91	S	S3892	001		1944.71		1944.71				
								S3893	001		1943.80		1943.80	-0.91	1944.26	1943.7	-0.56
		1 4	112		30SEP91	020CT91	S	S3890	001		2018.80		2018.80				
								S3891	001		2018.45		2018.45	-0.35	2018.63	2017.3	-1.33
		1 8	188		30SEP91	020CT91	S	S3888	001		2159.93		2159.93				
								S3889	001		2160.18		2160.18	+0.25	2160.05	2159.1	-0.95
		1 10	300		26SEP91	020CT91	S	S3886	001		2261.14		2261.14				
								S3887	001		2260.40		2260.40	-0.74	2260.77	2259.3	-1.47
		1 12	402		19SEP91	20SEP91	S	R4504	001		2287.13		2287.13				
								R4505	001		2284.44		2284.44	-2.69	2285.78	2281.5	-4.28

MANOMETER TYPE:

S = QUARTZ SPIRAL MANOMETER DATUM
M = CONSTANT VOLUME MERCURY MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
G: Severe bottle leak
EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
(UMOL/KG SW)																	
1	16-30N	1 14	597	20JUN91	18SEP91	20SEP91	S	R4502	001		2314.33		2314.33				
53	135-0W				18SEP91	20SEP91	S	R4503	001		2316.53		2316.53	+2.20	2315.43	2306.8	-8.63
		1 17	904		17SEP91	20SEP91	S	R4500	001		2343.16		2343.16				
					17SEP91	20SEP91	S	R4501	001		2342.63		2342.63	-0.53	2342.90	2337.4	-5.50
		1 19	1205		16SEP91	20SEP91	S	R4498	001		2360.09		2360.09				
					17SEP91	20SEP91	S	R4499	001		2359.18		2359.18	-0.91	2359.84	2350.7	-8.94
		1 21	1602		13SEP91	13SEP91	S	R4496	001		2369.00		2369.00		2369.00	2359.2	-9.80
		1 23	2008		13SEP91	13SEP91	S	R4494	001		2368.43		2368.43				
					13SEP91	13SEP91	S	R4495	001		2367.86		2367.86	-0.57	2368.15		
		1 28	3000		12SEP91	13SEP91	S	R4492	001		2357.88		2357.88				
					13SEP91	13SEP91	S	R4493	001		2353.83		2353.83	-4.05	2355.85	2349.2	-6.65
1	6-0N	1 1	-1	26JUN91	05DEC91	05DEC91	M	R4522	001		1914.53		1914.53				
74	135-00W				05DEC91	12DEC91	S	R4522	001		1915.16		1915.16				
					05DEC91	08DEC91	M	R4523	001		1916.39		1916.39	+1.86	1915.46	1915.8	0.34
					05DEC91	12DEC91	S	R4523	001		1916.71		1916.71	+1.55	1915.94	1915.8	-0.14
		1 29	2992		05DEC91	05DEC91	M	R4520	001		2353.96		2353.96				
					05DEC91	09DEC91	S	R4520	001		2353.74		2353.74				
					05DEC91	05DEC91	M	R4521	001		2354.24		2354.24	+0.28	2354.10	2358.3	4.20
					05DEC91	09DEC91	S	R4521	001		2354.81		2354.81	+1.07	2354.28	2358.3	4.02
1	1-00S	1 1	0	03JUL91	09DEC91	10DEC91	M	S3986	001		2017.01		2017.01				
104	135-0W				09DEC91	13DEC91	S	S3986	001		2017.31		2017.31				
					09DEC91	10DEC91	M	S3987	001		2016.77		2016.77	-0.24	2016.89	2015.6	-1.29
					09DEC91	13DEC91	S	S3987	001		2016.76		2016.76	-0.55	2017.04	2015.6	-1.44
		1 30	2999		06DEC91	06DEC91	M	R4544	001		2340.10		2340.10				
					06DEC91	12DEC91	S	R4544	001		2339.57		2339.57				
					06DEC91	06DEC91	M	R4545	001		2342.51		2342.51	+2.41	2341.31	2334.5	-8.81
					06DEC91	12DEC91	S	R4545	001		2342.36		2342.36	+2.79	2340.97	2334.5	-6.47
1	1-50S	1 30	2998	04JUL91	06DEC91	06DEC91	M	S3988	001		2332.03		2332.03				
110	135-0W				06DEC91	12DEC91	S	S3988	001		2331.71		2331.71				
					06DEC91	06DEC91	M	S3989	001		2331.95		2331.95	-0.08	2331.99	2330.2	-1.79
					06DEC91	12DEC91	S	S3989	001		2332.40		2332.40	+0.69	2332.05	2330.2	-1.85

MANOMETER TYPE:

S = QUARTZ SPIRAL MANOMETER DATUM

M = CONSTANT VOLUME MERCURY MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

G: Severe bottle leak

EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
													(UMOL/KG SW)				
1	4-00S	1	1	0	05JUL91	10DEC91	M	S4019	001		2004.84		2004.84				
119	135-0W					10DEC91	S	S4019	001		2006.22		2006.22				
						10DEC91	M	S4020	001		2004.38		2004.38	-0.46	2004.61	2006.1	1.49
						10DEC91	S	S4020	001		2006.65		2006.65	+0.43	2006.44	2006.1	-0.34
		1	29	3001		10DEC91	M	S4017	001		2329.60		2329.60				
						10DEC91	S	S4017	001		2328.97		2328.97				
						10DEC91	M	S4018	001		2327.62		2327.62	-1.98	2328.61		
						10DEC91	S	S4018	001		2327.83		2327.83	-1.14	2328.40		

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FLAGS:

F: No Hg found in bottle

G: Severe bottle leak

EX: Data excluded from analysis

NOTE: Dilution factor of 1.000170 has been applied.

SUMMARY OF DISSOLVED INORGANIC CARBON DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC (UMOL/KG SW)	BOTTLE DELTA	"NISKIN" AVG	LDEO DIC	LDEO -S.I.O.
2 180	23-43S 132-33W	1 19	909	01AUG91	11DEC91	11DEC91	M	S4158	001		2208.25		2208.25				
					11DEC91	20DEC91	S	S4158	001		2208.73		2208.73				
					11DEC91	12DEC91	M	S4159	001		2207.96		2207.96	-0.29	2208.10	2206.1	-2.00
					11DEC91	20DEC91	S	S4159	001		2208.23		2208.23	-0.50	2208.48	2206.1	-2.38
2 174	30-32S 134-20W	1 61	4	06AUG91	03DEC91	04DEC91	M	R4548	001		2023.46		2023.46				
					03DEC91	09DEC91	S	R4548	001		2022.97		2022.97				
					03DEC91	04DEC91	M	R4549	001		2023.77		2023.77	+0.31	2023.61	2024.2	0.59
					03DEC91	09DEC91	S	R4549	001		2024.61		2024.61	+1.64	2023.79	2024.2	0.41
		1 33	3081		03DEC91	03DEC91	M	R4546	001		2301.42		2301.42				
					03DEC91	06DEC91	S	R4546	001		2303.27		2303.27				
					03DEC91	03DEC91	M	R4547	001		2302.64		2302.64	+1.22	2302.03	2299.0	-3.03
					03DEC91	06DEC91	S	R4547	001		2302.94		2302.94	-0.33	2303.10	2299.0	-4.10
2 180	37-30S 150-30W	2 69	315	12AUG91	04DEC91	06DEC91	S	R4565	001		2121.42		2121.42		2121.42	2125.5	4.08
		2 11	469		11DEC91	11DEC91	M	R4562	001		2134.64		2134.64				
					11DEC91	19DEC91	S	R4562	001		2133.70		2133.70				
					11DEC91	11DEC91	M	R4563	001		2130.68		2130.68	-3.96	2132.66	2126.2	-6.46
					11DEC91	19DEC91	S	R4563	001		2129.14		2129.14	-4.56	2131.42	2126.2	-5.22
		2 13	622		16DEC91	17DEC91	M	R4560	001		2138.07		2138.07				
					16DEC91	20DEC91	S	R4560	001		2137.74		2137.74				
					16DEC91	17DEC91	M	R4561	001		2133.80		2133.80	-4.27	2135.94	2132.5	-3.44
					16DEC91	20DEC91	S	R4561	001		2134.91		2134.91	-2.83	2136.32	2132.5	-3.82
		2 16	931		06MAY92	17JUL92	E	R4558	001		2169.51		2169.51				
					06MAY92	17JUL92	E	R4558	002		2168.19	-1.32	2168.85				
					06MAY92	17JUL92	E	R4559	001		2168.22		2168.22				
					06MAY92	17JUL92	E	R4559	002		2168.53	+0.31	2168.38	-0.47	2168.61	2167.2	-1.41
		2 18	1188		05MAY92	17JUL92	E	R4556	001		2207.85		2207.85				
					05MAY92	17JUL92	E	R4556	002		2207.82	-0.03	2207.84				
					05MAY92	17JUL92	E	R4557	001		2207.12		2207.12				
					05MAY92	17JUL92	E	R4557	002		2206.20	-0.92	2206.66	-1.18	2207.25	2202.9	-4.35
		2 20	1543		04DEC91	04DEC91	M	R4554	001		2258.59		2258.59				
					04DEC91	09DEC91	S	R4554	001		2259.74		2259.74				
					04DEC91	05DEC91	M	R4555	001		2258.58		2258.58	-0.01	2258.59	2253.9	-4.69
					04DEC91	09DEC91	S	R4555	001		2257.71		2257.71	-2.03	2258.73	2253.9	-4.83

MANOMETER TYPE:

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
G: Severe bottle leak
EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA (UMOL/KG SW)	"NISKIN" AVG	LDEO DIC	LDEO -S.I.O.
2	37-30S	2	22	2052	12AUG91	05MAY92	10JUL92	E R4552	001	EX	2299.71						
180	150-30W					05MAY92	10JUL92	E R4552	002		2294.57		2294.57				
						05MAY92	10JUL92	E R4553	001		2295.61						
						05MAY92	10JUL92	E R4553	002		2295.46	-0.15	2295.54	+0.97	2295.66	2290.4	-4.66
		2	26	3051		04MAY92	10JUL92	E R4550	001		2309.37						
						04MAY92	10JUL92	E R4550	002		2309.74	+0.37	2309.56				
						04MAY92	10JUL92	E R4551	001		2308.23						
						04MAY92	10JUL92	E R4551	002	EX	2299.35		2308.23	-1.33	2308.90	2303.7	-5.20
2	21- 0S	1	3	62	23AUG91	12DEC91	13DEC91	M S4118	001		1997.57		1997.57				
213	150-30W					12DEC91	19DEC91	S S4118	001		1998.22		1998.22				
						12DEC91	13DEC91	M S4119	001		1995.37		1995.37	-2.20	1996.47	1992.9	-3.57
						12DEC91	20DEC91	S S4119	001		1995.98		1995.98	-2.24	1997.10	1992.9	-4.20

MANOMETER TYPE:

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BOTTLE TYPE:

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SUMMARY OF DISSOLVED INORGANIC CARBON DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA (UMOL/KG SW)	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
3 222	17-05 150-30W	1 36	6	01SEP91	090CT91	100CT91	S	R4568	001		1989.51		1989.51		1990.14		
					090CT91	100CT91	S	R4569	001		1990.76		1990.76	+1.25			
		1 5	3055		080CT91	100CT91	S	R4568	001		2301.30		2301.30		2301.30	2298.2	-3.10
					080CT91	100CT91	S	R4567	001	F	2313.12						
3 226	15-05 150-50W	1 36	7	03SEP91	06NOV91	06NOV91	S	R4592	001		2000.03		2000.03		2000.03	1999.2	-0.83
					06NOV91	06NOV91	S	R4593	001	EX	1996.88						
		1 35	50		06NOV91	06NOV91	S	R4590	001		2001.19		2001.19		2001.69	1999.8	-1.89
					06NOV91	06NOV91	S	R4591	001		2002.20		2002.20	+1.01			
		1 33	130		250CT91	280CT91	S	R4588	001		2028.37		2028.37		2028.68	2027.5	-1.18
					250CT91	280CT91	S	R4589	001		2028.99		2028.99	+0.62			
		1 31	211		240CT91	280CT91	S	R4586	001		2083.06		2083.06		2082.92	2081.2	-1.72
					240CT91	280CT91	S	R4587	001		2082.77		2082.77	-0.29			
		1 29	313		240CT91	280CT91	S	R4584	001		2105.52		2105.52		2105.77	2103.5	-2.27
					240CT91	280CT91	S	R4585	001		2106.01		2106.01	+0.49			
		1 27	413		230CT91	280CT91	S	R4582	001		2177.34		2177.34		2177.34	2170.9	-6.44
					230CT91	280CT91	S	R4583	001	F	2202.68						
		1 23	618		210CT91	220CT91	S	R4580	001		2210.90		2210.90		2211.29	2205.2	-6.09
					210CT91	280CT91	S	R4581	001		2211.69		2211.69	+0.79			
		1 18	926		210CT91	220CT91	S	R4578	001		2251.25		2251.25		2250.99	2246.5	-4.49
					210CT91	220CT91	S	R4579	001		2250.72		2250.72	-0.53			
		1 16	1232		170CT91	220CT91	S	R4576	001		2273.12		2273.12		2273.12	2274.0	0.88
					170CT91	220CT91	S	R4577	001	F	2322.69						
		1 14	1642		160CT91	220CT91	S	R4574	001		2295.35		2295.35		2295.35	2293.3	-2.05
					160CT91	220CT91	S	R4575	001	F	2316.44						
		1 12	2056		150CT91	220CT91	S	R4572	001		2304.49		2304.49		2303.73	2307.4	3.67
					150CT91	220CT91	S	R4573	001		2302.96		2302.96	-1.53			
		1 7	3090		090CT91	100CT91	S	R4570	001		2308.10		2308.10		2309.52	2297.4	-12.12
					090CT91	100CT91	S	R4571	001		2310.94		2310.94	+2.84			

MANOMETER TYPE:

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
G: Severe bottle leak
EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC (UMOL/KG SW)	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
3 230	13-05 151-0W	1 36	7	04SEP91	08NOV91	11NOV91	S	R4598	001	F	1995.36		1995.36		1995.36	1997.6	2.24
					08NOV91	11NOV91	S	R4597	001		2008.06						
		1 7	3139		08NOV91	11NOV91	S	R4594	001		2323.77		2323.77				
					08NOV91	11NOV91	S	R4596	001		2320.07		2320.07	-3.70	2321.92	2319.6	-2.32
3 235	10-30S 151-0W	4 36	6	06SEP91	11NOV91	11NOV91	S	R4600	001	EX F	1985.69		1985.69				
					11NOV91	11NOV91	S	R4601	001		1990.58		1990.58	+4.89	1988.14	1991.0	2.86
		4 9	3007		11NOV91	11NOV91	S	R4598	001		2345.77						
					11NOV91	11NOV91	S	R4599	001		2358.27				2335.8		
3 238	9-0S 151-0W	1 36	6	07SEP91	30APR92	08JUL92	E	R4624	001	EX	1987.25						
					30APR92	08JUL92	E	R4624	002		1987.16	-0.09	1987.21				
					04MAY92	08JUL92	E	R4625	001		1987.50						
					04MAY92	08JUL92	E	R4625	002		1987.53	+0.03	1987.52	+0.31	1987.36	1988.0	0.64
		1 34	60		30APR92	08JUL92	E	R4622	001		1986.11						
					30APR92	08JUL92	E	R4622	002		1986.48	+0.37	1986.30				
					30APR92	08JUL92	E	R4623	001		1988.45						
					30APR92	08JUL92	E	R4623	002		1986.93		1986.93	+0.63	1986.62	1988.9	2.28
		1 32	111		29APR92	07JUL92	E	R4620	001		1996.73						
					29APR92	07JUL92	E	R4620	002		1996.12	-0.61	1996.43				
					29APR92	07JUL92	E	R4621	001		1999.51						
					29APR92	07JUL92	E	R4621	002		2000.85	+1.34	2000.18	+3.75	1998.31	1999.5	1.19
		1 26	321		28APR92	07JUL92	E	R4616	001		2234.40						
					28APR92	07JUL92	E	R4616	002		2233.41						
					28APR92	07JUL92	E	R4617	001		2212.72						
					28APR92	07JUL92	E	R4617	002		2212.66	-0.06	2212.69		2212.69	2210.3	-2.39
		1 24	414		27APR92	07JUL92	E	R4614	001		2221.31						
					27APR92	07JUL92	E	R4614	002		2216.45	-4.86	2218.88		2218.88	2221.8	2.92
		1 21	619		27APR92	06JUL92	E	R4612	001		2242.28						
					27APR92	06JUL92	E	R4612	002		2246.68	+4.40	2244.48		2244.48	2241.5	-2.98
		1 18	925		23APR92	30JUN92	E	R4610	001		2277.16						
					23APR92	30JUN92	E	R4610	002		2276.67	-0.49	2276.92				
					23APR92	30JUN92	E	R4611	001		2277.54						
					23APR92	30JUN92	E	R4611	002		2277.07	-0.47	2277.31	+0.39	2277.11	2276.0	-1.11

MANOMETER TYPE:

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
G: Severe bottle leak
EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC (UMOL/KG SW)	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
3 238	9- 151- 0W	0S 1 16	1233	07SEP91	23APR92	24APR92	S	R4608	001	EX	2296.51		2296.51				
					23APR92	24APR92	S	R4609	001		2307.46				2296.51	2294.7	-1.81
		1 12	1643		22APR92	24APR92	S	R4606	001		2314.42		2314.42				
					22APR92	24APR92	S	R4607	001		2314.25		2314.25	-0.17	2314.33	2318.5	4.17
		1 10	2055		20APR92	22APR92	S	R4604	001	EX	2328.73		2328.73				
					20APR92	22APR92	S	R4605	001		2333.18				2328.73	2316.1	-12.63
		1 5	3088		20APR92	22APR92	S	R4602	001	EX	2325.50		2325.50				
					20APR92	22APR92	S	R4603	001		2349.12				2325.50	2319.8	-5.70
		1 36	7	08SEP91	17DEC91	18DEC91	M	R4628	001		1986.28		1986.28				
					17DEC91	18DEC91	M	R4629	001		1990.94		1990.94	+4.66	1988.61	1981.9	-6.71
		1 10	3018		16DEC91	17DEC91	M	R4626	001		2325.09		2325.09				
					16DEC91	17DEC91	M	R4627	001		2324.42		2324.42	-0.67	2324.76	2321.8	-2.96
3 246	5- 151- 0W	0S 2 36	8	09SEP91	15APR92	22APR92	S	R4652	001	EX	1997.78		1997.78				
					15APR92	22APR92	S	R4653	001		2007.45				1997.78	1993.5	-4.28
		2 35	60		15APR92	16APR92	S	R4650	001		1999.52		1999.52				
					15APR92	16APR92	S	R4651	001		1999.95		1999.95	+0.43	1999.73	1994.2	-5.53
		2 33	137		14APR92	16APR92	S	R4648	001		2078.98		2078.98				
					14APR92	16APR92	S	R4649	001		2079.55		2079.55	+0.57	2079.27	2075.3	-3.97
		2 31	215		14APR92	16APR92	S	R4646	001		2186.68		2186.68				
					14APR92	16APR92	S	R4647	001		2184.85		2184.85	-2.63	2185.36	2179.2	-6.16
		2 29	307		16APR92	18APR92	S	R4644	001		2202.10		2202.10				
					16APR92	18APR92	S	R4645	001		2203.25		2203.25	+1.15	2202.68	2198.0	-4.68
		2 27	409		09APR92	16APR92	S	R4642	001		2266.96		2266.96				
					16APR92	18APR92	S	R4643	001		2264.42		2264.42	-2.54	2265.69	2259.4	-6.29
		2 23	631		09APR92	16APR92	S	R4640	001		2260.93		2260.93				
					09APR92	18APR92	S	R4641	001		2262.44		2262.44	+1.51	2261.69	2255.5	-6.19
		2 20	917		07APR92	08APR92	S	R4638	001	G	2279.81						
					07APR92	08APR92	S	R4639	001		2282.19		2282.19		2282.19	2276.0	-6.19

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
G: Severe bottle leak
EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MAND TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.		
													(UMOL/KG SW)						
3 246	5- 0S 151- 0W	2 16	1629	09SEP91	03APR92	08APR92	S	R4634	001	EX	2344.53								
					03APR92	08APR92	S	R4635	001		2350.01		2350.01		2350.01	2327.2	-22.81		
					02APR92	06JUL92	E	R4632	001		2335.41								
					02APR92	06JUL92	E	R4632	002		2335.60	+0.19	2335.51						
			14	1982	02APR92	06JUL92	E	R4633	001		2341.49								
					02APR92	06JUL92	E	R4633	001	2342.23	+0.74	2341.86	+0.35	2338.69	2336.0	-2.69			
					02APR92	06JUL92	E	R4633	002	2342.23	+0.74	2341.86	+0.35	2338.69	2336.0	-2.69			
					02APR92	06JUL92	E	R4633	002	2342.23	+0.74	2341.86	+0.35	2338.69	2336.0	-2.69			
			9	3012	02APR92	22JUN92	E	R4630	001		2334.38								
					02APR92	22JUN92	E	R4630	002	2334.91	+0.53	2334.65							
					02APR92	22JUN92	E	R4631	001	2333.27									
					02APR92	22JUN92	E	R4631	002	2333.01	-0.26	2333.14	-1.51	2333.90	2327.1	-6.80			
3 250	3- 0S 151- 0W	1 36	6	11SEP91	30MAR92	19JUN92	E	R4656	001	EX	2013.31								
					30MAR92	19JUN92	E	R4656	002		2010.17		2010.17						
					30MAR92	19JUN92	E	R4657	001		2036.46								
					30MAR92	19JUN92	E	R4657	002		2010.88		2010.88	+0.71	2010.53	2008.4	-2.13		
			8	3084	26MAR92	19JUN92	E	R4654	001		2336.35								
					26MAR92	19JUN92	E	R4654	002	2335.67	-0.68	2336.01							
					26MAR92	19JUN92	E	R4655	001	2348.74									
					26MAR92	19JUN92	E	R4655	002	2336.62		2336.62	+0.61	2336.32	2329.9	-6.42			
		3 262	1- 0S 151- 0W	1 36	7	14SEP91	01APR92	22JUN92	E	R4660	001		2011.31						
							01APR92	22JUN92	E	R4660	002	2010.97	-0.34	2011.14					
							01APR92	22JUN92	E	R4661	001	2014.10							
							01APR92	22JUN92	E	R4661	002	2014.07	-0.03	2014.08	+2.94	2012.61	2001.1	-11.51	
	8			2980	01APR92	06JUL92	E	R4659	001		2355.34								
					01APR92	06JUL92	E	R4659	002	2442.14									
					01APR92	06JUL92	E	R4659	003	2363.41		2355.34		2355.34	2338.1	-17.24			
3 274	1- 0N 151- 0W			1 34	38	16SEP91	26MAR92	18JUN92	E	R4682	001		1985.80						
							26MAR92	18JUN92	E	R4682	002	1985.49	-0.31	1985.65					
							26MAR92	18JUN92	E	R4683	001	2022.66							
							26MAR92	18JUN92	E	R4683	002	2022.20				1985.65	1986.3	0.65	
			33	67	24MAR92	18JUN92	E	R4680	001		2007.19								
					24MAR92	18JUN92	E	R4680	002	2006.86	-0.53	2006.93							
					24MAR92	18JUN92	E	R4681	001	2004.94									
					24MAR92	18JUN92	E	R4681	002	2005.10	+0.10	2005.02	-1.91	2005.98	2007.3	1.32			

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

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G: Severe bottle leak
EX: Data excluded from analysis

SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC (UMOL/KG SW)	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
3 274	1- 0N 151- 0W	1 30	154	16SEP91	20MAR92	12JUN92	E	R4678	001	EX	2107.10						
					20MAR92	12JUN92	E	R4678	002		2104.63		2104.63				
					20MAR92	12JUN92	E	R4679	001	EX	2106.93						
					20MAR92	12JUN92	E	R4679	002		2105.27		2105.27	+0.64	2104.95	2104.8	-0.15
			278		20MAR92	12JUN92	E	R4676	001		2202.72						
					20MAR92	12JUN92	E	R4676	002		2202.77	+0.05	2202.75				
					20MAR92	12JUN92	E	R4677	001		2203.11						
					20MAR92	12JUN92	E	R4677	002		2202.77	-0.34	2202.94	+0.19	2202.84	2201.9	-0.94
		1 25	354		06MAR92	08JUN92	E	R4674	001		2242.33		2242.33				
					06MAR92	08JUN92	E	R4675	001		2242.49		2242.49	+0.16	2242.41	2239.6	-2.81
		1 18	801		06MAR92	08APR92	S	R4670	001		2287.11		2287.11				
					06MAR92	08APR92	S	R4671	001		2287.96		2287.96	+0.85	2287.54	2281.1	-6.44
		1 16	1007		05MAR92	18MAR92	S	R4668	001	EX	2305.69						
					05MAR92	08APR92	M	R4669	001		2298.18		2298.18		2298.18	2297.9	-0.28
					05MAR92	18MAR92	S	R4669	001		2300.80		2300.80		2300.80	2297.9	-2.90
		1 14	1368		05MAR92	18MAR92	S	R4666	001		2333.58		2333.58				
					05MAR92	18MAR92	S	R4667	001		2332.00		2332.00	-1.58	2332.79	2329.3	-3.49
		1 12	1778		03MAR92	06MAR92	M	R4664	001		2346.37		2346.37				
					03MAR92	04MAR92	S	R4664	001		2346.29		2346.29				
					03MAR92	06MAR92	M	R4665	001		2345.02		2345.02	-1.35	2345.70	2343.5	-2.20
					03MAR92	04MAR92	S	R4665	001	EX	2353.84				2346.29	2343.5	-2.79
3 286	3- 0N 151- 0W	1 35	7	18SEP91	18DEC91	19DEC91	M	R4690	001		1964.98		1964.98				
					18DEC91	19DEC91	M	R4691	001		1964.28		1964.28	-0.70	1964.63	1963.9	-0.73
		1 10	3084		17DEC91	18DEC91	M	R4687	001		2352.51		2352.51				
					17DEC91	18DEC91	M	R4688	001	F	2308.23				2352.51	2343.1	-9.41
3 290	5- 0N 151- 0W	1 36	8	20SEP91	27FEB92	28FEB92	S	R4714	001		1911.47		1911.47				
					27FEB92	28FEB92	S	R4715	001		1911.83		1911.83	+0.36	1911.65	1912.3	0.65
		1 34	81		27FEB92	28FEB92	S	R4712	001		1987.07		1987.07				
					02MAR92	04MAR92	S	R4713	001		1988.76		1988.76	+1.69	1987.92	1989.2	1.28
		1 33	120		27FEB92	28FEB92	S	R4710	001		2010.32		2010.32				
					27FEB92	28FEB92	S	R4711	001		2010.48		2010.48	+0.16	2010.40	2009.9	-0.50

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FLAGS:

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SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
(UMOL/KG SW)																	
3	5-0N	1 31	205	20SEP91	25FEB92	26FEB92	S	R4700	001		2183.54		2183.54				
290	151-0W				25FEB92	26FEB92	S	R4709	001		2184.77		2184.77	+1.23	2184.16	2183.8	-0.36
		1 29	296		25FEB92	26FEB92	S	R4700	001	G	2200.77				2198.48	2197.8	-0.68
					25FEB92	26FEB92	S	R4707	001		2198.48		2198.48				
		1 27	411		24FEB92	26FEB92	S	R4704	001		2228.90		2228.90				
					24FEB92	26FEB92	S	R4705	001		2232.08		2232.08	+3.18	2230.49	2225.6	-4.89
		1 23	616		20FEB92	21FEB92	S	R4702	001		2285.54		2285.54				
					20FEB92	21FEB92	S	R4703	001		2286.29		2286.29	+0.75	2285.92	2285.8	-0.12
		1 20	924		20FEB92	21FEB92	S	R4700	001		2317.36		2317.36				
					20FEB92	21FEB92	S	R4701	001		2318.51		2318.51	+1.15	2317.94	2318.2	0.26
		1 18	1230		20FEB92	21FEB92	S	R4698	001		2332.71		2332.71				
					20FEB92	21FEB92	S	R4699	001		2329.61		2329.61	-3.10	2331.16	2329.6	-1.56
		1 16	1642		18FEB92	19FEB92	S	R4696	001		2351.26		2351.26				
					18FEB92	19FEB92	S	R4697	001		2352.54		2352.54	+1.28	2351.90	2350.2	-1.70
		1 14	2054		18FEB92	19FEB92	S	R4694	001		2356.78		2356.78				
					18FEB92	19FEB92	S	R4695	001		2355.39		2355.39	-1.39	2356.08	2354.7	-1.38
		1 9	3089		18FEB92	19FEB92	S	R4692	001		2350.14		2350.14				
					18FEB92	19FEB92	S	R4693	001		2350.66		2350.66	+0.52	2350.40	2349.9	-0.50
3	6-58N	1 30	10	21SEP91	13FEB92	14FEB92	S	R4718	001		1876.38		1876.38				
294	151-22W				13FEB92	14FEB92	S	R4719	001		1876.88		1876.88	+0.50	1876.63	1874.1	-2.53
		1 10	3191		14FEB92	18FEB92	M	R4716	001	F	2370.05						
					14FEB92	14FEB92	S	R4716	001	F	2370.11						
					14FEB92	14FEB92	S	R4717	001		2351.85		2351.85		2351.85	2348.5	-3.35
3	8-56N	1 30	16	22SEP91	11FEB92	14FEB92	S	R4722	001		1874.30		1874.30				
298	151-45W				11FEB92	14FEB92	S	R4723	001		1875.76		1875.76	+1.46	1875.03	1873.0	-2.03
		1 9	3058		10FEB92	12FEB92	S	R4720	001		2356.37		2356.37				
					10FEB92	12FEB92	S	R4721	001	F	2372.85				2356.37	2351.2	-5.17

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BOTTLE TYPE:

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THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
TUNES Leg 3 1991 Pacific WOCE Line P16C

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SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA (UMOL/KG SW)	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
3 302	16-54N 152- 7W	1 36	8	23SEP91	06FEB92	07FEB92	S	R4746	001		1883.39		1883.39				
					06FEB92	07FEB92	S	R4747	001		1882.09		1882.09	-1.30	1882.74	1881.6	-1.14
		1 34	60		06FEB92	12FEB92	S	R4744	001		2019.82		2019.82				
					06FEB92	12FEB92	S	R4745	001		2018.41		2018.41	-1.41	2019.11	2018.1	-3.01
		1 32	110		04FEB92	07FEB92	S	R4742	001		2105.50		2105.50				
					04FEB92	07FEB92	S	R4743	001		2108.06		2108.06	+0.56	2105.78	2104.7	-1.08
		1 29	212		04FEB92	07FEB92	S	R4740	001		2256.50		2256.50				
					04FEB92	07FEB92	S	R4741	001		2256.63		2256.63	+0.13	2256.56	2251.8	-4.76
		1 27	314		03FEB92	05FEB92	S	R4738	001		2269.21		2269.21				
					03FEB92	05FEB92	S	R4739	001		2268.05		2268.05	-1.16	2268.63	2264.8	-3.83
		1 26	416		03FEB92	05FEB92	S	R4736	001		2283.28		2283.28				
					03FEB92	05FEB92	S	R4737	001		2284.03		2284.03	+0.75	2283.66	2278.7	-4.96
		1 24	621		30JAN92	31JAN92	S	R4734	001		2306.12		2306.12				
					30JAN92	31JAN92	S	R4735	001		2306.76		2306.76	+0.64	2306.44	2304.4	-2.04
		1 21	928		30JAN92	31JAN92	S	R4732	001		2337.18		2337.18				
					30JAN92	31JAN92	S	R4733	001		2336.67		2336.67	-0.51	2336.93	2336.0	-0.93
		1 19	1237		29JAN92	31JAN92	S	R4730	001		2346.32		2346.32				
					29JAN92	31JAN92	S	R4731	001		2346.92		2346.92	+0.60	2346.62	2344.4	-2.22
		1 17	1647		29JAN92	31JAN92	M	R4728	001		2356.28		2356.28				
					29JAN92	03FEB92	M	R4729	001		2356.63		2356.63	+0.35	2356.46		
		1 15	2058		28JAN92	31JAN92	M	R4726	001		2358.55		2358.55				
					28JAN92	31JAN92	M	R4727	001		2358.78		2358.78	+0.23	2358.67		
		1 10	3086		28JAN92	30JAN92	M	R4724	001		2352.68		2352.68				
					28JAN92	31JAN92	M	R4725	001		2354.21		2354.21	+1.53	2353.45	2352.0	-1.45
3 306	12-52N 152-30W	1 36	9	24SEP91	10FEB92	12FEB92	S	R4750	001		1902.07		1902.07				
					10FEB92	12FEB92	S	R4751	001		1902.50		1902.50	+0.43	1902.29	1901.8	-0.49
3 310	14-50N 152-53W	1 36	9	28SEP91	19DEC91	20DEC91	M	R4754	001		1905.97		1905.97				
					19DEC91	20DEC91	M	R4755	001		1905.89		1905.89	-0.08	1905.93	1907.5	1.57

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

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SUMMARY OF DISSOLVED INORGANIC CARBON DATA (cont)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	WHOI DIC	WHOI -S.I.O.
													(UMOL/KG SW)				
3	14-50N	1 12	3081	26SEP91	18DEC91	19DEC91	M	R4752	001		2350.86		2350.86				
310	152-53W				18DEC91	19DEC91	M	R4753	001	EX	2289.18				2350.86	2350.3	-0.56
3	16-48N	2 36	9	27SEP91	22JAN92	23JAN92	M	R4778	001		1945.09		1945.09				
314	153-16W				22JAN92	23JAN92	M	R4779	001		1944.96		1944.96	-0.13	1945.03	1943.0	-2.03
		2 34	76		21JAN92	22JAN92	M	R4776	001		1969.99		1969.99				
					21JAN92	22JAN92	M	R4777	001		1969.09		1969.09	-0.90	1969.54	1967.0	-2.54
		2 33	107		21JAN92	22JAN92	M	R4774	001		1992.20		1992.20				
					21JAN92	22JAN92	M	R4775	001		1991.67		1991.67	-0.53	1991.94	1990.3	-1.64
		2 30	216		17JAN92	17JAN92	M	R4772	001		2119.99		2119.99				
					17JAN92	17JAN92	M	R4773	001		2119.22		2119.22	-0.77	2119.60	2118.4	-1.20
		2 28	318		16JAN92	17JAN92	M	R4770	001		2203.32		2203.32				
					16JAN92	17JAN92	M	R4771	001		2204.20		2204.20	+0.88	2203.76	2201.3	-2.46
		2 25	442		16JAN92	17JAN92	M	R4768	001		2290.49		2290.49				
					16JAN92	17JAN92	M	R4769	001		2288.47		2288.47	-2.02	2289.48	2286.9	-2.58
		2 22	676		15JAN92	16JAN92	M	R4766	001		2317.23		2317.23				
					15JAN92	16JAN92	M	R4767	001		2316.61		2316.61	-0.62	2316.92	2313.5	-3.42
		2 20	933		15JAN92	16JAN92	M	R4764	001		2339.44		2339.44				
					15JAN92	16JAN92	M	R4765	001		2336.69		2336.69	-2.75	2338.06	2336.2	-1.86
		2 18	1291		14JAN92	16JAN92	S	R4762	001		2351.69		2351.69				
					14JAN92	16JAN92	S	R4763	001		2354.33		2354.33	+2.64	2353.01	2349.6	-3.41
		2 16	1698		08JAN92	16JAN92	S	R4760	001		2360.20		2360.20				
					08JAN92	16JAN92	S	R4761	001		2360.46		2360.46	+0.26	2360.33	2357.7	-2.63
		2 14	2113		08JAN92	16JAN92	S	R4758	001		2361.29		2361.29		2361.29	2358.6	-2.69
		2 9	3201		07JAN92	16JAN92	S	R4757	001	EX	2279.37					2346.1	

MANOMETER TYPE:

S = QUARTZ SPIRAL MANOMETER DATUM
E = ELECTRONIC CONSTANT-VOLUME MANOMETER DATUM
M = CONSTANT VOLUME MERCURY MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS S = S TYPE

NOTE: Dilution factor of 1.000170 has been applied.

FLAGS:

F: No Hg found in bottle
G: Severe bottle leak
EX: Data excluded from analysis

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
F/S Meteor Leg M15 1991 Atlantic WOCE Line A9

Table 3d

SUMMARY OF DISSOLVED INORGANIC CARBON DATA

LEG STN	LAT. LONG.	CST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE DELTA	"NISKIN" AVG	BNL DIC	BNL -S.I.O.
143	19-00S 30-01W	3 18	1593	16FEB91	05JUL91	19JUL91	S	R4934	001		2172.24		2172.24				
					09JUL91	19JUL91	S	R4935	001		2170.89		2170.89	-1.35	2171.50	2174.21	2.65
					26JUL91	07AUG91	S	R4933	001		2183.44		2183.44		2183.44	2180.38	-3.06
154	19-00S 23-15W	2 24	8	21FEB91	28JUN91	02JUL91	S	R4938	001		2093.52		2093.52				
					01JUL91	02JUL91	S	R4939	001		2097.64		2097.64	+4.12	2095.58	2084.12	-11.46
187	19-12S 08-12W	2 24	7	03MAR91	05JUL91	19JUL91	S	R4956	001		2073.47		2073.47				
					31JUL91	07AUG91	S	R4957	001		2077.70		2077.70	+4.23	2075.58	2073.05	-2.53
					09JUL91	19JUL91	S	R4962	001		2220.12		2220.12				
					09JUL91	19JUL91	S	R4963	001		2215.44		2215.44	-4.68	2217.78	2212.87	-4.91
					05JUL91	19JUL91	S	R4961	001		2183.74		2183.74		2183.74	2188.71	4.97
199	19-00S 01-54W	2 2	898	07MAR91	01JUL91	02JUL91	S	R4964	001		2228.93		2228.93				
					01JUL91	02JUL91	S	R4965	001		2227.83		2227.83	-1.10	2228.38	2220.60	-7.78

MANOMETER TYPE:

S = QUARTZ SPIRAL MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

G: Severe bottle leak

EX: Data excluded from analysis

NOTE: Dilution factor of 1.000170 has been applied..

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
F/S Meteor Leg M18 1991 Atlantic WOCE Line A1E

Table 3e

SUMMARY OF DISSOLVED INORGANIC CARBON DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	EXTRAC DATE	ANALYSIS DATE	MANO TYPE	SAMPLE BOTTLE	RUN	FLAG	S.I.O. RUN	RUN DELTA	BOTTLE DIC	BOTTLE "NISKIN" DELTA (UMOL/KG SW)	BNL DIC	BNL -S.I.O.
575	59-1N 32-46W	1 24	11	09SEP91	14FEB94	02MAR94	E	R4830	001		2087.98		2087.98		2088.09	0.11
		1 13	1101		11FEB94	02MAR94	E	R4828	A001		2154.58					
					11FEB94	02MAR94	E	R4828	B001		2155.11	+0.53	2154.85			
					11FEB94	02MAR94	E	R4829	A001		2154.44					
					11FEB94	02MAR94	E	R4829	B001		2154.04	-0.40	2154.24	-0.61	2154.55	-1.43
580	58-19N 29-56W	1 23	28	10SEP91	16FEB94	02MAR94	E	R4842	001		2093.78		2093.78			
					16FEB94	02MAR94	E	R4843	001		2095.39		2095.39	+1.61	2094.58	-10.31
		1 1	2333		14FEB94	02MAR94	E	R4839	001		2160.00		2160.00		2160.00	-4.90
581	58-11N 29-37W	1 2	2008	10SEP91	27JAN94	02FEB94	E	R4844	A001		2158.71					
					27JAN94	02FEB94	E	R4844	B001		2158.91	+0.20	2158.81			
					27JAN94	02FEB94	E	R4845	A001		2158.41					
					27JAN94	02FEB94	E	R4845	B001		2158.89	+0.48	2158.65	-0.16	2158.73	-2.21
596	45-22N 25-57W	1 14	689	14SEP91	15FEB94	02MAR94	E	R4874	001		2169.27		2169.27			
					15FEB94	02MAR94	E	R4875	001		2166.20		2166.20	-3.07	2167.74	-1.88
603	52-51N 22-23W	1 1	3984	16SEP91	15FEB94	02MAR94	E	R4878	001		2204.03		2204.03			
					15FEB94	02MAR94	E	R4879	001		2203.65		2203.65	-0.38	2203.84	-3.60

MANOMETER TYPE:

E = ELECTRONIC CONSTANT-VOLUME MANOMETER DATUM

BOTTLE TYPE:

R = RODAVISS ; = S TYPE

NOTE: Dilution factor of 1.000170 has been applied.

FLAGS:

F: No Hg found in bottle

G: Severe bottle leak

EX: Data excluded from analysis

Appendix Table 4. Summaries of Titration Alkalinity Data
for Replicate Sea Water Samples

Tables 4a to 4e summarize the laboratory ALK measurements by potentiometric titration of replicate samples collected on the five expedition legs of 1991, presented in the following order:

Table 4a.	TUNES Leg 1	WOCE Line	P17C
Table 4b.	TUNES Leg 2	WOCE Lines	P17S,P16S
Table 4c.	TUNES Leg 3	WOCE Line	P16C
Table 4d.	Meteor 15	WOCE Line	A9
Table 4e.	Meteor 18	WOCE Line	A1E

Comments on each column in the table follow:

LEG to STN	SAMPLE DATE	The identifying information for each Niskin bottle sampled at sea.
ANALYSIS DATE		The date of potentiometric titration of an aliquot of sea water taken from a replicate sample bottle. After the aliquot for DIC extraction was removed from a bottle, the bottle was immediately resealed and stored at room temperature for short periods of time or refrigerated for longer periods of time until titration.
TITR SYST		The system used for titration is identified: G, the gravimetric system; V, the volumetric system. Sometimes aliquots from the same bottle were titrated on both systems.
SAMPLE BOTTLE		The label number for the individual replicate sample bottle filled at sea. The prefix "S" indicates a standard 500 ml Corning borosilicate glass bottle with a hollow stopper (individually lapped to the bottle joint with carborundum grit) equipped with an aluminum bale type fixture for holding the stopper in its sealed position. The prefix "R" indicates a 500 ml borosilicate glass bottle equipped with a standard taper (24/40 size) joint and solid stopper with a Rodawiss plastic knurled nut system for holding the stopper.
TRIAL		This number indicates whether more than one titration was made on water from a replicate sample bottle. Sometimes titrations were deleted before reaching the data base at all, for example if the titration cell was filled improperly. Quite often, one or more of multiple trials are flagged in the data set: usually multiple trials were made because of a problem with the first trial.
FLAG		The flag code identifies trials that are rejected from further consideration due to identifiable experimental reasons. The flags used have the following meanings: F, evidence indicated that the sample had no mercuric chloride added (see text for further discussion); X, the titrator malfunctioned for some definable reason; EX, a general flag for some other experimental rejection, such as a very poor fit of the titration data.

Appendix Table 4. Summaries of Titration Alkalinity Data
for Replicate Sea Water Samples (cont.)

S.I.O TRIAL	The ALK in micromoles per kilogram of sea water of hydrogen ion equivalent is listed for an individual trial titration.
TRIAL DELTA	The trial difference for two trials as discussed above, if both trials are unflagged.
BOTTLE ALK	The average bottle ALK for unflagged trials. In most cases (single trials), the S.I.O. TRIAL and the BOTTLE ALK are identical.
BOTTLE DELTA	The difference in ALK between two bottles collected from a single Niskin bottle is listed.
"NISKIN" AVG	Here is listed the average S.I.O. laboratory ALK result for water from a particular Niskin bottle sampled at sea. If two titration systems were used (see TUNES Leg 3, station 222, bottle number R4569), the averages for both systems are listed.
{INSTITUTION} ALK	The shipboard ALK result from a shipboard titration. The institution abbreviations indicate the shipboard CO ₂ analytical group operating on that expedition leg, as follows: WHOI, the group of Dr. Catherine Goyet, P.I., of Woods Hole Oceanographic Institution, on TUNES Leg 1; CDRG, the group of Dr. Charles Keeling, P.I., of Scripps Institution of Oceanography, on TUNES Leg 3. The TUNES Leg 1 data is considered to be final, as reported to the Carbon Dioxide Information and Analysis Center. The TUNES Leg 3 data is NOT FINAL pending completion of a report in preparation. The remaining legs had no shipboard ALK measured by the U.S. CO ₂ group on board. No inference should be made from the listed data as to the imprecision of the data. Here we choose to list data to more places than are significant.
{INSTITUTION} - S.I.O. ALK	The difference between the shipboard ALK result and the average laboratory replicate sample ALK. Note again that for the case discussed above, the differences for both systems are listed.
NOTE: Dilution Factor	At the end of the Table 4 section for each leg is a note detailing the multiplicative dilution factor applied to account for the addition of the HgCl ₂ poison solution to the S.I.O. replicate sample bottles. The nominally 500 ml bottles actually hold about 585 ml. Thus for the addition of 0.1 ml of saturated aqueous HgCl ₂ , a dilution factor of 1.00017 is calculated. The shipboard data listed in the last two columns have also been appropriately corrected for dilution by each shipboard analysis group.

SUMMARY OF ALKALINITY DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA (UEQUIV/KG SW)	"NISKIN" AVG	WHOI ALK	WHOI -S.I.O.
1 5	35-33N 122-52W	1 1	1	03 JUN 91	22 AUG 91 29 AUG 91	G G	S3750 S3751	1 1		2204.15 2205.13		2204.15 2205.13	+0.98	2204.64		
1 8	34-49N 124-35W	1 1	1	04 JUN 91	22 AUG 91 22 AUG 91 22 AUG 91	G G G	S3772 S3772 S3773	1 2 1	EX	2316.17 2209.65 2203.60		2209.65 2203.60	-6.05	2206.63		
		1 3	66		29 AUG 91 30 AUG 91	G G	S3770 S3771	1 1		2220.45 2219.65		2220.45 2219.65	-0.80	2220.05		
1 11	34-35N 124-35W	1 29	2896	05 JUN 91	30 AUG 91	G	S3774	1		2435.74		2435.74		2435.74		
1 14	34-35N 131-19W	1 1	2	07 JUN 91	30 AUG 91 23 AUG 91	G G	S3781 S3782	1 1		2218.35 2217.58		2218.35 2217.58	-0.77	2217.97		
1 17	34-36N 134-58W	2 1	1	08 JUN 91	10 SEP 91 10 SEP 91	G G	S3806 S3807	1 1		2220.01 2218.75		2220.01 2218.75	-1.26	2219.38	2240.88	21.50
		2 2	52		11 SEP 91 09 SEP 91	G G	S3804 S3805	1 1	X	2222.88 2217.63		2217.63		2217.63	2228.51	10.88
		2 4	98		09 SEP 91 09 SEP 91	G G	S3802 S3803	1 1		2223.61 2222.49		2223.61 2222.49	-1.12	2223.05		
		2 8	201		30 AUG 91 30 AUG 91	G G	S3800 S3801	1 1		2228.37 2224.11		2228.37 2224.11	-4.26	2226.24	2237.92	11.68
		2 10	300		28 AUG 91 28 AUG 91	G G	S3798 S3799	1 1		2265.57 2266.51		2265.57 2266.51	+0.94	2266.04	2285.16	19.12
		2 12	401		28 AUG 91 28 AUG 91	G G	S3796 S3797	1 1		2285.54 2281.77		2285.54 2281.77	-3.77	2283.66		
		2 14	601		26 AUG 91 28 AUG 91 28 AUG 91	G G G	S3794 S3795 S3795	1 1 2	EX EX	2315.58 2333.46 2325.05		2315.58		2315.58		
		2 17	899		26 AUG 91 26 AUG 91	G G	S3792 S3793	1 1		2364.40 2364.20		2364.40 2364.20	-0.20	2364.30		
		2 19	1200		30 AUG 91 30 AUG 91	G G	S3790 S3791	1 1		2398.41 2390.65		2398.41 2390.65	-7.76	2394.53		

TITRATION SYSTEM:

G = GRAVIMETRIC
V = VOLUMETRIC

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
X: Titrator malfunction
EX: Data excluded from analysis

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK (UEQUIV/KG SW)	BOTTLE DELTA	"NISKIN" AVG	WHOI ALK	WHOI -S.I.O.
1	34-36N	2	21	1600	08JUN91	G	S3788	1		2411.69		2411.69				
17	134-58W				30AUG91	G	S3789	1		2411.69		2411.69	+0.00	2411.69		
1	33-4N	1	1	09JUN91	20SEP91	G	S3810	1		2248.16		2248.16				
20	135-00W				25SEP91	G	S3811	1		2247.08		2247.08	-1.08	2247.62	2257.66	10.04
		1	28	2798	17SEP91	G	S3808	1	EX	2432.87						
					19SEP91	G	S3809	1		2443.29		2443.29		2443.29		
1	31-32N	1	1	0	10JUN91	G	S3814	1		2271.47		2271.47				
23	135-0W				25SEP91	G	S3815	1		2268.13		2268.13	-3.34	2269.80		
		1	28	3003	25SEP91	G	S3812	1		2433.30		2433.30				
					25SEP91	G	S3813	1		2433.64		2433.64	+0.34	2433.47		
1	30-2N	2	1	1	11JUN91	G	R4478	1		2293.17		2293.17				
28	134-57W				20AUG91	G	R4479	1		2300.12		2300.12	+6.95	2296.65	2312.16	15.51
		2	2	64	09AUG91	G	R4476	1		2300.65		2300.65				
					13AUG91	G	R4477	1		2301.02		2301.02	+0.37	2300.83	2310.21	9.38
		2	4	109	09AUG91	G	R4474	1		2305.69		2305.69				
					12AUG91	G	R4475	1		2302.70		2302.70	-2.99	2304.20	2311.85	7.65
		2	7	206	06AUG91	G	R4472	1		2265.51		2265.51				
					09AUG91	G	R4473	1		2264.61		2264.61	-0.90	2265.06	2277.49	12.43
		2	10	324	06AUG91	G	R4470	1		2256.03		2256.03				
					06AUG91	G	R4471	1		2256.65		2256.65	+0.62	2256.34	2262.15	5.81
		2	11	400	12AUG91	G	R4468	1		2261.41		2261.41				
					12AUG91	G	R4469	1		2262.53		2262.53	+1.12	2261.97	2276.06	14.09
		2	13	606	05AUG91	G	R4466	1		2304.68		2304.68				
					06AUG91	G	R4467	1		2304.19		2304.19	-0.49	2304.44		
		2	16	909	30SEP91	G	S3824	2		2355.35		2355.35				
					26SEP91	G	S3825	1		2323.83		2323.83	-31.52	2339.59		
		2	18	1202	30SEP91	G	S3822	1		2393.21		2393.21				
					020CT91	G	S3823	1		2385.28		2385.28	-7.93	2389.25		

TITRATION SYSTEM:

G = GRAVIMETRIC
V = VOLUMETRIC

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
X: Titrator malfunction
EX: Data excluded from analysis

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA	"NISKIN" AVG	WHOI ALK	WHOI -S.I.O.
1 26	30-2N 134-57W	2 20	1605	11JUN91	26SEP91	G	S3820	1		2407.50		2407.50				
					01OCT91	G	S3821	1		2407.56		2407.56	+0.06	2407.53		
		2 22	2007		02OCT91	G	S3818	1		2414.88		2414.88				
					26SEP91	G	S3819	1		2417.05		2417.05	+2.17	2415.97		
		2 27	3000		26SEP91	G	S3816	1		2439.46		2439.46				
					26SEP91	G	S3817	1		2432.16		2432.16	-7.30	2435.81		
1 29	28-30N 135-00W	1 1	1	12JUN91	21AUG91	G	R4482	1		2294.95		2294.95				
					21AUG91	G	R4483	1		2290.86		2290.86	-4.09	2292.91	2306.02	13.11
		1 31	2951		20AUG91	G	R4480	1		2442.89		2442.89				
					20AUG91	G	R4481	1	X	2432.56						
					21AUG91	G	R4481	2		2435.40		2435.40	-7.49	2439.15		
1 47	19-30N 135-00W	1 1	0	18JUN91	10SEP91	G	R4486	1		2290.66		2290.66				
					10SEP91	G	R4487	1		2294.47		2294.47	+3.81	2292.56	2298.90	6.34
		1 27	3005		10SEP91	G	S3884	1		2435.33		2435.33				
					10SEP91	G	S3885	1		2434.26		2434.26	-1.07	2434.80		
1 50	18-00N 135-00W	1 1	0	19JUN91	11SEP91	G	R4490	1		2269.78		2269.78				
					11SEP91	G	R4491	1		2277.37		2277.37	+7.59	2273.58	2282.90	9.32
		1 27	2999		11SEP91	G	R4488	1		2396.89		2396.89				
					12SEP91	G	R4489	1		2393.93		2393.93	-2.96	2395.41		
1 53	16-30N 135-00W	1 1	0	20JUN91	23OCT91	G	S3894	1		2272.47		2272.47				
					23OCT91	G	S3895	1		2272.31		2272.31	-0.16	2272.39	2254.90	-17.49
		1 2	50		22OCT91	G	S3893	1		2270.20		2270.20		2270.20	2286.90	16.70
		1 4	112		02OCT91	G	S3890	1		2294.04		2294.04				
					22OCT91	G	S3891	1		2298.05		2298.05	+4.01	2296.05	2316.90	20.85
		1 8	188		01OCT91	G	S3888	1		2266.82		2266.82				
					02OCT91	G	S3889	1		2263.21		2263.21	-3.61	2265.02	2270.60	5.58
		1 10	300		01OCT91	G	S3886	1		2293.99		2293.99				
					02OCT91	G	S3887	1		2294.72		2294.72	+0.73	2294.35	2300.90	6.55
		1 12	402		19SEP91	G	R4504	1		2304.53		2304.53				
					19SEP91	G	R4505	1		2306.77		2306.77	+2.24	2305.65	2311.00	5.35

TITRATION SYSTEM:

G = GRAVIMETRIC

V = VOLUMETRIC

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

X: Titrator malfunction

EX: Data excluded from analysis

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK (UEQUIV/KG SW)	BOTTLE DELTA	"NISKIN" AVG	WHOI ALK	WHOI -S.I.O.
1 53	16-30N 135-00W	1 14	597	20JUN91	19SEP91	G	R4502	1		2328.49		2328.49				
					19SEP91	G	R4503	1		2323.91		2323.91	-4.58	2326.20	2330.90	4.70
		1 17	904		17SEP91	G	R4500	1		2363.87		2363.87				
					17SEP91	G	R4501	1		2360.56		2360.56	-3.31	2362.22		
		1 19	1205		19SEP91	G	R4498	1		2370.66		2370.66				
					19SEP91	G	R4499	1		2377.91		2377.91	+7.25	2374.28		
		1 21	1602		18SEP91	G	R4496	1		2407.97		2407.97		2407.97		
								1		2407.97		2407.97		2407.97		
		1 23	2008		13SEP91	G	R4494	1	EX	2428.50						
					18SEP91	G	R4494	2		2417.21		2417.21				
					17SEP91	G	R4495	1		2417.42		2417.42	+0.21	2417.31		
		1 28	3000		12SEP91	G	R4492	1		2424.59						
					13SEP91	G	R4492	2		2424.81	+0.22	2424.70				
					13SEP91	G	R4493	1		2439.80		2439.80	+15.10	2432.25		
1 74	6-00N 135-00W	1 1	-1	26JUN91	09JAN92	V	R4522	1		2255.26		2255.26				
					09JAN92	V	R4523	1		2268.50		2268.50	+13.24	2261.88	2251.00	-10.88
		1 29	2992		09JAN92	V	R4520	1		2436.85		2436.85				
					09JAN92	V	R4521	1		2429.18		2429.18	-7.67	2433.02		
1 104	1-00S 135-00W	1 1	0	03JUL91	13JAN92	V	S3986	1		2324.91		2324.91				
					13JAN92	V	S3987	1		2324.52		2324.52	-0.39	2324.72	2328.50	3.78
		1 30	2999		13JAN92	V	R4544	1		2418.96		2418.96				
					13JAN92	V	R4545	1		2416.92		2416.92	-2.04	2417.94		
1 110	1-58S 135-00W	1 30	2998	04JUL91	17JAN92	V	S3988	1		2425.00		2425.00				
					17JAN92	V	S3989	1		2421.67		2421.67	-3.33	2423.33		
1 119	4-00S 135-00W	1 1	0	05JUL91	20JAN92	V	S4019	1		2321.88		2321.88				
					20JAN92	V	S4020	1		2320.64		2320.64	-1.24	2321.26	2331.10	9.84
		1 29	3001		28JAN92	V	S4017	2		2420.98		2420.98				
					28JAN92	V	S4018	2		2422.30		2422.30	+1.32	2421.64		

TITRATION SYSTEM:

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BOTTLE TYPE:

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FLAGS:

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X: Titrator malfunction
EX: Data excluded from analysis

NOTE: Dilution factor of 1.000170 has been applied.

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
TUNES Leg 2 1991 WOCE Pacific Line P17S/P18S

Table 4b

SUMMARY OF ALKALINITY DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK (UEQIV/KG SW)	BOTTLE DELTA	"NISKIN" AVG
2	23-43S	1 19	989	01AUG91	20JAN92	V	S4158	1		2300.18		2300.18		
160	132-33W				20JAN92	V	S4159	1		2302.05		2302.05	+1.87	2301.11
2	30-32S	1 61	4	06AUG91	10JAN92	V	R4548	1		2318.15		2318.15		
174	134-20W				10JAN92	V	R4549	1		2324.19		2324.19	+6.04	2321.17
		1 33	3081		10JAN92	V	R4548	1		2395.78		2395.78		
					10JAN92	V	R4547	1		2396.62		2396.62	+0.84	2396.20
2	37-30S	2 69	315	12AUG91	14JAN92	V	R4564	1		2277.74		2277.74		
180	150-30W				14JAN92	V	R4565	1		2280.79		2280.79	+3.05	2279.27
		2 11	469		14JAN92	V	R4562	1		2275.55		2275.55		
					14JAN92	V	R4563	1		2273.45		2273.45	-2.10	2274.50
		2 13	622		17JAN92	V	R4560	1		2275.23		2275.23		
					17JAN92	V	R4561	1		2281.82		2281.82	+6.59	2278.53
		2 16	931		22JUN92	V	R4558	1		2290.65		2290.65		
					22JUN92	V	R4559	1		2285.23		2285.23	-5.42	2287.94
		2 18	1188		22JUN92	V	R4556	1		2304.57		2304.57		
					22JUN92	V	R4557	1		2304.45		2304.45	-0.12	2304.51
		2 20	1543		13JAN92	V	R4554	1		2343.31		2343.31		
					13JAN92	V	R4555	1		2343.93		2343.93	+0.62	2343.62
		2 22	2052		18JUN92	V	R4552	1		2380.77		2380.77		
					18JUN92	V	R4553	1		2382.52		2382.52	+1.75	2381.65
		2 26	3051		18JUN92	V	R4550	1		2403.47		2403.47		
					18JUN92	V	R4551	1		2404.50		2404.50	+1.03	2403.99
2	21-05S	1 3	62	23AUG91	20JAN92	V	S4118	1		2365.81		2365.81		
213	150-30W				20JAN92	V	S4119	1		2366.34		2366.34	+0.53	2366.08

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NOTE: Dilution factor of 1.000170 has been applied.

SUMMARY OF ALKALINITY DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK (UEQIV/KG SW)	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
3 222	17-05 150-30W	1 38	6	01SEP91	18OCT91	G	R4588	1		2369.35		2369.35				
					22OCT91	G	R4589	1		2365.81		2365.81	-3.54	2367.58	2365.21	-2.37
					03JUN92	V	R4589	5		2347.46		2347.46		2347.46	2365.21	17.75
		1 5	3055		18OCT91	G	R4588	1		2393.48		2393.48				
					18OCT91	G	R4587	1	F	2373.14				2393.48	2397.67	4.19
3 226	15-05 150-50W	1 38	7	03SEP91	18NOV91	G	R4592	1		2386.17		2386.17				
					18NOV91	G	R4593	1		2386.40		2386.40	+0.23	2386.28	2387.58	1.30
		1 35	50		15NOV91	G	R4590	1		2383.16		2383.16				
					15NOV91	G	R4591	1		2382.72		2382.72	-0.44	2382.94	2383.75	0.81
		1 33	130		15NOV91	G	R4588	1		2393.34						
					18NOV91	G	R4588	2	X	2358.20		2393.34				
					15NOV91	G	R4589	1	X	2412.23				2393.34	2391.97	-1.37
		1 31	211		15NOV91	G	R4586	1		2376.32		2376.32				
					15NOV91	G	R4587	1		2375.48		2375.48	-0.84	2375.90	2378.77	2.87
		1 29	313		24OCT91	G	R4584	1		2320.91		2320.91				
					24OCT91	G	R4585	1		2314.79		2314.79	-6.12	2317.85	2315.84	-2.01
		1 27	413		13NOV91	G	R4582	1		2285.19		2285.19				
					15NOV91	G	R4583	1		2286.84		2286.84	+1.65	2286.02	2293.12	7.10
		1 23	618		25OCT91	G	R4580	1		2301.78		2301.78				
					13NOV91	G	R4581	1		2300.40		2300.40	-1.38	2301.09	2303.49	2.40
		1 18	926		23OCT91	G	R4578	1		2326.90		2326.90				
					25OCT91	G	R4579	1		2331.31		2331.31	+4.41	2329.10	2333.60	4.50
		1 16	1232		23OCT91	G	R4576	1		2360.06		2360.06				
					23OCT91	G	R4577	1	F	2369.57				2360.06	2357.94	-2.12
		1 14	1642		23OCT91	G	R4574	1		2371.03						
					07NOV91	G	R4574	2		2369.53	-1.50	2370.28				
					23OCT91	G	R4575	1	F	2363.83				2370.28	2379.13	8.85
		1 12	2058		23OCT91	G	R4572	1		2386.19		2386.19				
					23OCT91	G	R4573	1		2390.19		2390.19	+4.00	2388.19	2393.54	5.35
		1 7	3090		22OCT91	G	R4570	1		2399.27		2399.27				
					22OCT91	G	R4571	1		2391.76		2391.76	-7.51	2395.52	2403.26	7.74

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SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA (UEQUIV/KG SW)	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
3 230	13-05 151-0W	1 36	7	04SEP91	19NOV91	G	R4596	1		2385.08		2385.08				
					20NOV91	G	R4597	1		2383.29		2383.29	-1.79	2384.19	2384.35	0.16
					19NOV91	G	R4594	1		2393.57		2393.91				
					19NOV91	G	R4594	2		2394.24	+0.67	2393.91				
					19NOV91	G	R4595	1		2400.67		2400.67	+6.76	2397.29	2423.69	26.40
3 235	10-30S 151-0W	4 36	6	06SEP91	20NOV91	G	R4600	1		2359.32		2359.32				
					20NOV91	G	R4601	1		2348.53		2348.53	-10.79	2353.93	2360.58	6.65
					20NOV91	G	R4598	1		2385.09		2385.09				
					20NOV91	G	R4599	1	F	2424.77				2385.09	2417.37	32.28
					24JUN92	V	R4622	1		2362.92		2362.92				
3 238	9-05 151-0W	1 34	60	07SEP91	25JUN92	V	R4623	1		2365.34		2365.34	+2.42	2364.13	2363.90	-0.23
					24JUN92	V	R4620	1		2370.45		2370.45				
					24JUN92	V	R4621	1		2365.87		2365.87	-4.58	2368.16	2370.94	2.78
					24JUN92	V	R4618	1		2371.74		2371.74				
					24JUN92	V	R4619	1		2372.88		2372.88	+1.14	2372.31	2374.50	2.19
					24JUN92	V	R4616	1		2306.75		2306.75				
					24JUN92	V	R4617	1		2297.02		2297.02	-9.73	2301.89	2306.34	4.45
					23JUN92	V	R4614	1		2302.86		2302.86				
					24JUN92	V	R4615	1		2302.18		2302.18	-0.68	2302.52	2302.29	-0.23
					23JUN92	V	R4612	1		2304.82		2304.82				
					23JUN92	V	R4613	1		2309.67		2309.67	+4.85	2307.25	2308.71	1.46
					23JUN92	V	R4611	1		2339.78		2339.78		2339.78	2342.12	2.34
					29APR92	V	R4608	1		2361.81		2361.81		2361.81	2366.27	4.46
					28APR92	V	R4606	1		2388.43		2388.43				
					28APR92	V	R4607	1		2397.44		2397.44	+9.01	2392.94	2390.04	-2.90
3 238	9-05 151-0W	1 10	2055		29APR92	V	R4604	1		2386.94		2386.94		2386.94	2402.16	15.22
					28APR92	V	R4602	1		2415.77		2415.77				
					29APR92	V	R4603	1		2417.29		2417.29	+1.52	2416.53	2415.86	-0.67

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AIM

Association for Information and Image Management

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2 of 2

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
TUNES Leg 3 1991 Pacific WOCE Line P16C

Table 4c, Page 3

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
3 242	7- 0S 151- 0W	1 36	7	08SEP91	14JAN92	V	R4628	1		2322.81		2322.81				
					14JAN92	V	R4629	1		2313.68		2313.68	-9.13	2318.25	2322.62	4.37
		1 10	3018		27DEC91	V	R4626	1		2423.34						
					09JAN92	V	R4626	3		2421.54	-1.80	2422.44				
					27DEC91	V	R4627	1		2420.80						
					09JAN92	V	R4627	2		2417.63	-3.17	2419.22	-3.22	2420.83	2421.04	0.21
3 246	5- 0S 151- 0W	2 36	8	09SEP91	29APR92	V	R4652	1		2322.37		2322.37				
					29APR92	V	R4653	1		2324.68		2324.68	+2.31	2323.53	2330.70	7.17
		2 35	60		28APR92	V	R4650	1		2324.31		2324.31				
					29APR92	V	R4651	1		2324.93		2324.93	+0.62	2324.62	2328.18	3.56
		2 33	137		28APR92	V	R4648	1		2391.43		2391.43				
					28APR92	V	R4649	1		2388.40		2388.40	-3.03	2389.92	2390.78	0.86
		2 31	215		27APR92	V	R4646	1		2317.16		2317.16				
					28APR92	V	R4647	1		2319.68		2319.68	+2.52	2318.42	2315.57	-2.85
		2 29	307		27APR92	V	R4644	1		2303.79		2303.79				
					28APR92	V	R4645	1		2302.89		2302.89	-0.90	2303.34	2304.23	0.89
		2 27	409		27APR92	V	R4642	1		2296.21		2296.21				
					27APR92	V	R4643	1		2303.38		2303.38	+7.17	2299.79	2305.23	5.44
		2 23	631		27APR92	V	R4640	1		2308.46		2308.46				
					27APR92	V	R4641	1		2305.95		2305.95	-2.51	2307.21	2309.52	2.31
		2 20	917		16APR92	V	R4638	1		2338.21		2338.21				
					16APR92	V	R4639	1		2334.98		2334.98	-3.23	2336.59	2340.41	3.82
		2 18	1221		14APR92	V	R4636	1		2363.64		2363.64				
					15APR92	V	R4637	1		2363.65		2363.65	+0.01	2363.65	2370.58	6.93
		2 16	1629		14APR92	V	R4634	1		2375.49		2375.49				
					14APR92	V	R4635	1		2368.65		2368.65	-6.84	2372.07	2394.12	22.05
		2 14	1982		14APR92	V	R4632	1		2405.05		2405.05				
					14APR92	V	R4633	1		2397.61		2397.61	-7.44	2401.33	2407.20	5.87

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SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK (UEQUIV/KG SW)	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
3 246	5- 151- 0S 0W	2 9	3012	09SEP91	14APR92	V	R4630	1		2424.18		2424.18				
					14APR92	V	R4631	1		2421.44		2421.44	-2.74	2422.81	2424.62	1.81
3 250	3- 151- 0S 0W	1 36	6	11SEP91	09APR92	V	R4656	1		2333.21		2333.21				
					09APR92	V	R4657	1		2330.49		2330.49	-2.72	2331.85	2328.48	-3.37
		1 8	3084		09APR92	V	R4654	1		2422.52		2422.52				
					09APR92	V	R4655	1		2424.76		2424.76	+2.24	2423.64	2422.42	-1.22
3 262	1- 151- 0S 0W	1 36	7	14SEP91	14APR92	V	R4660	1		2321.75		2321.75				
					14APR92	V	R4661	1		2317.14		2317.14	-4.61	2319.45	2329.90	10.45
		1 8	2980		27APR92	V	R4658	1		2378.73		2378.73				
					27APR92	V	R4659	1		2409.39		2409.39	+30.66	2394.06	2426.45	32.39
3 274	1- 151- 0N 0W	1 34	38	16SEP91	16APR92	V	R4682	1		2293.37		2293.37				
					16APR92	V	R4683	1		2300.63		2300.63	+7.26	2297.00	2292.02	-4.98
		1 33	67		15APR92	V	R4680	1	EX	2322.63						
					16APR92	V	R4680	2		2300.09		2300.09				
					16APR92	V	R4681	1		2303.56		2303.56	+3.47	2301.83	2301.57	-0.26
		1 30	154		15APR92	V	R4679	1		2297.45		2297.45		2297.45	2298.60	1.15
		1 27	278		14APR92	V	R4676	1		2308.10		2308.10				
					14APR92	V	R4677	1		2307.77		2307.77	-0.33	2307.94	2292.74	-15.20
		1 25	354		16MAR92	V	R4674	1		2303.65		2303.65				
					17MAR92	V	R4675	1	EX	2321.29						
					17MAR92	V	R4675	2		2305.28		2305.28	+1.63	2304.47	2303.31	-1.16
		1 36	393		27APR92	V	R4684	1		2306.02		2306.02				
					27APR92	V	R4685	1		2306.93		2306.93	+0.91	2306.48	2303.21	-3.27
		1 18	801		16MAR92	V	R4670	1		2334.23		2334.23				
					16MAR92	V	R4671	1		2335.95		2335.95	+1.72	2335.09	2334.54	-0.55
		1 16	1007		10MAR92	V	R4668	1		2351.71		2351.71				
					10MAR92	V	R4669	1		2353.33		2353.33	+1.62	2352.52	2350.74	-1.78
		1 14	1368		10MAR92	V	R4666	1		2383.81		2383.81				
					10MAR92	V	R4667	1		2383.55		2383.55	-0.26	2383.68	2388.19	4.51

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SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
(UEQUIV/KG SW)																
3	1- 0N	1 12	1778	16SEP91	06MAR92	V	R4664	1		2403.70		2403.70				
274	151- 0W				06MAR92	V	R4665	1		2405.01		2405.01	+1.31	2404.35	2407.50	3.15
		1 4	3126		14APR92	V	R4662	1		2408.86		2408.86		2408.86	2425.33	16.47
3	3- 0N	1 35	7	18SEP91	27DEC91	V	R4690	1		2291.47						
286	151- 0W				07JAN92	V	R4690	2		2286.62	-4.85	2289.05				
					27DEC91	V	R4691	1		2291.21						
					07JAN92	V	R4691	2		2285.21	-6.00	2288.21	-0.84	2288.63	2267.03	-21.60
		1 10	3084		17JAN92	V	R4687	1		2425.61						
					23JAN92	V	R4687	2		2419.23	-6.38	2422.42				
					17JAN92	V	R4688	1	F	2438.13				2422.42	2434.29	11.87
3	5- 0N	1 36	8	20SEP91	06MAR92	V	R4714	1		2268.77		2268.77				
290	151- 0W				06MAR92	V	R4715	1		2270.13		2270.13	+1.36	2269.45	2264.37	-5.08
		1 34	81		06MAR92	V	R4712	1		2301.23		2301.23				
					06MAR92	V	R4713	1		2298.33		2298.33	-2.90	2299.78	2297.08	-2.70
		1 33	120		06MAR92	V	R4710	1		2302.51		2302.51				
					06MAR92	V	R4711	1		2295.19		2295.19	-7.32	2298.85	2288.56	-10.29
		1 31	205		06MAR92	V	R4708	1		2290.66		2290.66				
					06MAR92	V	R4709	1		2292.09		2292.09	+1.43	2291.38	2290.10	-1.28
		1 29	296		16MAR92	V	R4706	2		2306.02		2306.02				
					16MAR92	V	R4707	1		2303.56		2303.56	-2.46	2304.79	2303.52	-1.27
		1 27	411		10MAR92	V	R4704	1		2306.81						
					16MAR92	V	R4704	2		2308.30	+1.49	2307.56				
					10MAR92	V	R4705	1		2293.86						
					16MAR92	V	R4705	2		2298.58	+4.72	2296.22	-11.34	2301.89	2306.92	5.03
		1 23	616		27FEB92	V	R4702	1		2317.84		2317.84				
					27FEB92	V	R4703	1	EX	2327.72						
					05MAR92	V	R4703	2		2315.42		2315.42	-2.42	2316.63	2317.17	0.54
		1 20	924		27FEB92	V	R4700	1		2344.09		2344.09				
					27FEB92	V	R4701	1		2341.15		2341.15	-2.94	2342.62	2347.91	5.29
		1 18	1230		24FEB92	V	R4698	1		2377.21		2377.21				
					24FEB92	V	R4699	1		2375.96		2375.96	-1.25	2376.58	2374.63	-1.95

TITRATION SYSTEM:

G = GRAVIMETRIC
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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle
X: Titrator malfunction
EX: Data excluded from analysis

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
(UEQUIV/KG SW)																
3	5-0N	1 16	1842	20SEP91	24FEB92	V	R4696	1		2404.42		2404.42				
290	151-0W				24FEB92	V	R4697	1		2398.55		2398.55	-5.87	2401.49	2402.44	0.95
		1 14	2054		24FEB92	V	R4694	1		2423.76		2423.76				
					24FEB92	V	R4695	1		2417.42		2417.42	-6.34	2420.59	2420.23	-0.36
		1 9	3089		24FEB92	V	R4692	1		2435.17		2435.17				
					24FEB92	V	R4693	1		2432.69		2432.69	-2.48	2433.93	2424.48	-9.45
3	6-58N	1 36	10	21SEP91	05MAR92	V	R4718	1		2223.80		2223.80				
294	151-22W				05MAR92	V	R4719	1	EX	2230.37						
					06MAR92	V	R4719	2		2227.42		2227.42	+3.62	2225.61	2227.68	2.07
		1 10	3191		05MAR92	V	R4716	1		2397.31		2397.31				
					05MAR92	V	R4717	1	F	2424.67				2397.31	2433.44	36.13
3	8-56N	1 36	16	22SEP91	05MAR92	V	R4722	1		2212.18		2212.18				
298	151-45W				05MAR92	V	R4723	1		2211.53		2211.53	-0.65	2211.85	2220.76	8.91
		1 9	3058		11FEB92	V	R4720	1		2428.54		2428.54				
					11FEB92	V	R4721	1	F	2410.73				2428.54	2438.19	9.65
3	10-54N	1 36	8	23SEP91	10FEB92	V	R4746	1		2224.68		2224.68				
302	152-7W				10FEB92	V	R4747	1		2226.17		2226.17	+1.49	2225.43	2219.63	-5.80
		1 34	60		10FEB92	V	R4744	1	EX	2300.11						
					11FEB92	V	R4744	2		2289.12		2289.12				
					10FEB92	V	R4745	1		2289.56		2289.56	+0.44	2289.34	2283.51	-5.83
		1 32	110		10FEB92	V	R4742	1		2274.25		2274.25				
					10FEB92	V	R4743	1		2274.71		2274.71	+0.46	2274.48	2272.20	-2.28
		1 29	212		07FEB92	V	R4740	1		2299.76		2299.76				
					07FEB92	V	R4741	1		2301.09		2301.09	+1.33	2300.43	2296.03	-4.40
		1 27	314		07FEB92	V	R4738	1		2308.10		2308.10				
					07FEB92	V	R4739	1		2309.66		2309.66	+1.56	2308.80	2305.85	-3.03
		1 26	416		07FEB92	V	R4736	1		2317.30		2317.30				
					07FEB92	V	R4737	1		2316.15		2316.15	-1.15	2316.73	2317.00	0.27
		1 24	621		07FEB92	V	R4734	1		2334.50		2334.50				
					07FEB92	V	R4735	1		2335.57		2335.57	+1.07	2335.04	2336.30	1.26

TITRATION SYSTEM:

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BOTTLE TYPE:

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FLAGS:

F: No Hg found in bottle

X: Titrator malfunction

EX: Data excluded from analysis

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK (UEQUIV/KG SW)	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
3	10-54N	1 21	928	23SEP91	03FEB92	V	R4732	1		2364.78		2364.78				
302	152-7W				03FEB92	V	R4733	1		2365.34		2365.34	+0.56	2365.06	2364.16	-0.90
		1 19	1237		03FEB92	V	R4730	1		2390.20		2390.20				
					03FEB92	V	R4731	1		2390.43		2390.43	+0.23	2390.31	2385.09	-5.22
		1 17	1647		03FEB92	V	R4728	1		2411.42		2411.42				
					03FEB92	V	R4729	1		2411.27		2411.27	-0.15	2411.34	2409.38	-1.98
		1 15	2058		03FEB92	V	R4726	1		2432.61		2432.61				
					03FEB92	V	R4727	1		2427.58		2427.58	-5.03	2430.10	2423.61	-6.49
		1 10	3086		03FEB92	V	R4724	1		2430.97		2430.97				
					03FEB92	V	R4725	1		2432.61		2432.61				
					03FEB92	V	R4725	2	EX	2436.95		2432.61	+1.64	2431.79	2436.65	4.86
3	12-52N	1 36	9	24SEP91	10FEB92	V	R4750	1		2244.44		2244.44				
306	152-30W				10FEB92	V	R4751	1		2246.90		2246.90	+2.46	2245.67	2242.65	-3.02
3	14-50N	1 36	9	26SEP91	09JAN92	V	R4754	2		2245.92		2245.92				
310	152-53W				09JAN92	V	R4755	1		2245.93		2245.93	+0.01	2245.93	2246.20	0.27
		1 12	3081		20JAN92	V	R4752	1		2432.55		2432.55				
					20JAN92	V	R4753	1		2431.47		2431.47	-1.08	2432.01	2432.53	0.52
3	16-48N	2 36	9	27SEP91	23JAN92	V	R4778	1		2283.39		2283.39				
314	153-16W				23JAN92	V	R4779	1		2282.56		2282.56	-0.83	2282.98	2280.08	-2.90
		2 34	76		23JAN92	V	R4776	1		2301.59		2301.59				
					23JAN92	V	R4777	1		2302.10		2302.10	+0.51	2301.85	2300.94	-0.91
		2 33	107		23JAN92	V	R4774	1		2311.76		2311.76				
					23JAN92	V	R4775	1		2313.75		2313.75	+1.99	2312.76	2307.89	-4.87
		2 30	216		21JAN92	V	R4772	1		2271.88		2271.88				
					21JAN92	V	R4773	1		2272.54		2272.54	+0.66	2272.21	2269.58	-2.63
		2 28	318		21JAN92	V	R4770	1		2281.47		2281.47				
					21JAN92	V	R4771	1		2280.45		2280.45	-1.02	2280.96	2280.04	-0.92

TITRATION SYSTEM:

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FLAGS:

F: No Hg found in bottle
X: Titrator malfunction
EX: Data excluded from analysis

SUMMARY OF ALKALINITY DATA (cont.)

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA	"NISKIN" AVG	CDRG ALK	CDRG -S.I.O.
3 314	16-48N 153-16W	2 25	442	27SEP91	20JAN92	V	R4768	1		2312.17						
					27JAN92	V	R4768	2		2312.34	+0.17	2312.26				
					20JAN92	V	R4769	1		2312.81						
					27JAN92	V	R4769	2		2312.05	-0.76	2312.43	+0.17	2312.34	2311.10	-1.24
		2 22	676		20JAN92	V	R4766	1		2334.20		2334.20				
					20JAN92	V	R4767	1		2339.02		2339.02	+4.82	2336.61	2338.75	2.14
		2 20	933		20JAN92	V	R4764	1		2362.07		2362.07				
					20JAN92	V	R4765	1		2365.13		2365.13	+3.06	2363.60	2364.44	0.84
		2 18	1291		20JAN92	V	R4762	1		2392.43		2392.43				
					20JAN92	V	R4763	1		2389.57		2389.57	-2.86	2391.00	2394.47	3.47
		2 16	1698		20JAN92	V	R4760	1	EX	2416.26						
					21JAN92	V	R4760	2		2410.51		2410.51				
					20JAN92	V	R4761	1		2409.25		2409.25	-1.26	2409.88	2410.35	0.47
		2 14	2113		21JAN92	V	R4758	1		2415.97		2415.97				
					21JAN92	V	R4759	1		2420.93		2420.93	+4.96	2418.45	2421.86	3.41
		2 9	3201		21JAN92	V	R4756	1		2429.71		2429.71				
					21JAN92	V	R4757	1		2429.92		2429.92	+0.21	2429.81	2431.89	2.08

TITRATION SYSTEM:

G = GRAVIMETRIC

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BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

X: Titrator malfunction

EX: Data excluded from analysis

NOTE: Dilution factor of 1.000170 has been applied.

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
F/S Meteor Leg M15 1991 Atlantic WOCE Line A9

Table 4d

SUMMARY OF ALKALINITY DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA	"NISKIN" AVG
												(UEQUIV/KG SW)		
143	19-00S 30-01W	3 18	1593	16FEB91	05JUL91	G	R4934	1		2315.05		2315.05		
					09JUL91	G	R4935	1		2313.39		2313.39	-1.66	2314.22
					19JUL91	G	R4932	1		2328.90		2328.90		
					29AUG91	G	R4933	1		2334.56		2334.56	+5.66	2331.73
154	19-00S 23-15W	2 24	8	21FEB91	03JUL91	G	R4938	1		2431.91		2431.91		
					05JUL91	G	R4939	1		2423.84				
					08JUL91	G	R4939	2		2424.59	+0.75	2424.22	-7.69	2428.06
187	19-12S 08-12W	2 24	7	03MAR91	05JUL91	G	R4956	1		2391.57		2391.57		
					06AUG91	G	R4957	1		2391.07		2391.07	-0.50	2391.32
					09JUL91	G	R4962	1		2298.10		2298.10		
					19JUL91	G	R4963	1		2312.57		2312.57	+14.47	2305.34
					08JUL91	G	R4961	1		2328.74		2328.74		2328.74
199	19-00S 01-54W	2 2	898	07MAR91	08JUL91	G	R4964	1		2294.07		2294.07		
					08JUL91	G	R4965	1		2297.84		2297.84	+3.77	2295.96

TITRATION SYSTEM:

G = GRAVIMETRIC

V = VOLUMETRIC

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

X: Titrator malfunction

EX: Data excluded from analysis

NOTE: Dilution factor of 1.000170 has been applied.

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
F/S Meteor Leg M18 1991 Atlantic WOCE Line A1E

Table 4e

SUMMARY OF ALKALINITY DATA

LEG STN	LAT. LONG.	CAST NISK	DEPTH (M)	SAMPLE DATE	ANALYSIS DATE	TITR SYST	SAMPLE BOTTLE	TRIAL	FLAG	S.I.O. TRIAL	TRIAL DELTA	BOTTLE ALK	BOTTLE DELTA (UEQUIV/KG SW)	"NISKIN" AVG
575	59-1N 32-46W	1 13	1101	09SEP91	27APR94	G	R4828	1		2290.33				
					29APR94	G	R4828	2		2291.32	+0.99	2290.83		
					28APR94	G	R4829	1		2295.18		2295.18	+4.35	2293.01
580	58-19N 29-56W	1 1	2333	10SEP91	28APR94	G	R4838	1		2301.97		2301.97		
					29APR94	G	R4839	1		2303.89		2303.89	+1.92	2302.93
581	58-11N 29-37W	1 2	2008	10SEP91	09FEB94	V	R4844	1		2301.35		2301.35		
					09FEB94	V	R4845	1		2300.74		2300.74	-0.61	2301.05
598	45-22N 25-57W	1 14	689	14SEP91	05MAY94	G	R4874	1		2304.68		2304.68		
					05MAY94	G	R4875	1		2304.81		2304.81	+0.13	2304.75
603	52-51N 22-23W	1 1	3984	16SEP91	05MAY94	G	R4878	1		2352.52		2352.52		
					05MAY94	G	R4879	1		2351.55		2351.55	-0.97	2352.04

TITRATION SYSTEM:

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V = VOLUMETRIC

BOTTLE TYPE:

R = RODAVISS S = S TYPE

FLAGS:

F: No Hg found in bottle

X: Titrator malfunction

EX: Data excluded from analysis

NOTE: Dilution factor of 1.000170 has been applied.

Appendix Table 5. Summaries of Salinity Data for Replicate Sea Water Samples

samples of sea water collected on the five expedition legs of 1991. The measurements were made on an inductive salinometer calibrated with standard sea water and were made by personnel of the Oceanographic Data Facility (ODF) at SIO. The data for the five legs are presented in the following order:

Table 5a.	TUNES Leg 1	WOCE Line	P17C
Table 5b.	TUNES Leg 2	WOCE Lines	P17S, P16S
Table 5c.	TUNES Leg 3	WOCE Line	P16C
Table 5d.	Meteor 15	WOCE Line	A9
Table 5e.	Meteor 18	WOCE Line	A1E

Comments on each column in the table follow:

LEG to DEPTH (M)	The identifying information for each Niskin bottle sampled at sea.
EXTRAC DATE	The date of extraction of CO ₂ gas from an aliquot of sea water taken from a given sample bottle is listed.
SAMPLE BOTTLE	The label number for the individual replicate sample bottle filled at sea is listed. The prefix "S" indicates a standard 500 ml Corning borosilicate glass bottle with a hollow stopper (individually lapped to the bottle joint with carborundum grit) equipped with an aluminum bale type fixture for holding the stopper in its sealed position. The prefix "R" indicates a 500 ml borosilicate glass bottle equipped with a standard taper (24/40 size) joint and solid stopper with a Rodawiss plastic knurled nut system for holding the stopper.
SAMPLE DATE	The date of collection of the replicate sample at sea.
EXTRAC DATE	The date of extraction of CO ₂ gas from an aliquot of sea water taken from a given sample bottle is listed.
STORAGE (E-S)	The number of days between the sample date and the extraction date. This indicates the storage time of a sample in the replicate sample bottle before it is first opened. The sample remains in the partially full replicate bottle until ALK measurements have been completed and then a subsample is taken into a 200 ml salinity bottle. The amount of storage time in this bottle varies from days to months.
ANALYS. DATE	The date of laboratory analysis for salinity by ODF. Subsamples are normally sent to ODF in batches of 100.
SALINITY o/oo	The individual shore salinity for a bottle.
BOTTLE DELTA	The difference in salinity units between shore analyses on the replicate bottle pair from a Niskin bottle.
BOTTLE AVG o/oo	The average shore salinity for a bottle pair collected from a Niskin bottle.

Appendix Table 5. Summaries of Salinity Data for
Replicate Sea Water Samples (cont.)

SHIPBOARD
SALINITY
o/oo

A PRELIMINARY shipboard Niskin salinity provided by the replicate sampler at sea. This salinity may be from the CTD or may be a preliminary discrete salinity determined on an inductive salinometer at sea. This will be replaced by the final salinity when released by the WOCE/HP. No shore data yet exists for the Meteor 18 samples. Table 4e is nevertheless included for completeness.

DELTA
(SHIP-
SHORE)

The difference between the PRELIMINARY shipboard salinity and the average shore salinity for a Niskin bottle.

COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD (ON DIC SAMPLE DATE) AND ON SHORE (ON DIC EXTRACTION DATE)

LEG	STATION	LAT.	LONG.	CAST	NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA		BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD o/oo	DELTA (SHIP- SHORE)
											ANALYS.	SALINITY				
1	5	35-33N	122-52W	1	1	1	S3750	910603	910820	78	911017	32.841	+0.003	32.840	32.843	+0.003
							S3751	910603	910821	79	911017	32.838				
1	8	34-49N	124-35W	1	1	1	S3772	910604	910821	78	911017	32.839	-0.020	32.849	32.833	-0.016
							S3773	910604	910822	79	911017	32.859				
1	8	34-49N	124-35W	1	3	66	S3770	910604	910821	78	911017	33.133	-0.010	33.138	33.133	-0.005
							S3771	910604	910821	78	911017	33.143				
1	11	34-35N	127-38W	1	29	2896	S3774	910605	910822	78	911017	34.661		34.661	34.655	-0.006
1	14	34-35N	131-19W	1	1	2	S3781	910607	910822	76	911017	33.062	-0.003	33.064	33.064	+0.000
							S3782	910607	910823	77	911017	33.065				
1	17	34-36N	134-58W	2	1	1	S3806	910608	910909	93	911017	33.063	+0.002	33.062	33.068	+0.006
							S3807	910608	910910	94	911017	33.061				
1	17	34-36N	134-58W	2	2	52	S3804	910608	910910	94	911017	33.104	+0.026	33.091	33.078	-0.013
							S3805	910608	910909	93	911017	33.078				
1	17	34-36N	134-58W	2	4	98	S3802	910608	910909	93	911017	33.246	+0.011	33.241	33.220	-0.021
							S3803	910608	910909	93	911017	33.235				
1	17	34-36N	134-58W	2	8	201	S3800	910608	910829	82	911017	33.433	+0.001	33.433	33.433	+0.000
							S3801	910608	910829	82	911017	33.432				
1	17	34-36N	134-58W	2	10	300	S3798	910608	910828	81	911017	33.991	-0.001	33.992	33.972	-0.020
							S3799	910608	910828	81	911017	33.992				
1	17	34-36N	134-58W	2	12	401	S3796	910608	910826	79	911017	34.022	+0.024	34.010	33.997	-0.013
							S3797	910608	910826	79	911017	33.998				
1	17	34-36N	134-58W	2	14	601	S3794	910608	910826	79	911017	34.091	-0.018	34.100	34.089	-0.011
							S3795	910608	910826	79	911017	34.109				
1	17	34-36N	134-58W	2	17	899	S3792	910608	910826	79	911017	34.370	-0.015	34.378	34.370	-0.008
							S3793	910608	910826	79	911017	34.385				
1	17	34-36N	134-58W	2	19	1200	S3790	910608	910823	76	911017	34.497	-0.028	34.511	34.497	-0.014
							S3791	910608	910823	76	911017	34.525				

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STORAGE:

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST	NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SHORE DATA SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
1	17	34-36N	134-58W	2	21	1600	S3788 S3789	910608 910608	910823 910823	76 76	911017 911017	34.562 34.563	-0.001	34.563	34.561	-0.002
1	20	33- 4N	135-00W	1	1	1	S3810 S3811	910609 910609	910920 910920	103 173	920318 920318	33.681 33.679	+0.002	33.680	33.682	+0.002
1	20	33- 4N	135-00W	1	28	2798	S3808 S3809	910609 910609	910917 910919	100 102	920318 920318	34.657 34.656	+0.007	34.654	34.655	+0.001
1	23	31-32N	135- 0W	1	1	0	S3814 S3815	910610 910610	910924 910924	106 106	920318 920318	34.201 34.186	+0.015	34.194	34.196	+0.002
1	23	31-32N	135- 0W	1	28	3003	S3812 S3813	910610 910610	910920 910924	102 106	920318 920318	34.671 34.661	+0.010	34.666	34.663	-0.003
1	26	30- 2N	134-57W	2	1	1	R4478 R4479	910611 910611	910819 910819	69 69	911017 911017	34.680 34.665	-0.005	34.663	34.669	+0.006
1	26	30- 2N	134-57W	2	2	64	R4476 R4477	910611 910611	910809 910809	59 59	911017 911017	34.747 34.750	-0.003	34.749	34.751	+0.002
1	26	30- 2N	134-57W	2	4	109	R4474 R4475	910611 910611	910808 910808	58 58	911017 911017	34.801 34.789	+0.012	34.795	34.801	+0.006
1	26	30- 2N	134-57W	2	7	206	R4472 R4473	910611 910611	910808 910808	58 58	911017 911017	34.335 34.329	+0.006	34.332	34.339	+0.007
1	26	30- 2N	134-57W	2	10	324	R4470 R4471	910611 910611	910808 910808	56 56	911017 911017	34.021 34.016	+0.005	34.019	34.028	+0.009
1	26	30- 2N	134-57W	2	11	400	R4468 R4469	910611 910611	910805 910805	55 55	911017 911017	34.015 34.012	+0.003	34.014	34.019	+0.005
1	26	30- 2N	134-57W	2	13	606	R4466 R4467	910611 910611	910805 910805	55 55	911017 911017	34.086 34.084	+0.002	34.085	34.093	+0.008
1	26	30- 2N	134-57W	2	16	909	S3824 S3825	910611 910611	910926 910926	107 107	920318 920318	34.364 34.360	+0.004	34.362	34.365	+0.003
1	26	30- 2N	134-57W	2	18	1202	S3822 S3823	910611 910611	910927 910927	108 108	920318 920318	34.493 34.482	+0.011	34.488	34.495	+0.007

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE AVG o/oo	SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
1	26	30- 2N	134-57W	2 20	1605	S3820 S3821	910611 910611	910925 910927	106 108	920318 920318	34.563 34.570	-0.007	34.567	34.571	+0.004
1	26	30- 2N	134-57W	2 22	2007	S3818 S3819	910611 910611	910925 910926	106 107	920318 920318	34.601 34.611	-0.010	34.606	34.615	+0.009
1	26	30- 2N	134-57W	2 27	3000	S3816 S3817	910611 910611	910925 910925	106 106	920318 920318	34.655 34.662	-0.007	34.659	34.665	+0.006
1	29	28-30N	135-00W	1 1	1	R4482 R4483	910612 910612	910820 910820	69 69	911017 911017	34.623 34.628	-0.005	34.626	34.633	+0.007
1	29	28-30N	135-00W	1 31	2951	R4480 R4481	910612 910612	910820 910820	69 69	911017 911017	34.666 34.664	+0.002	34.665	34.665	+0.000
1	47	19-30N	135- 0W	1 1	0	R4486 R4487	910618 910618	910910 910910	84 84	911017 911017	34.735 34.722	+0.013	34.729	34.739	+0.010
1	47	19-30N	135- 0W	1 27	3005	S3884 S3885	910618 910618	910910 910910	84 84	911017 911017	34.676 34.660	+0.016	34.668	34.669	+0.001
1	50	18- 0N	135- 0W	1 1	0	R4490 R4491	910619 910619	910911 910911	84 84	920318 911017	34.500 34.495	+0.005	34.498	34.501	+0.003
1	50	18- 0N	135- 0W	1 27	2999	R4488 R4489	910619 910619	910911 910911	84 84	911017 920318	34.663 34.664	-0.001	34.664	34.670	+0.006
1	53	16-30N	135- 0W	1 1	0	S3894 S3895	910620 910620	911002 911004	104 106	920318 920318	34.505 34.499	+0.006	34.502	34.499	-0.003
1	53	16-30N	135- 0W	1 2	50	S3892 S3893	910620 910620	911001 911001	103 103	920318 920318	34.490 34.500	-0.010	34.495	34.499	+0.004
1	53	16-30N	135- 0W	1 4	112	S3890 S3891	910620 910620	910930 910930	102 102	920318 920318	34.654 34.659	-0.005	34.657	34.660	+0.003
1	53	16-30N	135- 0W	1 8	188	S3888 S3889	910620 910620	910930 910930	102 102	920318 920318	34.274 34.274	+0.000	34.274	34.286	+0.012
1	53	16-30N	135- 0W	1 10	300	S3886 S3887	910620 910620	910926 910927	98 99	920318 920318	34.519 34.518	+0.001	34.519	34.517	-0.002

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST	DEPTH	SAMPLE	SAMPLE	EXTRAC	STORAGE	ANALYS.	SHORE DATA	BOTTLE	BOTTLE	SHIPBOARD	DELTA
				NISK	(M)	BOTTLE	DATE	DATE	(E-S)	DATE	SALINITY	DELTA	DELTA	AVG	(SHIP- SHORE)
											o/oo	o/oo	o/oo	o/oo	
1	53	16-30N	135-0W	1 12	402	R4504 R4505	910620 910620	910919 910919	91 91	920318 920318	34.479 34.480	-0.001	34.480	34.490	+0.010
1	53	16-30N	135-0W	1 14	597	R4502 R4503	910620 910620	910918 910918	90 90	920318 920318	34.440 34.450	-0.010	34.445	34.455	+0.010
1	53	16-30N	135-0W	1 17	904	R4500 R4501	910620 910620	910917 910917	89 89	920318 920318	34.505 34.506	-0.001	34.506	34.516	+0.010
1	53	16-30N	135-0W	1 19	1205	R4498 R4499	910620 910620	910916 910917	88 89	920318 920318	34.547 34.555	-0.008	34.551	34.556	+0.005
1	53	16-30N	135-0W	1 21	1602	R4496	910620	910913	85	920318	34.597		34.597	34.599	+0.002
1	53	16-30N	135-0W	1 23	2008	R4494 R4495	910620 910620	910913 910913	85 85	920318 920318	34.623 34.622	+0.001	34.623	34.630	+0.007
1	53	16-30N	135-0W	1 28	3000	R4492 R4493	910620 910620	910912 910913	84 85	920318 920318	34.658 34.662	-0.004	34.660	34.671	+0.011
1	74	6-0N	135-00W	1 1	-1	R4522 R4523	910626 910626	911205 911205	162 162	920428 920428	34.239 34.242	-0.003	34.241	34.248	+0.007
1	74	6-0N	135-00W	1 29	2992	R4520 R4521	910626 910626	911205 911205	162 162	920428 920428	34.673 34.669	+0.004	34.671	34.675	+0.004
1	104	1-00S	135-0W	1 1	0	S3986 S3987	910703 910703	911209 911209	159 159	920428 920428	35.355 35.356	-0.001	35.356	35.357	+0.001
1	104	1-00S	135-0W	1 30	2999	R4544 R4545	910703 910703	911206 911206	156 156	920428 920428	34.664 34.669	-0.005	34.667	34.682	+0.015
1	110	1-58S	135-0W	1 30	2998	S3988 S3989	910704 910704	911206 911206	155 155	920721 920428	34.675 34.674	+0.001	34.675	34.676	+0.001
1	119	4-00S	135-0W	1 1	0	S4019 S4020	910705 910705	911210 911210	158 158	920428 920428	35.264 35.255	+0.009	35.260	35.268	+0.008
1	119	4-00S	135-0W	1 29	3001	S4017 S4018	910705 910705	911210 911210	158 158	920721 920721	34.668 34.676	-0.008	34.672	34.676	+0.004

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD (ON DIC SAMPLE DATE) AND ON SHORE (ON DIC EXTRACTION DATE)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
2	160	23-43S	132-33W	1 19	909	S4158 S4159	910801 910801	911211 911211	132 132	920428 920428	34.347 34.339	+0.008	34.343	34.340	-0.003
2	174	30-32S	134-20W	1 61	4	R4548 R4549	910806 910806	911203 911203	119 119	920428 920428	35.377 35.378	-0.001	35.378	35.370	-0.008
2	174	30-32S	134-20W	1 33	3081	R4546 R4547	910806 910806	911203 911203	119 119	920428 920428	34.670 34.668	+0.002	34.669	34.670	+0.001
2	180	37-30S	150-30W	2 61	4	S4072 S4073	910812 910812	920508 920508	271 270					34.740	
2	180	37-30S	150-30W	2 2	49	S4070 S4071	910812 910812	920507 920507	269 269					34.740	
2	180	37-30S	150-30W	2 3	96	S4068 S4069	910812 910812	920507 920507	269 269					34.740	
2	180	37-30S	150-30W	2 7	233	S4066 S4067	910812 910812	920506 920506	268 268					34.560	
2	180	37-30S	150-30W	2 69	315	R4564 R4565	910812 910812	911204 911204	113 114	920428 920428	34.483 34.490	-0.007	34.487	34.490	+0.003
2	180	37-30S	150-30W	2 11	469	R4562 R4563	910812 910812	911211 911211	121 121	920428 920428	34.443 34.440	+0.003	34.442	34.440	-0.002
2	180	37-30S	150-30W	2 13	622	R4560 R4561	910812 910812	911216 911216	126 126	920428 920428	34.383 34.382	+0.001	34.383	34.380	-0.003
2	180	37-30S	150-30W	2 16	931	R4558 R4559	910812 910812	920506 920506	269 268	930107 930107	34.320 34.323	-0.003	34.322	34.320	-0.002
2	180	37-30S	150-30W	2 18	1188	R4556 R4557	910812 910812	920505 920505	267 267	930107 930107	34.360 34.355	+0.005	34.358	34.360	+0.002
2	180	37-30S	150-30W	2 20	1543	R4554 R4555	910812 910812	911204 911204	113 114	920428 920428	34.515 34.518	-0.003	34.517	34.520	+0.003
2	180	37-30S	150-30W	2 22	2052	R4552 R4553	910812 910812	920505 920505	268 267	930107 930107	34.622 34.620	+0.002	34.621	34.620	-0.001

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	SHORE DATA				SHIPBOARD			
								EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	AVG o/oo	DELTA (SHIP- SHORE)
2	180	37-30S	150-30W	2	26	3051	R4550	910812	920504	266	930107	34.670			
							R4551	910812	920504	266	930107	34.670	+0.000	34.670	34.670 +0.000
2	213	21-0S	150-30W	1	3	62	S4118	910823	911212	110	920428	35.970			
							S4119	910823	911212	111	920428	35.969	+0.001	35.970	35.970 +0.000

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD (ON DIC SAMPLE DATE) AND ON SHORE (ON DIC EXTRACTION DATE)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
3	222	17- 0S	150-30W	1 36	6	R4568 R4569	910901 910901	911009 911009	38 38	920318 920318	35.965 35.970	-0.005	35.968	35.977	+0.009
3	222	17- 0S	150-30W	1 5	3055	R4568 R4567	910901 910901	911008 911008	37 37	920318 920318	34.667 34.670	-0.003	34.669	34.679	+0.010
3	226	15- 0S	150-50W	1 36	7	R4592 R4593	910903 910903	911106 911106	64 64	920318 920318	36.196 36.204	-0.008	36.200	36.231	+0.031
3	226	15- 0S	150-50W	1 35	50	R4590 R4591	910903 910903	911106 911106	64 64	920318 920318	36.203 36.201	+0.002	36.202	36.213	+0.011
3	226	15- 0S	150-50W	1 33	130	R4588 R4589	910903 910903	911025 911025	52 52	920318	36.297		36.297	36.297	+0.000
3	226	15- 0S	150-50W	1 31	211	R4586 R4587	910903 910903	911024 911024	51 51	920318 920318	36.145 36.149	-0.004	36.147	36.155	+0.008
3	226	15- 0S	150-50W	1 29	313	R4584 R4585	910903 910903	911024 911024	51 51	920318 920318	35.222 35.219	+0.003	35.221	35.233	+0.012
3	226	15- 0S	150-50W	1 27	413	R4582 R4583	910903 910903	911023 911023	50 50	920318 920318	34.654 34.664	-0.010	34.659	34.670	+0.011
3	226	15- 0S	150-50W	1 23	618	R4580 R4581	910903 910903	911021 911021	48 48	920318 920318	34.460 34.460	+0.000	34.460	34.466	+0.006
3	226	15- 0S	150-50W	1 18	926	R4578 R4579	910903 910903	911021 911021	48 48	920318 920318	34.479 34.486	-0.007	34.483	34.499	+0.016
3	226	15- 0S	150-50W	1 16	1232	R4576 R4577	910903 910903	911017 911017	44 44	920318 920318	34.542 34.534	+0.008	34.538	34.553	+0.015
3	226	15- 0S	150-50W	1 14	1642	R4574 R4575	910903 910903	911016 911016	43 43	920318 920318	34.586 34.582	+0.004	34.584	34.599	+0.015
3	226	15- 0S	150-50W	1 12	2056	R4572 R4573	910903 910903	911015 911015	42 42	920318 920318	34.624 34.622	+0.002	34.623	34.639	+0.016
3	226	15- 0S	150-50W	1 7	3090	R4570 R4571	910903 910903	911009 911009	36 36	920318 920318	34.666 34.668	-0.002	34.667	34.678	+0.011

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	SHORE DATA					SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)	
								EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA			BOTTLE o/oo
3	230	13- 0S	151- 0W	1 36	7	R4596 R4597	910904 910904	911108 911108	65 65	920318 920318	36.170 36.182	-0.012	36.176	36.172	-0.004
3	230	13- 0S	151- 0W	1 7	3139	R4594 R4595	910904 910904	911108 911108	65 65	920318 920318	34.674 34.669	+0.005	34.672	34.680	+0.008
3	235	10-30S	151- 0W	4 36	6	R4600 R4601	910906 910906	911111 911111	66 66	920318 920318	35.826 35.825	+0.001	35.826	35.834	+0.008
3	235	10-30S	151- 0W	4 9	3007	R4598 R4599	910906 910906	911111 911111	66 66	920318 920318	34.670 34.675	-0.005	34.673	34.679	+0.006
3	238	9- 0S	151- 0W	1 36	6	R4624 R4625	910907 910907	920430 920504	237 240					35.792	
3	238	9- 0S	151- 0W	1 34	60	R4622 R4623	910907 910907	920430 920430	236 236					35.860	
3	238	9- 0S	151- 0W	1 32	111	R4620 R4621	910907 910907	920429 920429	235 235					35.976	
3	238	9- 0S	151- 0W	1 29	200	R4618 R4619	910907 910907	920429 920429	235 235	930107	36.022		36.022	36.026	+0.004
3	238	9- 0S	151- 0W	1 26	321	R4616 R4617	910907 910907	920428 920428	234 234	930107 930107	34.838 34.834	+0.004	34.836	34.835	-0.001
3	238	9- 0S	151- 0W	1 24	414	R4614 R4615	910907 910907	920427 920427	233 233	930107 930107	34.686 34.687	-0.001	34.687	34.690	+0.003
3	238	9- 0S	151- 0W	1 21	619	R4612 R4613	910907 910907	920427 920427	233 233	930107 930107	34.577 34.576	+0.001	34.577	34.580	+0.003
3	238	9- 0S	151- 0W	1 18	925	R4610 R4611	910907 910907	920423 920423	229 229	930107 930107	34.522 34.524	-0.002	34.523	34.530	+0.007
3	238	9- 0S	151- 0W	1 15	1233	R4608 R4609	910907 910907	920423 920423	229 229	920721 920721	34.563 34.570	-0.007	34.567	34.573	+0.006
3	238	9- 0S	151- 0W	1 12	1643	R4606 R4607	910907 910907	920422 920422	228 228	920721 920721	34.605 34.602	+0.003	34.604	34.607	+0.003

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SHORE DATA SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD AVG SALINITY o/oo	DELTA (SHIP- SHORE)
3	238	9- 0S	151- 0W	1 10	2055	R4604 R4605	910907 910907	920420 920420	226 226	920721	34.637		34.637	34.643	+0.006
3	238	9- 0S	151- 0W	1 5	3088	R4602 R4603	910907 910907	920420 920420	226 226	920721 920721	34.677 34.682	-0.005	34.680	34.679	-0.001
3	242	7- 0S	151- 0W	1 36	7	R4628 R4629	910908 910908	911217 911217	99 100	920428 920428	35.306 35.306	+0.000	35.306	35.309	+0.003
3	242	7- 0S	151- 0W	1 10	3018	R4626 R4627	910908 910908	911216 911216	99 99	920428	34.672		34.672	34.678	+0.006
3	246	5- 0S	151- 0W	2 36	8	R4652 R4653	910909 910909	920415 920415	220 219	920721 920721	35.402 35.401	+0.001	35.402	35.403	+0.001
3	246	5- 0S	151- 0W	2 35	60	R4650 R4651	910909 910909	920415 920415	219 219	920721 920721	35.401 35.399	+0.002	35.400	35.399	-0.001
3	246	5- 0S	151- 0W	2 33	137	R4648 R4649	910909 910909	920414 920414	218 218	920721 920721	36.297 36.290	+0.007	36.294	35.435	-0.859
3	246	5- 0S	151- 0W	2 31	215	R4646 R4647	910909 910909	920414 920414	218 218	920721 920721	35.115 35.113	+0.002	35.114	35.117	+0.003
3	246	5- 0S	151- 0W	2 29	307	R4644 R4645	910909 910909	920410 920410	214 214	920721 920721	34.852 34.848	+0.004	34.850	34.850	+0.000
3	246	5- 0S	151- 0W	2 27	409	R4642 R4643	910909 910909	920409 920410	213 214	920721 920721	34.716 34.721	-0.006	34.718	34.732	+0.014
3	246	5- 0S	151- 0W	2 23	631	R4640 R4641	910909 910909	920409 920409	213 213	920721 920721	34.587 34.585	+0.002	34.586	34.589	+0.003
3	246	5- 0S	151- 0W	2 20	917	R4638 R4639	910909 910909	920407 920407	211 211	920721 920721	34.537 34.534	+0.003	34.536	34.537	+0.001
3	246	5- 0S	151- 0W	2 18	1221	R4636 R4637	910909 910909	920407 920407	211 211	920721 920721	34.569 34.568	+0.001	34.569	34.569	+0.000

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	SHORE DATA					SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
								EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	
3	246	5- 0S	151- 0W	2 16	1629	R4634 R4635	910909 910909	920403 920403	207 207	920721 920721	34.607 34.608	-0.001	34.608	34.609 +0.001
3	246	5- 0S	151- 0W	2 14	1982	R4632 R4633	910909 910909	920402 920402	206 206	920721 920721	34.631 34.636	-0.005	34.634	34.635 +0.001
3	246	5- 0S	151- 0W	2 9	3012	R4630 R4631	910909 910909	920402 920402	206 206	920721 920721	34.676 34.674	+0.002	34.675	34.679 +0.004
3	250	3- 0S	151- 0W	1 36	6	R4656 R4657	910911 910911	920330 920330	201 201	920721 920721	35.418 35.419	-0.001	35.419	35.421 +0.002
3	250	3- 0S	151- 0W	1 8	3084	R4654 R4655	910911 910911	920326 920326	197 197	920721 920721	34.672 34.670	+0.002	34.671	34.673 +0.002
3	262	1- 0S	151- 0W	1 36	7	R4660 R4661	910914 910914	920401 920401	200 200	920721 920721	35.419 35.421	-0.002	35.420	35.421 +0.001
3	262	1- 0S	151- 0W	1 8	2980	R4658 R4659	910914 910914	920401 920401	200 200	920721 920721	34.685 34.674	+0.011	34.680	34.674 -0.006
3	274	1- 0N	151- 0W	1 34	38	R4682 R4683	910916 910916	920326 920326	192 192	930107 930107	34.868 34.876	-0.008	34.872	34.869 -0.003
3	274	1- 0N	151- 0W	1 33	67	R4680 R4681	910916 910916	920324 920324	190 190	920721 920721	35.037 35.032	+0.005	35.035	35.033 -0.002
3	274	1- 0N	151- 0W	1 30	154	R4678 R4679	910916 910916	920320 920320	186 186	920721 920721	34.807 34.798	+0.009	34.803	34.805 +0.002
3	274	1- 0N	151- 0W	1 27	278	R4676 R4677	910916 910916	920320 920320	186 186	920721 920721	34.833 34.832	+0.001	34.833	34.836 +0.003
3	274	1- 0N	151- 0W	1 25	354	R4674 R4675	910916 910916	920306 920306	172 172	920721 920721	34.788 34.792	-0.004	34.790	34.792 +0.002
3	274	1- 0N	151- 0W	1 36	393	R4684 R4685	910916 910916	920318 920318	184 184	930107	34.750		34.750	34.754 +0.004
3	274	1- 0N	151- 0W	1 18	801	R4670 R4671	910916 910916	920306 920306	172 172	920721 920721	34.544 34.544	+0.000	34.544	34.548 +0.004

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA		BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
										ANALYS.	SALINITY				
3	274	1- 0N 151- 0W	1 16	1007	R4688 R4689	910916	920305	171	920721	34.549					
						910916	920305	171	920721	34.553	-0.004	34.551	34.555	+0.004	
3	274	1- 0N 151- 0W	1 14	1368	R4686 R4687	910916	920305	171	920428	34.588					
						910916	920305	171	920428	34.584	+0.004	34.586	34.590	+0.004	
3	274	1- 0N 151- 0W	1 12	1778	R4684 R4685	910916	920303	169	920428	34.620					
						910916	920303	169	920428	34.622	-0.002	34.621	34.625	+0.004	
3	274	1- 0N 151- 0W	1 4	3128	R4682	910916	920303	169	920721	34.678		34.678	34.677	-0.001	
3	286	3- 0N 151- 0W	1 35	7	R4690 R4691	910918	911218	90	920428	34.757					
						910918	911218	91	920428	34.754	+0.003	34.756	34.755	-0.001	
3	286	3- 0N 151- 0W	1 10	3084	R4687 R4688	910918	911217	90	920428	34.674					
						910918	911217	90	920428	34.676	-0.002	34.675	34.674	-0.001	
3	290	5- 0N 151- 0W	1 36	8	R4714 R4715	910920	920227	161	920428	34.482					
						910920	920227	160	920428	34.485	-0.003	34.484	34.483	-0.001	
3	290	5- 0N 151- 0W	1 34	81	R4712 R4713	910920	920227	160	920428	34.975					
						910920	920302	164	920428	34.974	+0.001	34.975	34.977	+0.002	
3	290	5- 0N 151- 0W	1 33	120	R4710 R4711	910920	920227	160	920721	34.920					
						910920	920227	160	920428	34.922	-0.002	34.921	34.925	+0.004	
3	290	5- 0N 151- 0W	1 31	205	R4708 R4709	910920	920225	158	920428	34.626					
						910920	920225	158	920428	34.621	+0.005	34.624	34.625	+0.001	
3	290	5- 0N 151- 0W	1 29	296	R4706 R4707	910920	920225	158	920721	34.632					
						910920	920225	158	920721	34.647	-0.015	34.640	34.655	+0.015	
3	290	5- 0N 151- 0W	1 27	411	R4704 R4705	910920	920224	157	920721	34.637					
						910920	920224	157	920721	34.648	-0.011	34.643	34.645	+0.002	
3	290	5- 0N 151- 0W	1 23	616	R4702 R4703	910920	920220	153	920428	34.597					
						910920	920220	153	920428	34.593	+0.004	34.595	34.601	+0.006	
3	290	5- 0N 151- 0W	1 20	924	R4700 R4701	910920	920220	153	920428	34.551					
						910920	920220	153	920428	34.547	+0.004	34.549	34.554	+0.005	

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	SHORE DATA					SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
								EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	
3	290	5- 0N	151- 0W	1 18	1230	R4698 R4699	910920 910920	920220 920220	153 153	920428 920428	34.571 34.569	+0.002	34.570	34.574 +0.004
3	290	5- 0N	151- 0W	1 16	1642	R4696 R4697	910920 910920	920218 920218	151 151	920428 920428	34.606 34.608	-0.002	34.607	34.611 +0.004
3	290	5- 0N	151- 0W	1 14	2054	R4694 R4695	910920 910920	920218 920218	151 151	920428 920428	34.636 34.638	-0.002	34.637	34.640 +0.003
3	290	5- 0N	151- 0W	1 9	3089	R4692 R4693	910920 910920	920218 920218	151 151	920428 920428	34.670 34.673	-0.003	34.672	34.678 +0.006
3	294	6-58N	151-22W	1 36	10	R4718 R4719	910921 910921	920213 920213	145 145	920428 920428	33.931 33.940	-0.009	33.936	33.934 -0.002
3	294	6-58N	151-22W	1 10	3191	R4716 R4717	910921 910921	920214 920214	146 146	920428 920428	34.675 34.674	+0.001	34.675	34.679 +0.004
3	298	8-56N	151-45W	1 36	16	R4722 R4723	910922 910922	920211 920211	142 142	920428 920428	33.795 33.797	-0.002	33.796	33.797 +0.001
3	298	8-56N	151-45W	1 9	3058	R4720 R4721	910922 910922	920210 920210	141 141	920428 920428	34.670 34.669	+0.001	34.670	34.672 +0.002
3	302	10-54N	152- 7W	1 36	8	R4746 R4747	910923 910923	920206 920206	136 136	920428 920428	33.814 33.816	-0.002	33.815	33.818 +0.003
3	302	10-54N	152- 7W	1 34	60	R4744 R4745	910923 910923	920206 920206	136 136	920428 920428	34.486 34.479	+0.007	34.483	34.480 -0.003
3	302	10-54N	152- 7W	1 32	110	R4742 R4743	910923 910923	920204 920204	134 134	920428 920428	34.421 34.425	-0.004	34.423	34.422 -0.001
3	302	10-54N	152- 7W	1 29	212	R4740 R4741	910923 910923	920204 920204	134 134	920428 920428	34.594 34.594	+0.000	34.594	34.597 +0.003
3	302	10-54N	152- 7W	1 27	314	R4738 R4739	910923 910923	920203 920203	133 133	920428 920428	34.587 34.587	+0.000	34.587	34.591 +0.004
3	302	10-54N	152- 7W	1 26	416	R4736 R4737	910923 910923	920203 920203	133 133	920428 920428	34.555 34.557	-0.002	34.556	34.558 +0.002

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA.....				SHIPBOARD SALINITY o/oo	DELTA (SHIP- SHORE)
										ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE AVG o/oo		
3	302	10-54N	152- 7W	1 24	621	R4734 R4735	910923 910923	920130 920130	129 129	920428 920428	34.512 34.513	-0.001	34.513	34.518	+0.005
3	302	10-54N	152- 7W	1 21	928	R4732 R4733	910923 910923	920130 920130	129 129	920428 920428	34.545 34.544	+0.001	34.545	34.548	+0.003
3	302	10-54N	152- 7W	1 19	1237	R4730 R4731	910923 910923	920129 920129	128 128	920428 920428	34.577 34.576	+0.001	34.577	34.580	+0.003
3	302	10-54N	152- 7W	1 17	1647	R4728 R4729	910923 910923	920129 920129	128 128	920428 920428	34.608 34.608	+0.000	34.608	34.611	+0.003
3	302	10-54N	152- 7W	1 15	2058	R4726 R4727	910923 910923	920128 920128	127 127	920428 920428	34.639 34.639	+0.000	34.639	34.646	+0.007
3	302	10-54N	152- 7W	1 10	3086	R4724 R4725	910923 910923	920128 920128	127 127	920428 920428	34.673 34.675	-0.002	34.674	34.675	+0.001
3	306	12-52N	152-30W	1 36	9	R4750 R4751	910924 910924	920210 920210	139 139	920428 920428	34.093 34.094	-0.001	34.094	34.093	-0.001
3	310	14-50N	152-53W	1 36	9	R4754 R4755	910926 910926	911219 911219	83 84	920428 920428	34.156 34.157	-0.001	34.157	34.158	+0.001
3	310	14-50N	152-53W	1 12	3081	R4752 R4753	910926 910926	911218 911218	83 83	920428 920428	34.670 34.670	+0.000	34.670	34.673	+0.003
3	314	16-48N	153-16W	2 36	9	R4778 R4779	910927 910927	920122 920122	118 117	920428 920428	34.572 34.569	+0.003	34.571	34.572	+0.001
3	314	16-48N	153-16W	2 34	76	R4776 R4777	910927 910927	920121 920121	116 116	920428 920428	34.861 34.862	-0.001	34.862	34.863	+0.001
3	314	16-48N	153-16W	2 33	107	R4774 R4775	910927 910927	920121 920121	116 116	920428 920428	34.980 34.980	+0.000	34.980	34.982	+0.002
3	314	16-48N	153-16W	2 30	216	R4772 R4773	910927 910927	920117 920117	112 112	920428 920428	34.352 34.352	+0.000	34.352	34.355	+0.003

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD AND ON SHORE (cont.)

LEG	STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	SHORE DATA ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD AVG SALINITY o/oo	DELTA (SHIP- SHORE)
3	314	16-48N	153-16W	2 28	318	R4770 R4771	910927 910927	920116 920116	111 111	920428 920428	34.166 34.166	+0.000	34.166	34.168	+0.002
3	314	16-48N	153-16W	2 25	442	R4768 R4769	910927 910927	920116 920116	111 111	920428 920428	34.487 34.480	+0.007	34.484	34.484	+0.000
3	314	16-48N	153-16W	2 22	676	R4768 R4767	910927 910927	920115 920115	110 110	920428 920428	34.476 34.474	+0.002	34.475	34.479	+0.004
3	314	16-48N	153-16W	2 20	933	R4764 R4765	910927 910927	920115 920115	110 110	920428 920428	34.503 34.508	-0.005	34.506	34.517	+0.011
3	314	16-48N	153-16W	2 18	1291	R4762 R4763	910927 910927	920114 920114	109 109	920428 920428	34.562 34.557	+0.005	34.560	34.563	+0.003
3	314	16-48N	153-16W	2 16	1698	R4760 R4761	910927 910927	920108 920108	103 103	920428 920428	34.605 34.598	+0.007	34.602	34.604	+0.002
3	314	16-48N	153-16W	2 14	2113	R4758 R4759	910927 910927	920108 920108	103 103	920428 920428	34.630 34.626	+0.004	34.628	34.635	+0.007
3	314	16-48N	153-16W	2 9	3201	R4756 R4757	910927 910927	920107 920107	102 102	920428 920428	34.670 34.669	+0.001	34.670	34.673	+0.003

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COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD (ON DIC SAMPLE DATE) AND ON SHORE (ON DIC EXTRACTION DATE)

LEG STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SHORE DATA		BOTTLE DELTA	BOTTLE o/oo	SHIPBOARD o/oo	DELTA (SHIP- SHORE)
										SALINITY					
143	19-00S	30-01W	3 18	1593	R4934	910216	910705	139	911017	34.921					
					R4935	910216	910709	143	911017	34.931	-0.010	34.926	34.940	+0.014	
143	19-00S	30-01W	3 12	2995	R4932	910216	910709	143	911017	34.897					
					R4933	910216	910726	160	911017	34.904	-0.007	34.901	34.921	+0.020	
154	19-00S	23-15W	2 24	8	R4938	910221	910628	127	911017	37.168					
					R4939	910221	910701	130	911017	37.175	-0.007	37.172	37.217	+0.045	
187	19-12S	08-12W	2 24	7	R4956	910303	910705	124	911017	36.561					
					R4957	910303	910731	150	911017	36.518	+0.043	36.540	36.553	+0.013	
187	19-12S	08-12W	3 18	1194	R4962	910303	910709	128	911017	34.672					
					R4963	910303	910709	128	911017	34.676	-0.004	34.674	34.697	+0.023	
187	19-12S	08-12W	3 12	2492	R4961	910303	910705	124	911017	34.878		24.878	34.912	+0.034	
199	19-00S	01-54W	2 2	898	R4964	910307	910701	116	911017	34.506					
					R4965	910307	910701	116	911017	34.505	+0.001	34.506	34.513	+0.007	

DATES:

SAMPLE DATE = DATE OF THE DIC AND SHIPBOARD SALINITY SAMPLE
EXTRACTION DATE = DATE OF DIC EXTRACTION AND DATE OF
SUBSAMPLE FOR SHORE SALINITY
ANALYSIS DATE = DATE OF SHORE SALINITY ANALYSIS BY ODF

BOTTLE TYPE:

R = RODAVISS S = S TYPE

STORAGE:

E-S = (DIC EXTRACTION DATE - DIC SAMPLE DATE), IN DAYS

THE CARBON DIOXIDE PROJECT OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
F/S Meteor Leg 18 1991 Atlantic WOCE Line A1E

Table 5e

COMPARISON OF SALINITY DATA FOR SUBSAMPLES TAKEN SHIPBOARD (ON DIC SAMPLE DATE) AND ON SHORE (ON DIC EXTRACTION DATE)

LEG STATION	LAT.	LONG.	CAST NISK	DEPTH (M)	SAMPLE BOTTLE	SAMPLE DATE	SHORE DATA				SHIPBOARD AVG SALINITY o/oo	DELTA (SHIP- SHORE)
							EXTRAC DATE	STORAGE (E-S)	ANALYS. DATE	SALINITY o/oo	BOTTLE DELTA	BOTTLE o/oo
575	59- 1N	32-46W	1 24	11	R4830	910909	940214	889				
					R4831	910909	940214	889				34.721
575	59- 1N	32-46W	1 13	1101	R4828	910909	940211	886				
					R4829	910909	940211	886				34.901
580	58-19N	29-56W	1 23	28	R4842	910910	940216	890				
					R4843	910910	940216	890				34.948
580	58-19N	29-56W	1 1	2333	R4838	910910	940214	888				
					R4839	910910	940214	888				34.977
581	58-11N	29-37W	1 2	2008	R4844	910910	940127	870				
					R4845	910910	940127	870				34.975
596	45-22N	25-57W	1 14	689	R4874	910914	940215	885				
					R4875	910914	940215	885				34.991
603	52-51N	22-23W	1 1	3984	R4878	910916	940215	883				
					R4879	910916	940215	883				34.915

DATES:

SAMPLE DATE = DATE OF THE DIC AND SHIPBOARD SALINITY SAMPLE

EXTRACTION DATE = DATE OF DIC EXTRACTION AND DATE OF

SUBSAMPLE FOR SHORE SALINITY

ANALYSIS DATE = DATE OF SHORE SALINITY ANALYSIS BY ODF

BOTTLE TYPE:

R = RODAVISS

S = S TYPE

STORAGE:

E-S = (DIC EXTRACTION DATE - DIC SAMPLE DATE), IN DAYS

APPENDIX 6

SIO Shore Based CO₂ Sampling Instructions

30 MAY 91

Keeling-Guenther Total Carbon

SIO SHORE BASED CO₂ SAMPLING INSTRUCTIONS for Pacific
WOCE Legs 1 - 3 on R/V *Thomas Washington*, May to October, 1991

GENERAL PRECAUTIONS

Draw samples immediately following the shipboard CO₂ samples, as soon as possible after the Niskin bottle is opened.

Fill the two glass 500 ml sample bottles one after the other as quickly as possible to minimize the loss of CO₂ gas.

The chief concern in the collection of these stored samples is the prevention of leakage. The following steps must be done correctly: (1) An air space of 5 cc is left in the bottle. (2) The bottle joint is prepared and greased properly. (3) The stopper holder is attached properly.

There are two kinds of stopper holders on the bottles. Most have a metal "bail" assembly (called "Standard Corning Bottles" in these instructions) and require special attention before and after collection of the samples. NOTE ESPECIALLY STEPS (1) AND (13).

STEP BY STEP PROCEDURES

(1) SELECT AND PREPARE THE BOTTLES

Please try to use the boxes in numerical order (1 -19 on Leg 1, 1 - 20 on Leg 2 and 1 - 15 on Leg 3). Within each box fill the bottles in the "usual" order from left to right beginning with the marked position at the upper left.

Glass bottles are numbered on yellow labels. Record these numbers in correlation with Niskin cast and bottle numbers.

(a) Standard Corning Bottles. Bottle numbers begin with an "S".

These bottles have hollow stoppers held on with a metal "bail" type stopper holder. The stoppers have been ground individually to fit the bottles and must not be interchanged (stopper and bottle have matching numbers on decals). The metal bail assemblies have been tightened prior to shipment. Use the supplied Allen wrench to loosen the assemblies on all bottles to be used on the upcoming station.

(b) "Rodaviss" Joint Bottles. Bottle numbers begin with an "R".

These have solid stoppers held on with a plastic knurled nut assembly.

(2) CHECK THE ACCESSORIES

The following accessories are required:

- (a) Saturated aqueous HgCl_2 solution
- (b) 100-microliter Eppendorf pipette with yellow tip (or other device to add this amount of solution)
- (c) Plastic pipette with bulb ("kitchen baster")
- (d) One sample data sheet for each station sampled.
- (e) Paper cleansing tissues (Kimwipes) and a Kimwipe wrapped around an applicator stick.
- (f) Tygon drawing tube (pretreat by soaking in clean sea water for at least one day)
- (g) Apiezon "L" grease in a plastic 20ml syringe (refill from supplied tubes of grease when empty)
- (h) "Loctite" for Step (13) after all bottles from station are collected.

(3) GREASE THE STOPPER

When you are ready to sample, temporarily remove the stopper from the first bottle, and wipe the stopper with a Kimwipe to remove as much grease as possible. Then regrease the stopper with four thin vertical strips of grease using the syringe, spaced equidistant around the stopper. Set the stopper aside so that the grease does not get disturbed. (NOTE: If conditions do not allow this, do the greasing immediately prior to stopper insertion (Step (9)). *Do not remove the grease from the bottle opening. (see step (8)).*

(4) ATTACH THE DRAWING TUBE TO THE NISKIN BOTTLE

The Tygon tubing must be long enough to reach to the bottom of the sample bottle. Check that the vent is open on the top of the Niskin bottle.

(5) FILL THE SAMPLE BOTTLE

First enter the present time on the data sheet for the bottle (first or second) being filled. Then open the Niskin bottle drain. Flush the drawing tube with about 50ml of water. Then flow another 50ml water into the bottle. Swirl the water around and discard it. Then begin filling the bottle from the bottom. Determine with a watch the time it takes to fill the bottle. Allow the bottle to overflow for at least one-half the filling time.

(6) REMOVE EXCESS WATER

Using the plastic pipette, suck out the water in the sample bottle so that an air space of about 5 cc will remain in the bottle after replacing the stopper.

- (a) **Standard Corning Bottles.** Lines have been drawn on the bottles to show the 5 cc air space. Adjust the bottle volume so that the

meniscus is centered on this line, as viewed from the top.

- (b) **"Rodaviss" Joint Bottles.** The "bulging" vertical section of the bottle between the greased joint and the sloping shoulder of the bottle holds a 5 cc air space.

(7) ADD MERCURY SOLUTION

Using the Eppendorf pipette, add 100 μ l of the saturated aqueous HgCl₂ solution to the sample bottle. If a glass medicine dropper must be used, add 2 drops.

(8) SWAB THE SAMPLE BOTTLE JOINT

Remove any water remaining on the pregreased bottle neck. (Normally this water will be beaded up in a few small droplets.) Use the Kimwipe wrapped on the applicator stick.

(9) INSERT AND SECURE THE STOPPER

Insert the previously greased stopper straight into the sample bottle neck. Squeeze the air out of the grease to make a good seal. Do not turn the stopper until the grease has spread completely around the joint. Check that an air space of about 5 cc remains in the bottle.

- (a) **Standard Corning Bottles.** After the greased seal has been made, secure the stopper by tightening the top screw on the bail firmly down onto the stopper. *Finger tight is sufficient at this point.*

- (b) **"Rodaviss" Joint Bottles.** Simply insert the stopper into the the joint and screw down the nut firmly finger tight to slightly compress the enclosed O - ring.

(10) REPEAT THE PROCEDURE

Go immediately to step (3) to fill the second sample bottle. (The beginning of filling of the second bottle should be within 3 minutes of the beginning of the filling of the first bottle.) (Skip Step (4).) Do steps (5) through (9). Then proceed to instruction (11) below.

(11) FILL OUT THE DATA SHEET

Please enter the station particulars at the top of the sheet and identify all bottles filled with Niskin cast and bottle numbers and nominal depths. Enter preliminary water temperature and salinity if known. Please report any deviations in procedure or problems, for example a delay in filling the second bottle, in the "Remarks" section.

(12) REPACK THE BOTTLES

Shake the bottles gently to disperse the HgCl_2 solution. Check that the stoppers are firmly installed. Return the bottles to their packing box. Place the data sheet into the box with the bottles.

(13) TIGHTEN STOPPER HOLDERS

After the station is over, the bail assemblies on the Standard Corning Bottles need to be tightened. First add a drop of "Loctite" to the screw just above the bail as shown on the diagram. Then, using the Allen wrench, tighten the screw about one half turn beyond finger tight. The bail assembly should be firmly in place and not easily turned.

If a stopper holder breaks or doesn't work, please wrap several turns of electrical tape around the bottle from top to bottom to secure the stopper.

(14) STORE THE BOXES

The samples ideally should be stored refrigerated, but not frozen, to best preserve the greased stopper seals and to slow down reactions with the glass surface. If this is impossible, please store them in a cool, air conditioned area of the ship. Since light is also detrimental to the grease, the samples are best stored within their boxes at all times. Before stowing the boxes, secure the box lids with the enclosed "tie wraps."

SUMMARY OF SAMPLING INSTRUCTIONSKeeling-Guenther Total Carbon
Page 5

APPENDIX 7

**Laboratory method for total dissolved inorganic carbon
and titration alkalinity***Determination of DIC in sea water*

We have developed a manometric procedure for measuring dissolved inorganic carbon (DIC), based on initial work of C. S. Wong [1970] in our laboratory. Water samples collected at sea in borosilicate reagent bottles are stored at 5°C, then warmed to 20°C just prior to analysis. Pipettes equipped with vacuum stopcocks are evacuated, cleaned, and weighed to ± 1 mg. The sample bottle is opened and an aliquot of about 40 g of seawater is taken from the bottle by forcing water under pressure of compressed air through the pipette. The pipette is flushed, by displacing one extra volume of water, and then closed off, cleaned, dried, and reweighed. The sample weight, about 40 g, is determined to 1 part in 40,000, and the pipette is attached to a vacuum extraction system, as shown in Figure 1.

After evacuating the system to a pressure of about 1 mTorr, the seawater is flowed into an extraction chamber, followed by 40 ml of a degassed one-molar solution of phosphoric acid which converts all carbonate and bicarbonate of the DIC to CO₂ gas. The gas is then sucked slowly through a trap cooled with dry ice in ethanol, which removes most of the water vapour and then through a trap cooled with liquid nitrogen, which freezes out the CO₂. Additional vacuum sublimations purify the CO₂, after which the gas is transferred into a glass storage tube. The amount of extracted CO₂ gas is determined using either a constant volume, mercury column manometer and/or a quartz spiral manometer.

If the mercury manometer is used, the CO₂ gas sample is transferred into the appropriate chamber of the manometer and brought to constant temperature. The mercury level in the manometer is raised into near contact with a glass pointer, at which time the heights of the this mercury column and a connecting reference column under vacuum are measured to a precision of about 5 micromoles using a special cathetometer mounted on a precisely calibrated screw. The amount of CO₂ gas is calculated from the manometric data using a virial equation of state. The DIC concentration in $\mu\text{m/kg}$ is calculated from the amount of CO₂ gas and the weight of seawater extracted.

If the quartz spiral manometer is used, the sample is similarly transferred and brought to constant temperature. The manometer then measures the pressure of the CO₂ gas sample to high precision relative to a set of gas samples which are

Appendix 7, Figure 1. Schematic of vacuum line used to extract CO_2 gas quantitatively from dissolved inorganic carbon (DIC) in sea water.

periodically measured on the constant volume mercury manometer.

Precision of DIC Analyses

The constant volume mercury manometer has been exhaustively calibrated in connection with the atmospheric CO₂ program at SIO. The quartz spiral manometer is calibrated with standards measured on the constant volume manometer. For each day in which quartz spiral measurements are made, a factor is determined which relates the pressure on an arbitrary counter scale to the number of moles of gas in the manometric standards. This factor then relates the pressure of a given seawater sample to the amount of gas in that sample. Many seawater samples from our time-series stations have been measured on both the mercury manometer and the original quartz spiral manometer in use from 1981 to 1992. These data provide a definitive basis for calculating the imprecision of the quartz spiral manometer compared to the constant volume mercury manometer. For 136 samples measured on both manometers the standard deviation for individual differences is 0.75 $\mu\text{mole/kg}$.

Additional estimates of the imprecision of the DIC analyses are obtained from data on replicate sea water samples (usually pairs) summarized as follows:

Year	Station/ Cruise	Ocean	No. of Bottle Pairs	Standard Deviation of Individual Analysis ($\mu\text{M/kg}$)	Device
1983-1989	BERMUDA TIME SERIES	N. Atlantic	101	0.71	CV
1979-1987	NEAR TAHITI TIME SERIES	S. Pacific	68	0.70	CV
1988	SAVE legs 1-3	S. Pacific	52	0.69	QS
1988	WECOMA	Equatorial Pacific	14	0.82	QS
1989	ROUNABOUT	Equatorial Pacific	31	0.69	QS

Note: CV = constant volume manometer, QS = quartz spiral manometer

Accuracy of DIC Analysis. The constant volume manometer has been exhaustively calibrated in connection with measurements of atmospheric CO₂. As a further check, we carried out a series of assays of Baker's Ultrex sodium carbonate which had first been brought to constant weight following recommended procedures. Each weighed carbonate sample was placed in the extraction apparatus used routinely for sea water samples. It was acidified with the same acid solution, and the evolved CO₂ was then analyzed manometrically. The mean of 11 assays was $100.50 \pm .05\%$; thus a systematic error of 1 part in 2000.

Our accuracy of analysis is thus likely to be within a factor two of our precision. This result is made possible because of the fundamental simplicity of our method: we remove CO₂ quantitatively from an accurately weighed amount of sea water, and we determine the evolved gas with a manometer which is calibrated to such high accuracy with respect to volume, temperature and pressure that we achieve an overall accuracy of 1 part in 2000 and a precision of 1 part in 4000.

Determination of ALK in sea water (gravimetric method)

The development of the instrumentation and procedure for measuring alkalinity followed the work of Dickson [1981] and his cited predecessors. The sea water samples remaining after analysis of aliquots for DIC as described above were titrated in a closed, jacketed glass cell manufactured by Metrohm (#EA 880 T-V). Figure 2 illustrates the system. A Dosimat burette system (Metrohm model 655) with a precision glass tip delivered titrant to the cell. The reversible cell potential (emf) was measured in the solution by either an Orion combination electrode (model 81-02) or a Radiometer combination electrode (model GK2402C), a high impedance voltage follower, and a Hewlett Packard (HP) voltmeter (model 3478A) with one microvolt sensitivity. The cell was designed to compensate for the additional titrant volume by compressing a vinyl bladder inserted into the solution.

The titrations were controlled using an HP 86B desktop computer connected to the Dosimat with an HP 82940A GP-IO interface, and to the voltmeter with an IEEE 488 interface. For each step in the titration, the computer activated the Dosimat and recorded the acid volume, emf data, and time at one second intervals.

The hydrochloric acid, used as titrant, was prepared in batches of 4 to 20 liters using a concentrated HCl solution (Fisher cat # SA49) and Milli-Q water, at a concentration of about 0.22 mol/kg. Reagent grade sodium chloride (Fisher #S271-10) was added to the acid to give a total ionic strength of 0.7 [Dyrssen and Sillén, 1967].

Appendix 7, Figure 2. Diagram of gravimetric titration alkalinity system.

Titration Procedure

Each sample bottle was first wiped dry and a filling adapter inserted into the greased joint, as shown in Figure 2. This bottle assembly was weighed on a digital top-loading balance to a precision of 0.01 grams. The titration cell, rinsed with Milli-Q water and wiped dry after the previous titration, was assembled with the thermometer and the burette tip. The sample was dispensed into the cell by pressurizing the head space with nitrogen gas while observing the solution level through an opening in the cell top. When nearly full, the pressure in the bottle was released, and the cell top was stoppered, trapping about 5 cc of air in contact with the solution. The bottle was weighed again, and the weight of solution dispensed into the cell was determined by difference, typically 170-180 grams. After recording the temperatures of the cell and acid and measuring the emf for 3 to 5 minutes, the titrant was added in 0.100 ml increments until a final volume of 2.2 ml was attained. Shortly before the bicarbonate equivalence point was attained, the titrant increments were reduced to 0.020 ml to obtain more closely spaced data.

During the titration the emf was recorded once per second, beginning two seconds after addition of acid. The extent of reaction, observed as the rate of change in emf, was plotted for each titration step. A change in emf not greater than 10 microvolts over a 5 second interval was considered to indicate that the solution had attained equilibrium with the titrant, and after 4 such increments were recorded, the next titrant dose was delivered. A complete titration took about 40 minutes.

The measurements of emf with respect to each volume of HCl titrant were processed using a non-linear least squares minimization procedure described by Dickson [1981].

Sea water standards for DIC and Alkalinity.

Our primary standards consist of sodium carbonate and sodium chloride dissolved together in highly purified water. The carbonate is brought to constant weight at 275°C. We assay the salt for total carbon by evolving CO₂ which is afterwards measured manometrically. The titration alkalinity of each individual standard is determined immediately after preparation and compared to the value expected from the gravimetric data. Using various proportions of carbonate and chloride salts we have established that the sodium chloride which we use contains a small fraction of alkaline impurities which we treat as a constant alkaline blank. We compare the alkalinity of these primary standards with the results of differential titrations of sodium borate decahydrate, and we use the resulting data from both types of standards to assign a normality to the

hydrochloric acid solution used in our titrations.

Our secondary standards consist of sodium carbonate and sodium chloride, dissolved in purified water, and converted to lower pH and to ambient $p\text{CO}_2$ by bubbling laboratory air through the solution. The standard solutions, prepared in 20 to 50 liter batches, are stored in glass 1-liter bottles of vitreous quartz or borosilicate. We immediately determine the titration alkalinity and DIC on approximately 8 aliquots drawn from two such bottles. We analyze the remaining solutions periodically with respect to both DIC and alkalinity, and we overlap batches to provide continuity.

We have achieved a combined bottle and analysis imprecision (1 sigma) of 1.38 $\mu\text{M/kg}$ for DIC and 1.45 $\mu\text{Eq/kg}$ for titration alkalinity on replicate bottles of our secondary standards analyzed repetitively over periods as long as 1 year. These results, taken together with comparable results for pairs of sea water sample analyzed for DIC and alkalinity up to two years apart, indicate our secondary standards are stable over that period of time.

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