RADIOCARBON, Vol 46, Nr 3, 2004, p 1161–1187

CARIACO BASIN CALIBRATION UPDATE: REVISIONS TO CALENDAR AND ^{14}C CHRONOLOGIES FOR CORE PL07-58PC

Konrad A Hughen[1,2] • John R Southon[3] • Chanda J H Bertrand[1] • Brian Frantz[4] • Paula Zermeño[4]

ABSTRACT. This paper describes the methods used to develop the Cariaco Basin PL07-58PC marine radiocarbon calibration data set. Background measurements are provided for the period when Cariaco samples were run, as well as revisions leading to the most recent version of the floating varve chronology. The floating Cariaco chronology has been anchored to an updated and expanded Preboreal pine tree-ring data set, with better estimates of uncertainty in the wiggle-match. Pending any further changes to the dendrochronology, these results represent the final Cariaco 58PC calibration data set.

INTRODUCTION

Calibration of the radiocarbon time scale is critical in order to fully utilize this important dating tool as a tracer of geochemical and geophysical processes. Tree-ring chronologies provide high-resolution calibration back to ~12,400 cal BP (Friedrich et al., this issue), but dendrochronologies beyond that age are currently "floating" and not anchored in absolute age (Kromer et al., this issue). For the previous IntCal98 data set (Stuiver et al. 1998), high-resolution calibration data older than tree rings were provided by Cariaco Basin piston core PL07-PC56 (Hughen et al. 1998). Core 56PC was selected for ^{14}C dating from a suite of 4 adjacent piston cores, mostly due to the quality of its high-resolution grayscale record. The core was sampled every 10 cm, yielding approximately 100- to 200-yr resolution. Cariaco piston core PL07-58PC, on the other hand, has a ~25% higher deposition rate than 56PC (Peterson et al. 1990). Core 58PC was sampled every 1.5 cm, providing ^{14}C calibration at 10–15-yr resolution throughout the period of deglaciation, ~10,500–14,700 cal BP (Hughen et al. 2000). Until now, however, these data were never converted into a smoothed curve, or combined with other data sets for use in calibration. The methodologies for combining 58PC data with tree-ring and coral data for the IntCal04 atmospheric and marine ^{14}C calibration curves are described elsewhere in this volume (Reimer et al., this issue; Hughen et al., this issue). Here, we present the updated anchoring of the floating Cariaco varve chronology to the revised and extended German pine chronology (Friedrich et al., this issue). In addition, we detail the changes made to the calendar age varve chronology between the publication of the 56PC and 58PC ^{14}C calibrations, and summarize the ^{14}C sample treatment and statistics for accelerator mass spectrometry (AMS) measurement of blanks and small samples for this work.

VARVE CHRONOLOGY

In order to visually analyze and count varves in unconsolidated Cariaco sediments, a continuous strip of ~7-cm blocks with ~1-cm overlaps was embedded in epoxy resin and subsequently processed into polished petrographic thin sections (Hughen et al. 1996). Acetone exchanges followed by resin exchanges (Clark 1988), as well as freeze-drying, were used to remove water from interstitial spaces and allow the resin to penetrate fully into the sediments (Hughen et al. 1996). Thin sections were analyzed under a light microscope to determine the internal structure and composition of individual light and dark laminae, and to count and measure varves. A video camera connected to the light microscope captured digital images that were processed using NIH Image analysis soft-

[1]Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA.
[2]Corresponding author. Email: khughen@whoi.edu.
[3]Department of Earth Systems Science, University of California-Irvine, Irvine, California, USA.
[4]Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore, California, USA.

ware. The original 1998 varve chronology (Hughen et al. 1998) was counted using both thin sections and digital images where the laminations were thick and distinct (Figure 1). However, approximately one-third of the sediment sequence contains darker-colored sediments with thinner, relatively indistinct laminae (Figure 2). For the calibration from core PL07-56PC (Hughen et al. 1998), several of these indistinct sections were interpreted as bioturbated, and varve thickness averaged over adjacent intervals with thicker varves was used to interpolate through these sections.

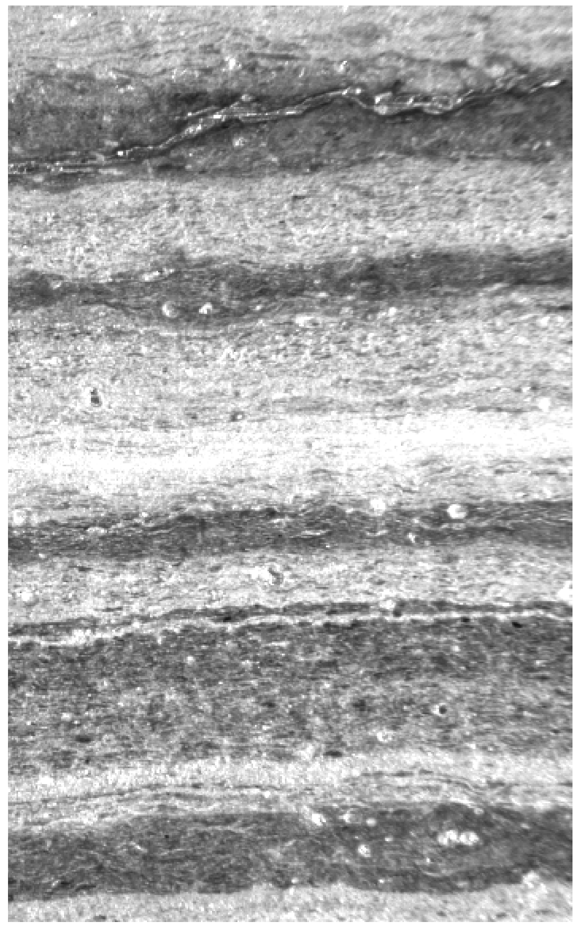

Figure 1 Thin section of Cariaco Basin varves from core PL07-58PC, 599–600 cm. These varves are from the Younger Dryas interval and are relatively thick, with distinct light-dark couplets. Thick, distinct varves such as these account for about 65% of the 10,500–14,700-BP section of 58PC covered by the detailed ^{14}C chronology. Image shows ~1 cm top to bottom.

For the high-resolution ^{14}C calibration from Cariaco PL07-58PC (Hughen et al. 2000), the entire sequence of sediment thin sections and digital photomicrographs was re-examined. Image enhancement of the digital images provided increased contrast and magnification to aid identification of laminations wherever they were thinner or less distinct. During reanalysis, many of the indistinct sections originally thought to have been bioturbated were found to have subtle laminations that could be traced across the thin section, more consistent with minimal bioturbation (Figure 2, top). Another hypothesis is that the varves in these sections are undisturbed but very thin and difficult to recognize using the normal interpretation of alternating laminae with the same distinct dark and light values as elsewhere in the core. Therefore, we adopted a revised protocol for identifying varves in these indistinctly laminated sediment sections. We interpreted each of the faint lamination couplets found within these sections as a single-year's varve. As reported earlier, there are infrequent sediment sections 1–2 cm thick, comprising a small minority (<1%) of the sediment sequence, that do not appear to contain laminations at all (Figure 2, bottom). For the 58PC varve chronology, average varve thicknesses measured immediately above and below these bioturbated sections were used to bridge the gaps.

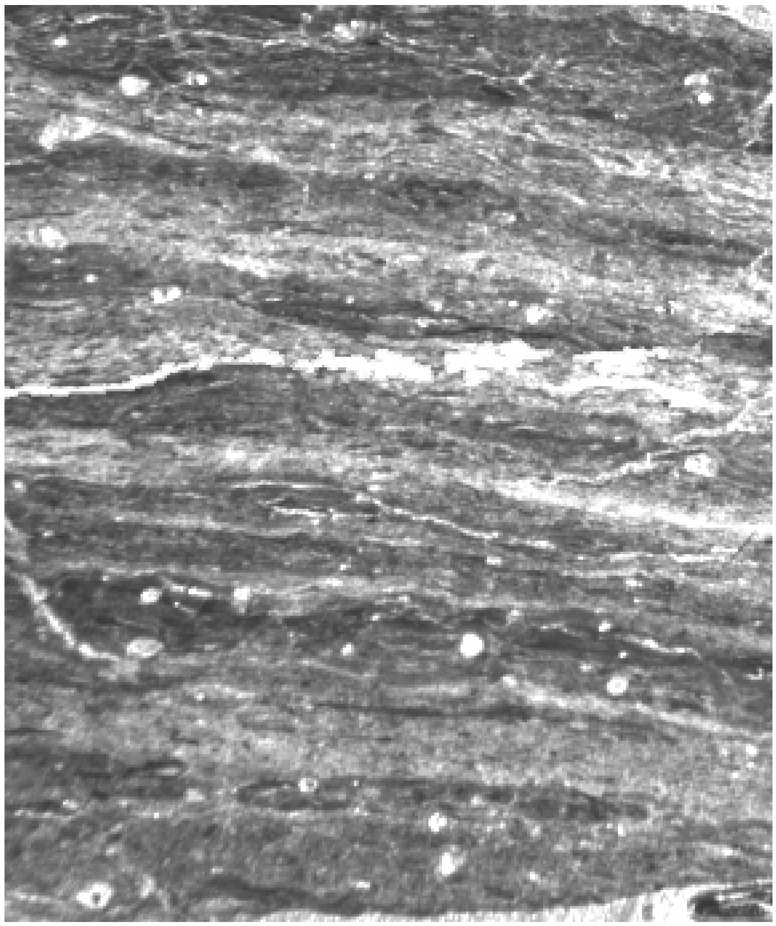

Figure 2 Thin section of Cariaco Basin varves from core PL07-58PC, 899–900 cm. These varves are from the Bølling interval and are relatively thin and indistinct compared to other Cariaco deglacial sediments. Approximately 35% of the 4200-yr 58PC record corresponds to weak banding such as this. The lower portion of the slide shows an example of potential microbioturbation, which occurs in <1% of the deglacial 58PC sediments. Image enhancement allows accurate identification and measurement of thin indistinct varves, whereas bioturbated sections require interpolation using averaged local sedimentation rates (see text). Cracks in the thin section occurred during the resin embedding procedure. Image shows ~8 mm top to bottom.

As a result of this reinterpretation, intervals of the varve chronology containing these faintly laminated sections were expanded as numerous thin varves were counted and added to the chronology. The majority of the chronology was unaffected; however, there were substantial changes in 2 discrete intervals (Figure 3). The earliest Bølling—a period where thick, distinct varves gradually transition from massive, bioturbated sediments of the Last Glacial—was extended with the result that the Bølling period grew by 25%, from 634 to 790 yr. Similarly, during the onset of the Younger Dryas, a large number of additional years lengthened the transition by 33%, from 150 yr to 200 yr. Differences in calendar ages for climate shifts between the 1998 and 2000 varve chronologies resulted from a combination of these discrete additions to the varve chronology as well as the match anchoring Cariaco to tree rings. The 2000 match to tree rings, using much higher resolution Cariaco data than in 1998, resulted in the Cariaco curve shifting to younger ages by ~85 yr. The longer transition into the Younger Dryas also increased the calculated duration of the event itself. If the Younger Dryas is measured from the mid-points of the transitions into and out of the event, the duration is 1335 yr. If the Younger Dryas is defined exclusively by the period of minimum (grayscale) values, its duration is 1235 yr. There is no evidence to support substantial changes in Cariaco sedimentation during the Younger Dryas, such as deposition of 4 couplets per year rather than two. Therefore, it is unlikely that the length of the Younger Dryas event measured in Cariaco Basin sediments can be much shorter than reported here.

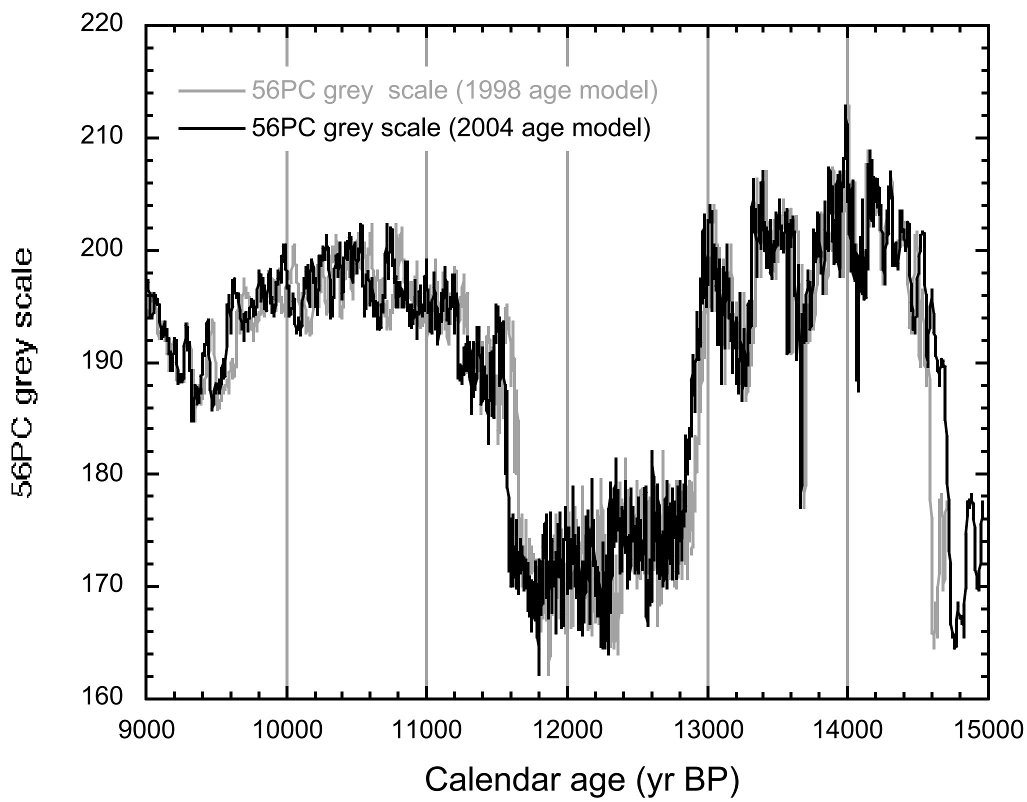

Figure 3 Cariaco Basin grayscale for the last deglaciation plotted versus old and newly revised calendar age. Calendar ages were derived by matching Cariaco ^{14}C variations to anchored tree-ring data sets. The gray line represents the 1998 varve chronology anchored using lower-resolution Cariaco ^{14}C data (Hughen et al. 1998). The black line shows the new chronology for this study resulting from reanalysis of the varves (Hughen et al. 2000), as well as matching the higher-resolution Cariaco ^{14}C data to a revised and extended tree-ring calibration (Friedrich et al., this issue).

The new 2004 match to a revised and extended tree-ring chronology (this work—described below) has shifted the Cariaco chronology back older by 14 yr, but there are no other changes relative to the 2000 varve chronology. The age of the Younger Dryas/Preboreal transition is now placed in the Cariaco chronology at 11,580 cal BP.

^{14}C CHRONOLOGY

Sample Preparation

The PL07-58PC core was cut into 1.5-cm-long sections, and *Globigerina bulloides* samples (10 mg of carbonate, typically 2000 foram tests) were picked from the >250-µm sediment fraction after wet sieving. Since our AMS backgrounds and uncertainties are size-dependent (Brown and Southon 1997; Kirner et al. 1997), we used large samples (1 mg of carbon) wherever possible. In some of the deeper sections of the core, notably around 845–860 cm and 900–910 cm, there were insufficient *bulloides* in a 1.5-cm slice to provide full-sized samples, and mixed planktonic samples (usually *bulloides*-rich) were used. Results from mixed planktonic and *bulloides* samples in other core intervals (Table 1) show no evidence of systematic age offsets. When duplicate samples were required, they were obtained from the upper part of the core by repicking *bulloides* from >250-µm sediments, or from the 150–250-µm fraction if the larger fraction was exhausted. In some of the lower sections of the core where *bulloides* were less common (e.g. 860–870 and 930–945 cm), duplicates were mixed assemblage samples from the >250-µm fraction.

Samples were sonicated in methanol for a few seconds immediately after picking. In the AMS laboratory, a small fraction of the calcite (<1%) was removed by leaching for a few minutes in ~1 mL of 0.001N HCl in covered 13-mm culture tubes. Samples were then dried in a vacuum centrifuge and transferred to 3-mL Vacutainer disposable blood vials (Becton-Dickinson Corp.) for hydrolysis. Each Vacutainer was evacuated via a 1.3-cm-long #26 hypodermic needle through the septum seal, 1 mL of 85% phosphoric acid was injected, and the vial was heated for 1 hr at 90 °C. The evolved CO_2 was transferred cryogenically to a vacuum line via a #26 needle, purified in a dry ice/alcohol trap, and converted to graphite using hydrogen reduction with an iron catalyst (Vogel et al. 1987). Although some samples in the deeper part of the core contained pyrite, no problems of sulfur poisoning of the graphitization reaction were encountered.

^{14}C Measurements

Radiocarbon was measured as $^{14}C/^{12}C$ ratios relative to multiple OX1 standards by AMS (5–8 separate measurements on each unknown spaced over a period of 2–3 hr 15,000 ^{14}C counts per 60- to 80-second measurement). The entire core was initially measured at half-resolution and then remeasured to fill in the intervening points, so that data from at least 2 and sometimes 3 measurement runs spaced a year or more apart are interleaved. Results (Table 1) are expressed as conventional ^{14}C ages (Stuiver and Polach 1977; Donahue et al. 1990). The uncertainties quoted (typically ±40 yr or 5‰) reflect contributions from measurements of the normalizing standards and the blanks in addition to those from the samples. They represent the larger of internal and external errors in the mean for each unknown based on statistical errors propagated through the calculations and the scatter in the data from the multiple runs, respectively. Results on secondary standards run with each set of samples (OX2, TIRI B wood, IAEA C2 carbonate, and TIRI K turbidite) suggest that the calculated errors are good estimates of the actual variance and that any biases are small.

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC.

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
423.75	62358	10,503	15	22.3	9680	40	420	30	9260	50	15.6	—	15.6	16.0	—	*bulloides*
425.25	62359	10,518	15	22.1	9680	30	420	30	9260	42	15.3	—	15.3	16.0	—	*bulloides*
426.75	62360	10,532	14	22.0	9680	40	420	30	9260	50	15.0	—	15.0	16.0	—	*bulloides*
428.25	62361	10,546	14	21.8	9690	40	420	30	9270	50	14.8	—	14.8	16.0	—	*bulloides*
429.75	62362	10,560	14	21.6	9690	40	420	30	9270	50	14.6	—	14.6	16.0	—	*bulloides*
431.25	62363	10,574	14	21.5	9750	30	420	30	9330	42	14.3	—	14.3	16.0	—	*bulloides*
432.75	63242	10,585	11	21.3	9730	40	420	30	9310	50	14.1	—	14.1	16.0	—	*bulloides*
433.5	62364	10,590	5	21.2	9810	30	420	30	9390	42	13.9	—	13.9	16.0	—	*bulloides*
434.25	63243	10,595	5	21.1	9840	40	420	30	9420	50	13.8	—	13.8	16.0	—	*bulloides*
435.75	62365	10,606	11	21.1	9880	40	420	30	9460	50	13.7	—	13.7	16.0	—	*bulloides*
435.75	64016	10,606	—	21.1	9830	40	420	30	9410	50	13.7	—	13.7	16.0 duplicate	—	*bulloides*
437.25	62366	10,625	19	21.0	9790	30	420	30	9370	42	13.5	—	13.5	16.0	—	*bulloides*
437.25	64017	10,625	—	21.0	9840	40	420	30	9420	50	13.5	—	13.5	16.0 duplicate	—	*bulloides*
438.75	62367	10,644	19	20.7	9820	40	420	30	9400	50	13.2	—	13.2	16.0	—	*bulloides*
440.25	62368	10,663	19	20.5	9830	40	420	30	9410	50	12.9	—	12.9	16.0	—	*bulloides*
441.75	62369	10,682	19	20.3	9860	40	420	30	9440	50	12.6	—	12.6	16.0	—	*bulloides*
443.25	62370	10,701	19	20.1	9940	40	420	30	9520	50	12.2	—	12.2	16.0	—	*bulloides*
444.75	62371	10,720	19	19.9	9900	40	420	30	9480	50	11.9	—	11.9	16.0	—	*bulloides*
446.25	62372	10,739	19	19.9	9800	30	420	30	9380	42	11.9	—	11.9	16.0	—	*bulloides*
446.25	63244	10,739	—	19.7	9930	40	420	30	9510	50	11.6	—	11.6	16.0 duplicate	—	*bulloides*
447.75	62779	10,758	19	19.6	10,000	30	420	30	9580	42	11.2	—	11.2	16.0	—	*bulloides*
449.25	62780	10,777	19	19.4	9890	30	420	30	9470	42	10.9	—	10.9	16.0	—	*bulloides*
449.25	64018	10,777	—	19.2	9970	60	420	30	9550	67	10.6	—	10.6	16.0 duplicate	0.2	*bulloides*
450.75	47448	10,796	19	19.2	9930	60	420	30	9510	67	10.6	—	10.6	16.0	0.35	*bulloides*
452.25	47449	10,815	19	19.0	10,000	70	420	30	9580	76	10.3	—	10.3	16.0	0.26	*bulloides*
453.75	47450	10,833	18	18.8	9980	60	420	30	9560	67	9.9	—	9.9	16.0	0.38	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
455.25	47451	10,853	20	18.7	9960	50	420	30	9540	58	9.6	—	9.6	16.0	—	*bulloides*
456.75	47452	10,872	19	18.7	9840	50	420	30	9420	58	9.6	—	9.6	16.0 duplicate	0.37	*bulloides*
456.75	64019	10,872	—	18.5	9950	40	420	30	9530	50	9.3	—	9.3	16.0	—	*bulloides*
458.25	47453	10,889	17	18.5	9860	50	420	30	9440	58	9.3	—	9.3	16.0 duplicate	—	*bulloides*
458.25	64020	10,889	—	18.3	9990	40	420	30	9570	50	9.0	—	9.0	16.0	—	*bulloides*
459.75	47454	10,908	19	18.2	9970	40	420	30	9550	50	8.7	—	8.7	16.0	—	*bulloides*
461.25	47455	10,928	20	18.0	10,040	50	420	30	9620	58	8.3	—	8.3	16.0	—	*bulloides*
462.75	47456	10,949	21	17.9	10,000	40	420	30	9580	50	8.0	—	8.0	16.0	—	*bulloides*
464.25	47457	10,966	17	17.7	9980	50	420	30	9560	58	7.6	—	7.6	16.0	0.27	*bulloides*
465.75	47458	10,983	17	17.6	9990	50	420	30	9570	58	7.3	—	7.3	16.0	0.37	*bulloides*
467.25	47459	11,001	18	17.5	9950	50	420	30	9530	58	7.0	—	7.0	16.0	0.33	*bulloides*
468.75	47460	11,020	19	17.4	9920	40	420	30	9500	50	6.7	—	6.7	16.0	—	*bulloides*
468.75	64021	11,020	—	17.2	10,040	50	420	30	9620	58	6.4	—	6.4	16.0 duplicate	0.31	*bulloides*
470.25	57306	11,030	10	17.2	10,030	40	420	30	9610	50	6.4	—	6.4	16.0	—	*bulloides*
470.25	64022	11,030	—	17.1	9990	40	420	30	9570	50	6.1	—	6.1	16.0 duplicate	—	mixed
471.75	47461	11,040	10	17.2	9950	40	420	30	9530	50	6.2	—	6.2	16.0	—	*bulloides*
471.75	64023	11,040	—	17.1	9900	40	420	30	9480	50	5.9	—	5.9	16.0 duplicate	—	*bulloides*
473.25	57307	11,049	9	17.1	10,020	40	420	30	9600	50	6.1	—	6.1	16.0	—	*bulloides*
474.75	47462	11,058	9	17.1	10,060	50	420	30	9640	58	5.9	—	5.9	16.0	—	*bulloides*
476.25	57308	11,069	11	17.0	10,070	40	420	30	9650	50	5.8	—	5.8	16.0	—	*bulloides*
477.75	47463	11,080	11	16.9	9950	40	420	30	9530	50	5.6	—	5.6	16.0	—	*bulloides*
477.75	64024	11,080	—	16.9	10,000	40	420	30	9580	50	5.4	—	5.4	16.0 duplicate	—	mixed
479.25	57309	11,091	11	16.9	10,050	50	420	30	9630	58	5.4	—	5.4	16.0	—	*bulloides*
480.75	48285	11,102	11	16.8	10,050	40	420	30	9630	50	5.2	—	5.2	16.0	—	*bulloides*
482.25	57310	11,111	9	16.8	10,060	40	420	30	9640	50	5.0	—	5.0	16.0	—	*bulloides*
483.75	48286	11,120	9	16.7	10,160	40	420	30	9740	50	4.8	—	4.8	16.0	—	*bulloides*
485.25	57311	11,130	10	16.7	10,120	40	420	30	9700	50	4.7	—	4.7	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
486.75	48287	11,139	9	16.6	10,140	40	420	30	9720	50	4.5	—	4.5	16.0	—	*bulloides*
488.25	57312	11,145	6	16.6	10,090	40	420	30	9670	50	4.4	—	4.4	16.0	—	*bulloides*
489.75	48288	11,151	6	16.6	10,180	40	420	30	9760	50	4.3	—	4.3	16.0	—	*bulloides*
491.25	57313	11,157	6	16.5	10,110	40	420	30	9690	50	4.2	—	4.2	16.0	—	*bulloides*
492.75	48289	11,162	5	16.5	10,250	50	420	30	9830	58	4.1	—	4.1	16.0	—	*bulloides*
494.25	57314	11,171	9	16.5	10,150	40	420	30	9730	50	4.0	—	4.0	16.0	—	*bulloides*
495.75	48290	11,179	8	16.4	10,230	40	420	30	9810	50	3.8	—	3.8	16.0	—	*bulloides*
497.25	57315	11,185	6	16.4	10,210	40	420	30	9790	50	3.7	—	3.7	16.0	—	*bulloides*
498.75	48291	11,192	7	16.4	10,230	40	420	30	9810	50	3.6	—	3.6	16.0	—	*bulloides*
500.25	58009	11,201	9	16.4	10,220	50	420	30	9800	58	3.5	—	3.5	16.0	—	*bulloides*
501.75	48292	11,209	8	16.3	10,290	40	420	30	9870	50	3.3	—	3.3	16.0	—	*bulloides*
503.25	58010	11,215	6	16.3	10,250	50	420	30	9830	58	3.2	—	3.2	16.0	—	*bulloides*
504.75	48293	11,221	6	16.3	10,280	50	420	30	9860	58	3.1	—	3.1	16.0	—	*bulloides*
506.25	58011	11,228	7	16.3	10,320	30	420	30	9900	42	3.0	—	3.0	16.0	—	*bulloides*
507.75	48294	11,235	7	16.2	10,300	40	420	30	9880	50	2.8	—	2.8	16.0	—	*bulloides*
509.25	58012	11,243	8	16.2	10,380	40	420	30	9960	50	2.7	—	2.7	16.0	—	*bulloides*
510.75	48892	11,251	8	16.2	10,340	40	420	30	9920	50	2.6	—	2.6	16.0	—	*bulloides*
511.75	58013	11,257	6	16.2	10,380	40	420	30	9960	50	2.4	—	2.4	16.0	—	*bulloides*
513.25	48295	11,263	6	16.2	10,370	50	420	30	9950	58	2.3	—	2.3	16.0	—	*bulloides*
514.75	58014	11,269	6	16.2	10,370	40	420	30	9950	50	2.2	—	2.2	16.0	—	*bulloides*
516.25	48296	11,276	7	16.1	10,360	50	420	30	9940	58	2.1	—	2.1	16.0	—	*bulloides*
517.75	58015	11,283	7	16.1	10,380	50	420	30	9960	58	2.0	—	2.0	16.0	—	*bulloides*
519.25	48297	11,290	7	16.1	10,410	40	420	30	9990	50	1.9	—	1.9	16.0	—	*bulloides*
520.75	58016	11,298	8	16.1	10,360	40	420	30	9940	50	1.8	—	1.8	16.0	—	*bulloides*
522.25	48298	11,306	8	16.1	10,340	40	420	30	9920	50	1.6	—	1.6	16.0	—	*bulloides*
523.75	58017	11,313	7	16.1	10,380	40	420	30	9960	50	1.5	—	1.5	16.0	—	*bulloides*
525.25	48878	11,320	7	16.1	10,390	40	420	30	9970	50	1.4	—	1.4	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
526.75	58018	11,328	8	16.0	10,420	40	420	30	10,000	50	1.3	—	1.3	16.0	—	*bulloides*
528.25	48879	11,336	8	16.0	10,390	40	420	30	9970	50	1.1	—	1.1	16.0	—	*bulloides*
529.75	58019	11,344	8	16.0	10,390	40	420	30	9970	50	1.0	—	1.0	16.0	—	*bulloides*
531.25	48880	11,352	8	16.0	10,430	40	420	30	10,010	50	0.8	—	0.8	16.0	—	*bulloides*
532.75	58020	11,359	7	16.0	10,400	40	420	30	9980	50	0.7	—	0.7	16.0	—	*bulloides*
534.25	48881	11,367	8	16.0	10,470	40	420	30	10,050	50	0.6	—	0.6	16.0	—	*bulloides*
535.75	58021	11,374	7	16.0	10,460	40	420	30	10,040	50	0.4	—	0.4	16.0	—	*bulloides*
537.25	48882	11,380	6	16.0	10,430	50	420	30	10,010	58	0.3	—	0.3	16.0	—	*bulloides*
538.75	58022	11,388	8	16.0	10,500	40	420	30	10,080	50	0.2	—	0.2	16.0	—	*bulloides*
540.25	48883	11,395	7	16.0	10,430	40	420	30	10,010	50	0.1	—	0.1	16.0	—	*bulloides*
541.75	58023	11,403	8	16.0	10,450	40	420	30	10,030	50	0.0	—	0.0	16.0	—	*bulloides*
543.25	48884	11,421	18	16.0	10,540	50	420	30	10,120	58	0.2	—	0.2	16.0	—	*bulloides*
544.75	64947	11,435	14	16.0	10,480	40	420	30	10,060	50	0.5	—	0.5	16.0	—	*bulloides*
546.25	48885	11,449	14	16.0	10,530	40	420	30	10,110	50	0.7	—	0.7	16.0	—	*bulloides*
547.75	64948	11,463	14	16.0	10,440	40	420	30	10,020	50	1.0	—	1.0	16.0	—	*bulloides*
549.25	48886	11,477	14	16.0	10,500	40	420	30	10,080	50	1.2	—	1.2	16.0	—	*bulloides*
550.75	64949	11,489	12	16.1	10,490	40	420	30	10,070	50	1.5	—	1.5	16.0	—	*bulloides*
552.25	48887	11,500	11	16.1	10,490	40	420	30	10,070	50	1.7	—	1.7	16.0	—	*bulloides*
553.75	64950	11,510	10	16.1	10,430	40	420	30	10,010	50	1.8	—	1.8	16.0	—	*bulloides*
555.25	48888	11,520	10	16.1	10,520	40	420	30	10,100	50	2.0	—	2.0	16.0	—	*bulloides*
556.75	64951	11,533	13	16.2	10,420	40	420	30	10,000	50	2.2	—	2.2	16.0	—	*bulloides*
556.75	64025	11,533	—	16.2	10,490	40	420	30	10,070	50	2.4	—	2.4	16.0	—	*bulloides*
558.25	48889	11,546	13	16.2	10,410	40	420	30	9990	50	2.4	—	2.4	16.0	—	*bulloides*
559.75	64952	11,558	12	16.2	10,450	40	420	30	10,030	50	2.6	—	2.6	16.0	—	*bulloides*
561.25	48890	11,569	11	16.3	10,510	40	420	30	10,090	50	2.8	—	2.8	16.0	—	*bulloides*
562.75	64953	11,579	10	16.3	10,470	40	420	30	10,050	50	—	0.5	3.3	16.0	—	*bulloides*
564.25	48891	11,589	10	16.4	10,520	40	420	30	10,100	50	—	1	3.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
565.75	64954	11,597	8	16.4	10,470	40	420	30	10,050	50	—	1	3.8	16.0	—	*bulloides*
567.25	49338	11,605	8	16.4	10,440	40	420	30	10,020	50	—	1	3.8	16.0	—	*bulloides*
568.75	64955	11,615	10	16.6	10,440	40	420	30	10,020	50	—	1.5	4.3	16.0	—	*bulloides*
570.25	49339	11,624	9	16.7	10,450	40	420	30	10,030	50	—	2	4.8	16.0	—	*bulloides*
571.75	64956	11,633	9	16.7	10,540	40	420	30	10,120	50	—	2	4.8	16.0	—	*bulloides*
573.25	49340	11,642	9	16.7	10,480	40	420	30	10,060	50	—	2	4.8	16.0	—	*bulloides*
574.75	64957	11,651	9	16.9	10,490	40	420	30	10,070	50	—	2.5	5.3	16.0	—	*bulloides*
576.25	49341	11,660	9	17.0	10,480	40	420	30	10,060	50	—	3	5.8	16.0	—	*bulloides*
577.75	64958	11,669	9	17.0	10,550	40	420	30	10,130	50	—	3	5.8	16.0	—	*bulloides*
579.25	49342	11,678	9	17.0	10,450	40	420	30	10,030	50	—	3	5.8	16.0	—	*bulloides*
580.75	64959	11,687	9	17.2	10,520	40	420	30	10,100	50	—	3.5	6.3	16.0	—	*bulloides*
582.25	49343	11,696	9	17.4	10,470	50	420	30	10,050	58	—	4	6.8	16.0	—	*bulloides*
583.75	64960	11,704	8	17.6	10,500	40	420	30	10,080	50	—	4.5	7.3	16.0	—	*bulloides*
585.25	49344	11,713	9	17.8	10,530	40	420	30	10,110	50	—	5	7.8	16.0	—	*bulloides*
586.75	64961	11,722	9	17.8	10,490	40	420	30	10,070	50	—	5	7.8	16.0	—	*bulloides*
588.25	49345	11,731	9	17.8	10,560	40	420	30	10,140	50	—	5	7.8	16.0	—	*bulloides*
589.75	64962	11,741	10	18.0	10,470	40	420	30	10,050	50	—	5.5	8.3	16.0	—	*bulloides*
591.25	49346	11,750	9	18.3	10,500	50	420	30	10,080	58	—	6	8.8	16.0	—	*bulloides*
592.75	64963	11,759	9	18.3	10,560	40	420	30	10,140	50	—	6	8.8	16.0	—	*bulloides*
594.25	49347	11,768	9	18.3	10,530	40	420	30	10,110	50	—	6	8.8	16.0	—	*bulloides*
595.75	65433	11,777	9	18.5	10,590	40	420	30	10,170	50	—	6.5	9.3	16.0	—	*bulloides*
597.25	49348	11,785	8	18.8	10,550	40	420	30	10,130	50	—	7	9.8	16.0	—	*bulloides*
598.75	65434	11,794	9	18.8	10,510	40	420	30	10,090	50	—	7	9.8	16.0	—	*bulloides*
600.25	49349	11,803	9	18.8	10,550	40	420	30	10,130	50	—	7	9.8	16.0	—	*bulloides*
601.75	65435	11,812	9	18.8	10,560	30	420	30	10,140	42	—	7	9.8	16.0	—	*bulloides*
603.25	49350	11,821	9	18.8	10,540	40	420	30	10,120	50	—	7	9.8	16.0	—	*bulloides*
604.75	65436	11,830	9	18.8	10,570	30	420	30	10,150	42	—	7	9.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
606.25	49351	11,839	9	18.8	10,630	40	420	30	10,210	50	—	7	9.8	16.0	—	*bulloides*
607.75	62781	11,847	8	18.8	10,600	40	420	30	10,180	50	—	7	9.8	16.0	—	*bulloides*
609.25	49352	11,855	8	18.8	10,480	40	420	30	10,060	50	—	7	9.8	16.0	—	*bulloides*
609.25	64026	11,855	—	18.8	10,650	40	420	30	10,230	50	—	7	9.8	16.0 duplicate	—	mixed
610.75	62782	11,863	8	18.8	10,610	40	420	30	10,190	50	—	7	9.8	16.0	—	*bulloides*
612.25	49933	11,872	9	19.3	10,630	40	420	30	10,210	50	—	8	10.8	16.0	—	*bulloides*
613.75	65437	11,881	9	19.3	10,550	40	420	30	10,130	50	—	8	10.8	16.0	—	*bulloides*
615.25	49934	11,890	9	19.3	10,630	40	420	30	10,210	50	—	8	10.8	16.0	—	*bulloides*
616.75	65438	11,899	9	19.3	10,600	40	420	30	10,180	50	—	8	10.8	16.0	—	*bulloides*
618.25	49935	11,907	8	19.3	10,600	40	420	30	10,180	50	—	8	10.8	16.0	—	*bulloides*
619.75	65439	11,916	9	19.3	10,600	30	420	30	10,180	42	—	8	10.8	16.0	—	*bulloides*
621.25	49936	11,924	8	19.3	10,650	50	420	30	10,230	58	—	8	10.8	16.0	—	*bulloides*
622.75	65440	11,934	10	19.3	10,670	30	420	30	10,250	42	—	8	10.8	16.0	—	*bulloides*
624.25	49937	11,943	9	19.3	10,620	40	420	30	10,200	50	—	8	10.8	16.0	—	*bulloides*
625.75	65441	11,952	9	19.6	10,610	40	420	30	10,190	50	—	8.5	11.3	16.0	—	*bulloides*
627.25	49938	11,961	9	19.9	10,650	40	420	30	10,230	50	—	9	11.8	16.0	—	*bulloides*
628.75	65442	11,971	10	19.9	10,600	40	420	30	10,180	50	—	9	11.8	16.0	—	*bulloides*
630.25	49939	11,980	9	19.9	10,660	40	420	30	10,240	50	—	9	11.8	16.0	—	*bulloides*
631.75	65443	11,990	10	20.2	10,690	30	420	30	10,270	42	—	9.5	12.3	16.0	—	*bulloides*
633.25	49940	11,999	9	20.5	10,660	40	420	30	10,240	50	—	10	12.8	16.0	—	*bulloides*
634.75	65444	12,009	10	20.5	10,650	40	420	30	10,230	50	—	10	12.8	16.0	—	*bulloides*
636.25	49941	12,018	9	20.5	10,710	50	420	30	10,290	58	—	10	12.8	16.0	—	*bulloides*
637.75	65445	12,026	8	20.5	10,710	40	420	30	10,290	50	—	10	12.8	16.0	—	*bulloides*
639.25	49942	12,033	7	20.5	10,700	50	420	30	10,280	58	—	10	12.8	16.0	—	*bulloides*
640.75	65446	12,043	10	20.8	10,690	30	420	30	10,270	42	—	10.5	13.3	16.0	—	*bulloides*
642.25	49943	12,052	9	21.1	10,680	40	420	30	10,260	50	—	11	13.8	16.0	—	*bulloides*
643.75	65447	12,062	10	21.1	10,740	30	420	30	10,320	42	—	11	13.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
645.25	49944	12,071	9	21.1	10,760	40	420	30	10,340	50	—	11	13.8	16.0	—	*bulloides*
646.75	66269	12,081	10	21.5	10,840	40	420	30	10,420	50	—	11.5	14.3	16.0	—	*bulloides*
648.25	49945	12,090	9	21.8	10,800	40	420	30	10,380	50	—	12	14.8	16.0	—	*bulloides*
649.75	66270	12,099	9	21.8	10,720	30	420	30	10,300	42	—	12	14.8	16.0	—	*bulloides*
651.25	49946	12,108	9	21.8	10,690	40	420	30	10,270	50	—	12	14.8	16.0	—	*bulloides*
651.25	64946	12,108	—	21.8	10,800	40	420	30	10,380	50	—	12	14.8	16.0 duplicate	—	*bulloides*
652.75	66271	12,118	10	21.8	10,800	40	420	30	10,380	50	—	12	14.8	16.0	—	*bulloides*
654.25	49947	12,127	9	21.8	10,770	40	420	30	10,350	50	—	12	14.8	16.0	—	*bulloides*
655.75	66272	12,136	9	22.1	10,850	40	420	30	10,430	50	—	12.5	15.3	16.0	—	*bulloides*
657.25	51142	12,146	10	22.5	10,670	40	420	30	10,250	50	—	13	15.8	16.0	—	*bulloides*
657.25	56389	12,146	—	22.5	10,760	40	420	30	10,340	50	—	13	15.8	16.0 duplicate	—	mixed
658.75	66273	12,156	10	22.5	10,790	40	420	30	10,370	50	—	13	15.8	16.0	—	*bulloides*
660.25	51143	12,165	9	22.5	10,760	40	420	30	10,340	50	—	13	15.8	16.0	—	mixed
660.25	56390	12,165	—	22.5	10,780	40	420	30	10,360	50	—	13	15.8	16.0 duplicate	—	mixed
661.75	66274	12,174	9	22.5	10,830	30	420	30	10,410	42	—	13	15.8	16.0	—	*bulloides*
663.25	51144	12,183	9	22.5	10,760	40	420	30	10,340	50	—	13	15.8	16.0	—	*bulloides*
664.75	66275	12,192	9	22.5	10,820	40	420	30	10,400	50	—	13	15.8	16.0	—	*bulloides*
666.25	51145	12,202	10	22.5	10,780	40	420	30	10,360	50	—	13	15.8	16.0	—	*bulloides*
667.75	66276	12,211	9	22.5	10,780	30	420	30	10,360	42	—	13	15.8	16.0	—	*bulloides*
669.25	51146	12,221	10	22.5	10,820	40	420	30	10,400	50	—	13	15.8	16.0	—	*bulloides*
670.75	66277	12,231	10	22.5	10,840	40	420	30	10,420	50	—	13	15.8	16.0	—	*bulloides*
672.25	51147	12,240	9	22.5	10,780	50	420	30	10,360	58	—	13	15.8	16.0	—	*bulloides*
673.75	66278	12,249	9	22.8	10,880	30	420	30	10,460	42	—	13.5	16.3	16.0	—	*bulloides*
675.25	51148	12,258	9	23.2	10,890	40	420	30	10,470	50	—	14	16.8	16.0	—	*bulloides*
676.75	62783	12,270	12	23.2	10,810	30	420	30	10,390	42	—	14	16.8	16.0	—	*bulloides*
678.25	51149	12,281	11	23.2	10,800	40	420	30	10,380	50	—	14	16.8	16.0	—	*bulloides*
679.75	62784	12,292	11	23.2	10,810	30	420	30	10,390	42	—	14	16.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncertainty	^{14}C raw age	±1 σ	Reservoir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
681.25	51150	12,302	10	23.2	10,840	40	420	30	10,420	50	—	14	16.8	16.0	—	*bulloides*
682.75	62785	12,315	13	23.2	10,820	30	420	30	10,400	42	—	14	16.8	16.0	—	*bulloides*
684.25	51151	12,328	13	23.9	10,820	40	420	30	10,400	50	—	15	17.8	16.0	—	*bulloides*
685.75	62786	12,340	12	23.9	10,890	30	420	30	10,470	42	—	15	17.8	16.0	—	*bulloides*
687.25	51152	12,352	12	23.9	10,870	40	420	30	10,450	50	—	15	17.8	16.0	—	*bulloides*
688.75	62787	12,364	12	23.9	10,810	30	420	30	10,390	42	—	15	17.8	16.0	—	*bulloides*
690.25	51153	12,376	12	23.9	10,910	40	420	30	10,490	50	—	15	17.8	16.0	—	*bulloides*
691.75	62788	12,391	15	24.7	10,870	40	420	30	10,450	50	—	16	18.8	16.0	—	*bulloides*
693.25	51154	12,404	13	24.7	10,800	40	420	30	10,380	50	—	16	18.8	16.0	—	*bulloides*
694.75	62789	12,414	10	24.7	10,800	40	420	30	10,380	50	—	16	18.8	16.0	—	*bulloides*
696.25	51155	12,423	9	24.7	10,850	40	420	30	10,430	50	—	16	18.8	16.0	—	*bulloides*
697.75	62790	12,435	12	25.5	10,840	30	420	30	10,420	42	—	17	19.8	16.0	—	*bulloides*
699.25	51156	12,446	11	25.5	10,940	40	420	30	10,520	50	—	17	19.8	16.0	—	*bulloides*
700.75	62791	12,459	13	25.5	10,860	40	420	30	10,440	50	—	17	19.8	16.0	—	*bulloides*
702.25	51157	12,471	12	25.5	10,890	40	420	30	10,470	50	—	17	19.8	16.0	—	*bulloides*
703.75	62792	12,483	12	26.2	10,910	30	420	30	10,490	42	—	18	20.8	16.0	—	*bulloides*
705.25	51158	12,494	11	26.2	10,990	40	420	30	10,570	50	—	18	20.8	16.0	—	*bulloides*
706.75	62793	12,506	12	26.2	10,930	40	420	30	10,510	50	—	18	20.8	16.0	—	*bulloides*
708.25	51159	12,518	12	26.2	10,930	40	420	30	10,510	50	—	18	20.8	16.0	—	*bulloides*
709.75	62794	12,530	12	26.2	10,870	30	420	30	10,450	42	—	18	20.8	16.0	—	*bulloides*
711.25	53643	12,541	11	27.0	10,900	40	420	30	10,480	50	—	19	21.8	16.0	—	*bulloides*
712.75	62795	12,552	11	27.0	10,860	30	420	30	10,440	42	—	19	21.8	16.0	—	*bulloides*
714.25	53644	12,563	11	27.0	10,890	50	420	30	10,470	58	—	19	21.8	16.0	—	*bulloides*
715.75	62796	12,574	11	27.0	10,910	40	420	30	10,490	50	—	19	21.8	16.0	—	*bulloides*
717.25	53645	12,596	22	27.0	10,920	50	420	30	10,500	58	—	19	21.8	16.0	—	*bulloides*
718.75	66279	12,608	12	27.0	10,920	30	420	30	10,500	42	—	19	21.8	16.0	—	*bulloides*
720.25	53646	12,619	11	27.0	10,920	40	420	30	10,500	50	—	19	21.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
721.75	66280	12,630	11	27.4	10,990	30	420	30	10,570	42	—	19.5	22.3	16.0	—	*bulloides*
723.25	53647	12,641	11	27.9	10,930	40	420	30	10,510	50	—	20	22.8	16.0	—	*bulloides*
724.75	66281	12,653	12	27.9	10,900	30	420	30	10,480	42	—	20	22.8	16.0	—	*bulloides*
726.25	53648	12,664	11	27.9	11,040	40	420	30	10,620	50	—	20	22.8	16.0	—	*bulloides*
727.75	66282	12,675	11	27.9	10,980	30	420	30	10,560	42	—	20	22.8	16.0	—	*bulloides*
729.25	53649	12,685	10	27.9	11,030	40	420	30	10,610	50	—	20	22.8	16.0	—	*bulloides*
730.75	66283	12,696	11	27.9	11,000	40	420	30	10,580	50	—	20	22.8	16.0	—	*bulloides*
732.25	53650	12,707	11	27.9	10,990	40	420	30	10,570	50	—	20	22.8	16.0	—	*bulloides*
733.75	66284	12,719	12	27.9	10,970	40	420	30	10,550	50	—	20	22.8	16.0	—	*bulloides*
735.25	53651	12,731	12	27.9	11,010	50	420	30	10,590	58	—	20	22.8	16.0	—	*bulloides*
736.75	66285	12,743	12	28.3	11,080	60	420	30	10,660	67	—	20.5	23.3	16.0	0.24	*bulloides*
738.25	53652	12,754	11	28.7	10,990	40	420	30	10,570	50	—	21	23.8	16.0	—	*bulloides*
739.75	66286	12,764	10	28.7	11,000	30	420	30	10,580	42	—	21	23.8	16.0	—	*bulloides*
741.25	53653	12,775	11	28.7	10,970	50	420	30	10,550	58	—	21	23.8	16.0	—	*bulloides*
742.75	66287	12,781	6	29.1	11,020	40	420	30	10,600	50	—	21.5	24.3	16.0	—	*bulloides*
744.25	53654	12,786	5	29.5	11,040	40	420	30	10,620	50	—	22	24.8	16.0	—	*bulloides*
745.75	62045	12,797	11	29.5	11,110	40	420	30	10,690	50	—	22	24.8	16.0	—	*bulloides*
747.25	53655	12,808	11	29.5	11,090	60	420	30	10,670	67	—	22	24.8	16.0	—	*bulloides*
748.75	62044	12,818	10	30.4	11,170	40	420	30	10,750	50	—	23	25.8	16.0	—	*bulloides*
750.25	53656	12,825	7	30.4	11,100	40	420	30	10,680	50	—	23	25.8	16.0	—	*bulloides*
751.75	62043	12,834	9	30.4	11,110	40	420	30	10,690	50	—	23	25.8	16.0	—	*bulloides*
753.25	53657	12,842	8	30.4	11,150	40	420	30	10,730	50	—	23	25.8	16.0	—	*bulloides*
754.75	62042	12,851	9	30.4	11,160	40	420	30	10,740	50	—	23	25.8	16.0	—	*bulloides*
756.25	53658	12,859	8	30.4	11,300	40	420	30	10,880	50	—	23	25.8	16.0	—	*bulloides*
757.75	62041	12,868	9	31.2	11,290	40	420	30	10,870	50	—	24	26.8	16.0	—	*bulloides*
759.25	54451	12,876	8	31.2	11,300	40	420	30	10,880	50	—	24	26.8	16.0	—	*bulloides*
760.75	62040	12,885	9	31.2	11,280	40	420	30	10,860	50	—	24	26.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
762.25	54452	12,893	8	31.2	11,310	40	420	30	10,890	50	—	24	26.8	16.0	—	*bulloides*
763.75	62039	12,902	9	31.2	11,330	40	420	30	10,910	50	—	24	26.8	16.0	—	*bulloides*
765.25	54453	12,910	8	31.2	11,390	50	420	30	10,970	58	—	24	26.8	16.0	—	*bulloides*
766.75	62038	12,918	8	31.2	11,330	40	420	30	10,910	50	—	24	26.8	16.0	—	*bulloides*
768.25	54454	12,927	9	32.1	11,420	40	420	30	11,000	50	—	25	27.8	16.0	—	*bulloides*
769.75	62037	12,936	9	32.1	11,450	40	420	30	11,030	50	—	25	27.8	16.0	—	*bulloides*
771.25	54455	12,944	8	32.1	11,450	40	420	30	11,030	50	—	25	27.8	16.0	—	*bulloides*
772.75	62036	12,952	8	32.1	11,480	40	420	30	11,060	50	—	25	27.8	16.0	—	*bulloides*
774.25	54456	12,961	9	32.1	11,510	50	420	30	11,090	58	—	25	27.8	16.0	—	*bulloides*
775.75	62035	12,969	8	32.1	11,560	40	420	30	11,140	50	—	25	27.8	16.0	—	*bulloides*
777.25	54457	12,978	9	32.1	11,590	40	420	30	11,170	50	—	25	27.8	16.0	—	*bulloides*
778.75	62034	12,987	9	32.1	11,530	40	420	30	11,110	50	—	25	27.8	16.0	—	*bulloides*
780.25	54458	12,995	8	32.1	11,610	50	420	30	11,190	58	—	25	27.8	16.0	—	*bulloides*
781.75	62033	13,004	9	32.9	11,580	40	420	30	11,160	50	—	26	28.8	16.0	—	*bulloides*
783.25	54459	13,012	8	32.9	11,630	50	420	30	11,210	58	—	26	28.8	16.0	—	*bulloides*
784.75	62032	13,021	9	32.9	11,610	50	420	30	11,190	58	—	26	28.8	16.0	—	*bulloides*
786.25	54460	13,029	8	32.9	11,660	50	420	30	11,240	58	—	26	28.8	16.0	—	*bulloides*
787.75	62373	13,039	10	33.8	11,520	40	420	30	11,100	50	—	27	29.8	16.0	—	mixed
789.25	54461	13,049	10	33.8	11,610	40	420	30	11,190	50	—	27	29.8	16.0	—	*bulloides*
789.25	63246	13,049	—	33.8	11,630	40	420	30	11,210	50	—	27	29.8	16.0 duplicate	—	mixed
790.75	62031	13,059	10	34.7	11,620	40	420	30	11,200	50	—	28	30.8	16.0	—	*bulloides*
792.25	54462	13,069	10	34.7	11,540	40	420	30	11,120	50	—	28	30.8	16.0	—	*bulloides*
792.25	63247	13,069	—	34.7	11,710	40	420	30	11,290	50	—	28	30.8	16.0 duplicate	—	mixed
793.75	62030	13,079	10	35.6	11,630	40	420	30	11,210	50	—	29	31.8	16.0	—	*bulloides*
795.25	54463	13,089	10	36.5	11,700	40	420	30	11,280	50	—	30	32.8	16.0	—	*bulloides*
796.75	61592	13,100	11	36.5	11,660	40	420	30	11,240	50	—	30	32.8	16.0	—	*bulloides*
798.25	54464	13,110	10	37.4	11,680	40	420	30	11,260	50	—	31	33.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
799.75	61593	13,120	10	37.4	11,700	40	420	30	11,280	50	—	31	33.8	16.0	—	*bulloides*
801.25	54465	13,130	10	37.4	11,660	40	420	30	11,240	50	—	31	33.8	16.0	—	*bulloides*
802.75	61594	13,140	10	37.4	11,700	40	420	30	11,280	50	—	31	33.8	16.0	—	*bulloides*
804.25	54466	13,150	10	37.4	11,720	50	420	30	11,300	58	—	31	33.8	16.0	—	*bulloides*
805.75	62374	13,160	10	37.4	11,720	30	420	30	11,300	42	—	31	33.8	16.0	—	mixed
807.25	54467	13,170	10	37.4	11,770	50	420	30	11,350	58	—	31	33.8	16.0	—	mixed
807.25	56391	13,170	—	37.4	11,760	40	420	30	11,340	50	—	31	33.8	16.0 duplicate	—	mixed
808.75	61595	13,180	10	37.4	11,700	40	420	30	11,280	50	—	31	33.8	16.0	—	*bulloides*
810.25	54786	13,190	10	38.3	11,770	40	420	30	11,350	50	—	32	34.8	16.0	—	*bulloides*
811.75	61596	13,201	11	38.3	11,770	40	420	30	11,350	50	—	32	34.8	16.0	—	*bulloides*
813.25	54787	13,211	10	38.3	11,750	40	420	30	11,330	50	—	32	34.8	16.0	—	*bulloides*
814.75	61597	13,221	10	38.3	11,810	40	420	30	11,390	50	—	32	34.8	16.0	—	*bulloides*
816.25	54788	13,231	10	38.3	11,690	40	420	30	11,270	50	—	32	34.8	16.0	—	*bulloides*
816.25	56392	13,231	—	38.3	11,800	40	420	30	11,380	50	—	32	34.8	16.0 duplicate	—	mixed
817.75	61598	13,241	10	38.3	11,760	40	420	30	11,340	50	—	32	34.8	16.0	—	*bulloides*
819.25	54789	13,251	10	38.3	11,790	40	420	30	11,370	50	—	32	34.8	16.0	—	*bulloides*
820.75	61599	13,262	11	38.3	11,840	40	420	30	11,420	50	—	32	34.8	16.0	—	*bulloides*
822.25	54790	13,272	10	38.3	11,880	40	420	30	11,460	50	—	32	34.8	16.0	—	*bulloides*
823.75	61600	13,282	10	38.3	11,840	40	420	30	11,420	50	—	32	34.8	16.0	—	*bulloides*
825.25	54791	13,292	10	38.3	11,920	50	420	30	11,500	58	—	32	34.8	16.0	—	*bulloides*
826.75	61601	13,302	10	38.3	11,940	50	420	30	11,520	58	—	32	34.8	16.0	—	*bulloides*
828.25	57316	13,312	10	38.3	11,890	50	420	30	11,470	58	—	32	34.8	16.0	—	mixed
829.75	61602	13,322	10	38.3	11,940	50	420	30	11,520	58	—	32	34.8	16.0	—	*bulloides*
831.25	54792	13,332	10	38.3	11,920	50	420	30	11,500	58	—	32	34.8	16.0	—	*bulloides*
832.75	61603	13,346	14	38.3	12,010	40	420	30	11,590	50	—	32	34.8	16.0	—	*bulloides*
834.25	54793	13,360	14	38.3	12,000	50	420	30	11,580	58	—	32	34.8	16.0	—	*bulloides*
835.75	61604	13,377	17	39.2	11,930	50	420	30	11,510	58	—	33	35.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
837.25	54794	13,394	17	39.2	12,010	50	420	30	11,590	58	—	33	35.8	16.0	—	*bulloides*
838.75	61605	13,411	17	39.2	11,980	40	420	30	11,560	50	—	33	35.8	16.0	—	*bulloides*
840.25	54795	13,427	16	39.2	12,090	50	420	30	11,670	58	—	33	35.8	16.0	—	*bulloides*
841.75	61606	13,444	17	39.2	12,080	40	420	30	11,660	50	—	33	35.8	16.0	—	*bulloides*
843.25	54796	13,461	17	39.2	12,130	40	420	30	11,710	50	—	33	35.8	16.0	—	*bulloides*
844.75	61607	13,478	17	39.2	12,120	50	420	30	11,700	58	—	33	35.8	16.0	—	*bulloides*
846.25	54797	13,495	17	39.2	12,180	50	420	30	11,760	58	—	33	35.8	16.0	—	*bulloides*
847.75	62029	13,512	17	39.2	12,200	40	420	30	11,780	50	—	33	35.8	16.0	—	mixed
849.25	57317	13,529	17	40.1	12,240	50	420	30	11,820	58	—	34	36.8	16.0	—	mixed
850.75	60699	13,546	17	40.1	12,180	50	420	30	11,760	58	—	34	36.8	16.0	—	mixed
852.25	57318	13,562	16	40.1	12,140	50	420	30	11,720	58	—	34	36.8	16.0	—	mixed
853.75	60700	13,579	17	41.0	12,250	40	420	30	11,830	50	—	35	37.8	16.0	—	mixed
855.25	57319	13,596	17	41.0	12,120	50	420	30	11,700	58	—	35	37.8	16.0	0.35	mixed
856.75	60701	13,613	17	41.0	12,240	50	420	30	11,820	58	—	35	37.8	16.0	—	mixed
858.25	57320	13,629	16	42.0	12,170	50	420	30	11,750	58	—	36	38.8	16.0	—	mixed
859.75	60702	13,646	17	42.0	12,290	50	420	30	11,870	58	—	36	38.8	16.0	—	mixed
861.25	54798	13,662	16	42.0	12,200	50	420	30	11,780	58	—	36	38.8	16.0	—	*bulloides*
861.25	63248	13,662	—	42.0	12,320	40	420	30	11,900	50	—	36	38.8	16.0 duplicate	—	mixed
862.75	60703	13,676	14	42.9	12,340	50	420	30	11,920	58	—	37	39.8	16.0	—	*bulloides*
862.75	63249	13,676	—	42.9	12,270	40	420	30	11,850	50	—	37	39.8	16.0 duplicate	—	mixed
864.25	54799	13,689	13	42.9	12,200	50	420	30	11,780	58	—	37	39.8	16.0	—	*bulloides*
864.25	63250	13,689	—	42.9	12,290	50	420	30	11,870	58	—	37	39.8	16.0 duplicate	—	mixed
865.75	60704	13,703	14	42.9	12,270	40	420	30	11,850	50	—	37	39.8	16.0	—	mixed
867.25	54800	13,716	13	43.8	12,210	40	420	30	11,790	50	—	38	40.8	16.0	—	*bulloides*
868.75	60705	13,730	14	43.8	12,290	40	420	30	11,870	50	—	38	40.8	16.0	—	*bulloides*
868.75	63252	13,730	—	43.8	12,310	40	420	30	11,890	50	—	38	40.8	16.0 duplicate	—	mixed
870.25	54801	13,743	13	43.8	12,250	50	420	30	11,830	58	—	38	40.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
870.25	63253	13,743	—	43.8	12,350	40	420	30	11,930	50	—	38	40.8	16.0 duplicate	—	mixed
873.25	55377	13,771	28	44.8	12,390	40	420	30	11,970	50	—	39	41.8	16.0	—	*bulloides*
874.75	60707	13,784	13	44.8	12,360	50	420	30	11,940	58	—	39	41.8	16.0	—	*bulloides*
876.25	55378	13,797	13	45.7	12,290	50	420	30	11,870	58	—	40	42.8	16.0	—	*bulloides*
876.25	64027	13,797	—	45.7	12,400	40	420	30	11,980	50	—	40	42.8	16.0 duplicate	—	mixed
877.75	60305	13,811	14	45.7	12,440	50	420	30	12,020	58	—	40	42.8	16.0	—	*bulloides*
879.25	55379	13,824	13	45.7	12,370	50	420	30	11,950	58	—	40	42.8	16.0	—	*bulloides*
880.75	60306	13,837	13	46.6	12,490	60	420	30	12,070	67	—	41	43.8	16.0	0.28	*bulloides*
882.25	57321	13,851	14	46.6	12,420	50	420	30	12,000	58	—	41	43.8	16.0	—	mixed
883.75	60307	13,865	14	46.6	12,510	50	420	30	12,090	58	—	41	43.8	16.0	—	*bulloides*
885.25	55380	13,878	13	47.6	12,450	50	420	30	12,030	58	—	42	44.8	16.0	—	*bulloides*
886.75	60308	13,892	14	47.6	12,470	40	420	30	12,050	50	—	42	44.8	16.0	—	*bulloides*
888.25	55381	13,905	13	47.6	12,470	50	420	30	12,050	58	—	42	44.8	16.0	—	*bulloides*
889.75	60309	13,918	13	48.5	12,460	40	420	30	12,040	50	—	43	45.8	16.0	—	*bulloides*
891.25	55382	13,932	14	48.5	12,450	40	420	30	12,030	50	—	43	45.8	16.0	—	*bulloides*
892.75	60310	13,946	14	48.5	12,530	40	420	30	12,110	50	—	43	45.8	16.0	—	*bulloides*
894.25	55383	13,959	13	48.5	12,530	50	420	30	12,110	58	—	43	45.8	16.0	—	*bulloides*
895.75	60311	13,973	14	49.5	12,580	40	420	30	12,160	50	—	44	46.8	16.0	—	*bulloides*
897.25	55384	13,986	13	49.5	12,510	50	420	30	12,090	58	—	44	46.8	16.0	—	*bulloides*
898.75	60312	13,999	13	49.5	12,550	40	420	30	12,130	50	—	44	46.8	16.0	—	*bulloides*
900.25	55385	14,012	13	50.4	12,580	50	420	30	12,160	58	—	45	47.8	16.0	—	*bulloides*
901.75	60313	14,026	14	50.4	12,650	60	420	30	12,230	67	—	45	47.8	16.0	—	*bulloides*
901.75	63254	14,026	—	50.4	12,670	40	420	30	12,250	50	—	45	47.8	16.0 duplicate	—	mixed
903.25	57322	14,039	13	50.4	12,500	50	420	30	12,080	58	—	45	47.8	16.0	—	mixed
904.75	61608	14,054	15	51.4	12,490	50	420	30	12,070	58	—	46	48.8	16.0	—	mixed
906.25	55386	14,068	14	51.4	12,540	50	420	30	12,120	58	—	46	48.8	16.0	—	*bulloides*
906.25	64028	14,068	—	51.4	12,490	40	420	30	12,070	50	—	46	48.8	16.0 duplicate	—	mixed

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
907.75	60314	14,084	16	52.3	12,710	40	420	30	12,290	50	—	47	49.8	16.0	—	*bulloides*
907.75	64029	14,084	—	52.3	12,600	40	420	30	12,180	50	—	47	49.8	16.0 duplicate	—	mixed
909.25	55387	14,099	15	52.3	12,650	40	420	30	12,230	50	—	47	49.8	16.0	—	*bulloides*
909.25	65448	14,099	—	52.3	12,610	40	420	30	12,190	50	—	47	49.8	16.0	—	mixed
910.75	60315	14,116	17	52.3	12,600	40	420	30	12,180	50	—	47	49.8	16.0	—	*bulloides*
910.75	63255	14,116	—	52.3	12,850	50	420	30	12,430	58	—	47	49.8	16.0 duplicate	—	*bulloides*
912.25	55388	14,132	16	53.3	12,725	45	420	30	12,305	54	—	48	50.8	16.0	—	*bulloides*
912.25	66288	14,132	—	53.3	12,730	40	420	30	12,310	50	—	48	50.8	16.0 duplicate	—	mixed
913.75	65449	14,150	18	53.3	12,650	30	420	30	12,230	42	—	48	50.8	16.0	—	mixed
913.75	60316	14,150	—	53.3	12,760	40	420	30	12,340	50	—	48	50.8	16.0	—	*bulloides*
915.25	55389	14,167	17	54.2	12,830	60	420	30	12,410	67	—	49	51.8	16.0	—	*bulloides*
916.75	60317	14,185	18	55.2	12,780	40	420	30	12,360	50	—	50	52.8	16.0	—	*bulloides*
918.25	55390	14,207	22	55.2	12,810	50	420	30	12,390	58	—	50	52.8	16.0	—	*bulloides*
919.75	60318	14,230	23	55.2	12,850	40	420	30	12,430	50	—	50	52.8	16.0	—	*bulloides*
921.25	55391	14,252	22	56.1	12,870	50	420	30	12,450	58	—	51	53.8	16.0	—	*bulloides*
924.25	55392	14,297	45	57.1	12,890	50	420	30	12,470	58	—	52	54.8	16.0	0.38	*bulloides*
925.75	60320	14,319	22	58.0	12,860	40	420	30	12,440	50	—	53	55.8	16.0	—	*bulloides*
927.25	55393	14,341	22	59.0	12,860	40	420	30	12,440	50	—	54	56.8	16.0	—	*bulloides*
928.75	60708	14,369	28	60.0	12,810	50	420	30	12,390	58	—	55	57.8	16.0	—	*bulloides*
930.25	55394	14,401	32	60.0	12,870	50	420	30	12,450	58	—	55	57.8	16.0	—	*bulloides*
931.75	60709	14,432	31	60.9	12,940	60	420	30	12,520	67	—	56	58.8	16.0	—	*bulloides*
931.75	63256	14,432	—	60.9	12,870	40	420	30	12,450	50	—	56	58.8	16.0 duplicate	—	mixed
933.25	56376	14,459	27	61.9	12,750	40	420	30	12,330	50	—	57	59.8	16.0	—	*bulloides*
933.25	64030	14,459	—	61.9	12,960	40	420	30	12,540	50	—	57	59.8	16.0 duplicate	—	mixed
934.75	60710	14,486	27	61.9	12,820	40	420	30	12,400	50	—	57	59.8	16.0	—	*bulloides*
934.75	63257	14,486	—	61.9	12,960	40	420	30	12,540	50	—	57	59.8	16.0 duplicate	—	mixed
936.25	56377	14,513	27	62.9	12,870	50	420	30	12,450	58	—	58	60.8	16.0	—	*bulloides*

Table 1 Revised ^{14}C calibration data set from Cariaco Basin piston core PL07-58PC. *(Continued)*

Sample ID	Lab code	Cariaco 58PC cal age BP	cal yr span (# of varves)	cal uncer-tainty	^{14}C raw age	±1 σ	Reser-voir age	Uncertainty in reservoir age	^{14}C age (reservoir corrected)	±1 σ	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr	Varve count uncertainty based on count est alone	Varve count uncertainty (yr) based on 1.7% to 11.57 kyr, count errors 11.57–14.66 kyr	Varve count uncertainty (yr) based on wiggle-match alone	Size (mg)	Species
936.25	64031	14,513	—	62.9	12,920	40	420	30	12,500	50	—	58	60.8	16.0 duplicate	—	mixed
937.75	60711	14,540	27	62.9	12,930	80	420	30	12,510	85	—	58	60.8	16.0	0.23	*bulloides*
937.75	63258	14,540	—	62.9	12,970	40	420	30	12,550	50	—	58	60.8	16.0 duplicate	—	mixed
939.25	56378	14,567	27	63.8	12,850	40	420	30	12,430	50	—	59	61.8	16.0	—	*bulloides*
939.25	64032	14,567	—	63.8	12,940	40	420	30	12,520	50	—	59	61.8	16.0 duplicate	—	mixed
940.75	60712	14,594	27	64.8	12,940	50	420	30	12,520	58	—	60	62.8	16.0	—	*bulloides*
940.75	63259	14,594	—	64.8	12,950	50	420	30	12,530	58	—	60	62.8	16.0 duplicate	—	mixed
942.25	57323	14,621	27	64.8	12,800	50	420	30	12,380	58	—	60	62.8	16.0	0.37	mixed
943.75	60713	14,648	54	65.8	12,990	60	420	30	12,570	67	—	61	63.8	16.0	—	mixed
945.25	56379	14,673	25	65.8	12,940	50	420	30	12,520	58	—	61	63.8	16.0	—	*bulloides*
945.25	64033	14,673	—	65.8	12,960	30	420	30	12,540	42	—	61	63.8	16.0 duplicate	—	mixed

Backgrounds

Background samples were 5–10-mg aliquots of calcite sampled as several mg-sized chunks. Typically, 2 calcites were prepared and run with every set of 15–20 samples, and the mean value was used for the background corrections for that set. We made no major changes in laboratory procedures over the period of this study, but backgrounds improved from 0.26% modern carbon (pMC) (equivalent ^{14}C age of 48,000 BP) for samples of 1 mg of carbon in 1998 to 0.09 pMC (56,000 BP) in 2001. Part-way through this work, we became aware of the background improvements achieved by the Kiel group through use of an H_2O_2 leach followed by transfer of samples to the final hydrolysis vessel while still wet (Schleicher et al. 1998). For consistency, we retained the weak HCl leach and dry transfer procedures used initially, and our calcite blanks are as good as those achieved by the Kiel group, but their data are important because they suggest that further background reductions may be possible via improved techniques.

Run-to-run variations for large (>0.75 mg C) calcite aliquots were around ±30% at 1 σ (Figure 4). However, differences between dual blank aliquots from the same run were somewhat smaller (average ±17% with a range of 1% to 41%, excluding data from 1 run where we suspect 1 background sample was slightly contaminated). Based on these results, we adopted an uncertainty of ±20% for background subtractions for samples >0.75 mg C.

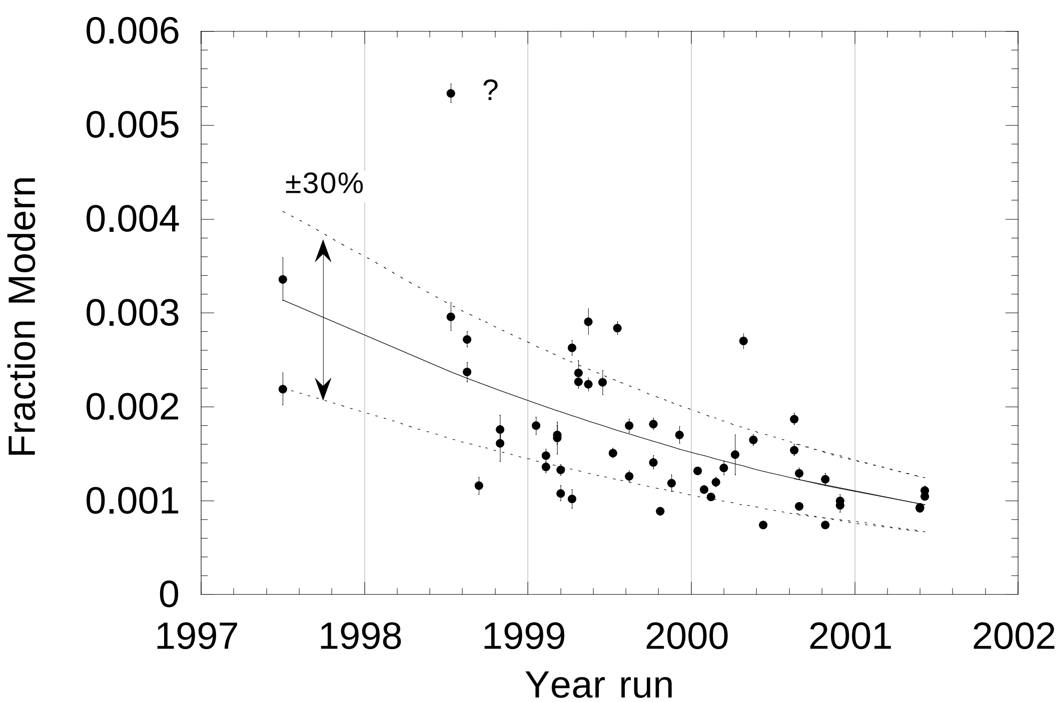

Figure 4 Calcite blanks run with Cariaco Basin data plotted versus year of analysis. These results are for calcite aliquots >0.75 mg C, and constrain the uncertainty for background corrections in larger (>0.75 mg C) samples to ±20% (see text). Error bars are 1 σ.

For smaller samples from core sections where forams were scarce, size-dependent background corrections were used. The algorithms used are similar to those reported previously (Donahue et al. 1990; Brown and Southon 1997). A minor difference is that we have mathematically decomposed the carbon blank into a near-contemporary component with ^{14}C content equal to that of the OX1 standard plus a ^{14}C-dead component which acts purely as a diluant. This convention probably reflects the actual composition of much of the blank—a mixture of contemporary carbon (ambient CO_2, fingerprints, pollen, spores, etc.) and dead material such as O-ring grease and other hydrocarbon residues, fossil fuel-derived aerosols, and dry ice CO_2. Importantly, it also allows us to determine the magnitudes and uncertainties of these 2 fractions independently through periodic measurements of small calcite samples (to evaluate the modern component) and small OX1 samples (for the dead fraction). The calculated contemporary and dead components determined from these small-sample blank measurements decreased from 1.2 ± 0.4 µg and 1.8 ± 0.6 µg, respectively, in 1998, to 1 ± 0.4 µg and 1.2 ± 0.6 µg in 2001. The uncertainties reflect the overall scatter in all of the small-sample blank data accumulated over 6–12-month periods, not just the backgrounds measured with the Cariaco samples. We did not attempt to correct for possible run-to-run variations in the small-sample blank, and used the long-term averages and associated scatter when calculating the small-sample background corrections.

Calcite vs Foram Blanks

We used calcite blanks for this study, since the extra effort involved in picking 50–100 foram blank samples from ^{14}C-dead sediments would have been considerable. However, persistent differences between ^{14}C results on calcite and supposedly ^{14}C-free North Atlantic forams have been reported (Schleicher et al. 1998), and we have encountered similar problems in samples from a tropical Atlantic core (EW9209; Ceara Rise, unpublished data). The 58PC forams are particularly clean and leave very little detrital residue in the hydrolysis vials, but nevertheless, it is important to directly test the equivalence of the calcite and foram blanks.

Results on background *bulloides* samples from the nearby Ocean Drilling Program (ODP) Site 1002 on the Cariaco Basin saddle (Peterson et al. 2000) are shown in Table 2. ^{14}C concentrations in 7 ODP 1002 Hole C and D samples at or beyond the age limit of ^{14}C dating are all within 2 σ of zero after calcite background subtraction, but a small mean offset of 0.03 pMC is present. The very old 15X-CCW samples yielded more sediment residue after hydrolysis than most of the 58PC forams and perhaps this contributed to the higher ^{14}C levels in those samples compared to the calcites. A 0.03-pMC offset would introduce a bias of just 7 yr into the calculated ages for samples around 2 ^{14}C half-lives old.

Table 2 Results for Cariaco Basin foram samples beyond the ^{14}C age limit.

		Calculated pMC and ^{14}C ages			Measured pMC and ^{14}C ages[a]					
Sample	Age (cal BP)	pMC[b]	^{14}C age (BP)[b]	Lab nr CAMS-	pMC	±	^{14}C age (BP)[c]	±	pMC offset (meas.–calc.)	±
1002C 4H-2:150–153 cm	62,000[d]	0.053	60,600	38297	.054	.102	>48,100	—	.001	.102
1002C 4H-5:150–153 cm	80,000[d]	0.006	78,100	38298	.130	.102	>45,900	—	.124	.102
1002C 5H-3:150–153 cm	101,000[d]	0	98,500	38299	–.034	.102	>49,900	—	–.034	.102
1002D 15X-CCW:0–36 cm	500,000[d]	0	486,000	75884	.024	.031	>57,300	—	.024	.031
				75885	.028	.031	>56,300	—	.028	.031
				76127	.043	.041	>54,000	—	.043	.041
				76128	.039	.041	>54,000	—	.039	.041
								MEAN	**0.32**	**.018**

[a]pMC and conventional ^{14}C ages after calcite background subtraction.
[b]Calculated pMC and conventional ^{14}C ages for marine materials, assuming an atmospheric ^{14}C of 0‰ and a marine offset of 400 yr.
[c]Age limits are at 2 σ (Stuiver and Polach 1977).
[d]Ages from ^{18}O (SPECMAP) stratigraphy (Peterson et al. 2000).

Contamination and Outliers

Low-level contamination of samples prior to or during sample preparation is an ever-present threat in high-resolution ^{14}C dating studies on old samples. Of 7 background foram samples in Table 2 and another 12 near-background *bulloides* samples from deep sections of core ODP 1002D (Table S1 in Hughen et al. 2004b), one result appears clearly too young, by around 0.15 pMC. Of 80 calcite blanks run with the samples in this study, one of the 53 full-sized blanks is suspiciously high, by about 0.3 pMC (Figure 2). In addition, one small-sample blank (not shown) showed clear evidence of contamination, yielding a result 0.6 pMC higher than expected. In none of these cases was there evidence that other samples in the same batch were similarly affected. The age shifts corresponding to these levels of contamination in samples with ^{14}C ages of 10–12 kyr are about 35, 70, and 145 ^{14}C yr, respectively. The *bulloides* data suggest that, if those data are typical, up to 5% (1 out of 19) of the results from this study may be shifted to younger ages by about 35 yr—somewhat less than the 40- to 50-yr 1-σ uncertainty in the data. Similarly, the calcite blank results suggest that 1 to 3% (1 or 2 out of 80) may be biased young by 2–3 σ.

Duplicates and Reproducibility

At these levels, any biases from occasional contamination episodes will mostly lie within the normal statistical scatter and will have little overall effect. However, in light of the above, we were particularly suspicious of results which appeared significantly younger than neighboring samples, and picked and measured new aliquots from the same sediment slices wherever possible. In most cases, the second aliquot was older, suggesting that trace contamination may indeed have affected the initial result. Duplicates in this study are therefore biased toward cases where the initial result appeared discrepant, and do not necessarily reflect the overall reproducibility of the ^{14}C data.

A better representation of ^{14}C reproducibility for this study can be obtained by the results of 28 measurements of the foram-rich TIRI/FIRI turbidite sample made at CAMS (Guilderson et al. 2003). The measurements resulted in a low reduced chi-squared value (χ^2/Ndeg = 0.93), showing that the scatter is consistent with the uncertainty estimates derived from measurement error and background correction uncertainties. Additional confirmation can be seen in the comparison of ^{14}C measurements between Cariaco foraminifera and tree rings shown in Figure 3 and quantified in Figure 4. Again, the low best-fit reduced χ^2 (χ^2/Ndeg = 0.90) suggests that there is no significant additional variance in either the foraminifera or the tree-ring dates, and implies that our measurements are reproducible and precise within the quoted uncertainties.

Marine Reservoir Effect

The local Cariaco marine ^{14}C reservoir age was determined by dating 2 samples of pre-bomb forams of known calendar age from box core PL07-BC81 (Hughen et al. 1996). The calendar ages for the samples are 15 and 40 BP, constrained by varve counts, ^{210}Pb ages, and historical dates for 2 large earthquakes in the region that resulted in distinct turbidites in the upper 25 cm (Hughen et al. 1996). The ^{14}C ages measured for the samples are 490 ± 60 and 460 ± 50 BP, whereas the marine model from IntCal98 (Stuiver et al. 1998) yields marine ages of 462 and 450 BP, respectively. This results in ΔR values of +28 and +10, for an average of about +20 yr. On this basis, we assigned a Cariaco reservoir age of 420 yr. An alternate reservoir age determination uses the weighted mean difference of Cariaco and tree-ring ^{14}C ages between 10.5 and 12.5 cal kyr BP (Hughen et al., this issue). The mean of the differences, weighted by error, gives the average reservoir age, and the square root of the variance gives the uncertainty. This resulted in a reservoir age of 430 ± 30 yr, close to the original value as expected, since the Cariaco calendar age was determined by wiggle-matching the reservoir-corrected data to IntCal04 tree rings. However, the reservoir uncertainty of ±30 yr is robust and is adopted in Table 1. The reservoir age is assumed to have remained constant through the last deglaciation, and has been used to convert Cariaco marine ^{14}C ages to atmospheric values. The best evidence for a constant local Cariaco reservoir age is seen in the close agreement between Cariaco and tree-ring ^{14}C ages across the abrupt Younger Dryas termination (Figure 5). There is no discernible offset between terrestrial and marine ^{14}C despite strongly increased Cariaco upwelling during the Younger Dryas period. This agrees with evidence for a short residence time of carbon in the deep basin, ~100 yr (Holman and Rooth 1990), suggesting that increased upwelling does not result in significantly "older" water reaching the surface.

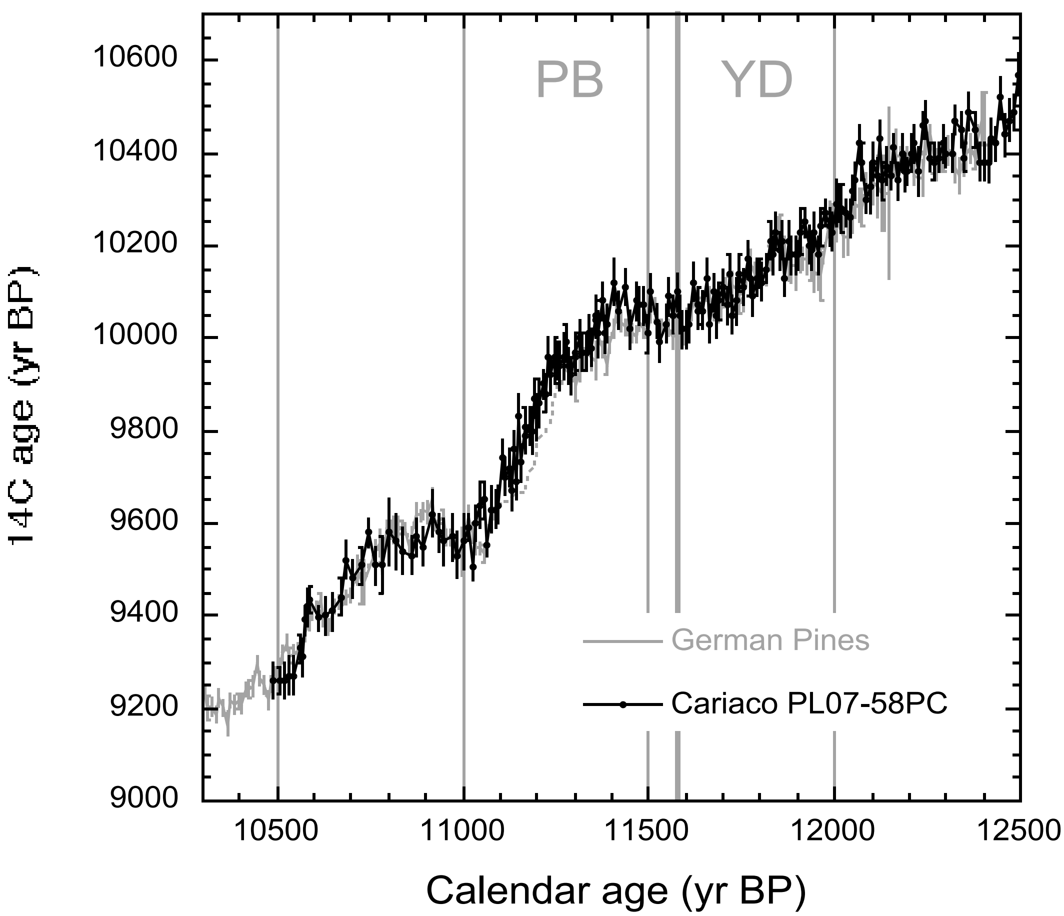

Figure 5 Floating Cariaco Basin PL07-58PC ^{14}C data (black), plotted with the anchored Preboreal pine chronology (PPC) data (gray). Both data sets have been resampled into 5-yr bins and the PPC interpolated at 5-yr resolution. A 200-yr steep section of the PPC data set (dotted line) was removed to eliminate biasing the correlation procedure (see text). Error bars are 1 σ.

There is preliminary evidence from floating tree-ring sequences matched to the Cariaco record suggesting a possible increased marine reservoir age during the Allerød period (Kromer et al., this issue). These data suggest that the reservoir age from 14,000 to 13,000 BP may have been as high as ~650 yr, decreasing to ~420 yr during the transition into the Younger Dryas. Given the evidence above for a short Cariaco residence time, this may indicate a change in the tropical Atlantic reservoir age in general rather than the Cariaco Basin in particular. If these preliminary results remain robust as the floating dendrochronology is strengthened and eventually linked to the anchored chronology <12,500 cal BP, they will provide a valuable record of changes in Atlantic reservoir age relative to abrupt climate shifts during deglaciation. The reservoir age uncertainties calculated for this data set (Table 1) reflect the variability in reservoir age measurements themselves, and do not take into account potential changes in reservoir age through time, which may be much larger.

CARIACO ANCHOR TO TREE RINGS

To anchor the floating Cariaco varve chronology to absolute age, we matched ^{14}C variations with the oldest portion of the Preboreal pine chronology (PPC) (Friedrich et al., this issue). The period of overlap is 1900 yr, centered approximately at 11,403 cal BP. Cariaco 58PC ^{14}C ages were binned into nearest 5-yr calendar age increments. PPC data were measured at approximate 10-yr resolution and were binned at 10 yr and then interpolated into 5-yr increments. The PPC data set has one 30-yr gap centered at 10,750 cal BP, and three 20-yr gaps centered at 11,975, 12,015, and 12,155 cal BP. In addition, we removed 4 Cariaco samples from the analysis that were anomalously young, possibly due to low-level contamination as discussed above. The 2 data sets were aligned using a stepped correlation in which the Cariaco data were shifted in 5-yr steps relative to the PPC, and correlations calculated for each shift. For this analysis, we also excluded the steep portion of the PPC curve around 11,200 cal BP (Figure 5), which exerts a strong influence on the correlation. Such an abrupt ^{14}C change might be expected to show a distinct lag in marine data relative to the atmosphere depending on whether the cause of the shift is changes in production rate or ocean circulation. Therefore, in order to avoid biasing our stepped correlation, we removed PPC data between 11,095 and 11,305 cal BP (indicated by a dotted line in Figure 5).

To determine the optimum fit, we used a χ^2 approach (Bevington 1969). For degrees of freedom $N = 140$, and significance $P = 0.33$ (to represent ± 1 standard deviation), the calculated value of CHISQ/N must be ≤1.05 (Bevington 1969). The range of shifts for which CHISQ/$N \leq 1.05$ is –2 to +30 yr (Figure 6), yielding a best fit of +14 (±16) yr. The PL07-58PC chronology of Hughen et al. (2000) has thus been shifted by +14 yr, and the ±16-yr uncertainty in the wiggle-match procedure is incorporated into the calendar age error in Table 1. Additional uncertainty due to 1.7% cumulative counting error in the varve chronology itself (Hughen et al. 1998) is placed with ±0 yr at the center of the overlap with tree rings at 11,403 cal BP, growing incrementally outward in both directions, but with the maximum uncertainty at the oldest part of the chronology (Table 1). All age uncertainties in Table 1 are calculated as the quadrature sum of errors from the different sources discussed above.

CONCLUSIONS

The entire set of Cariaco PL07-58PC ^{14}C results is presented in Table 1, apart from a few measurements on very small (<0.2 mg) samples which gave very large uncertainties, and results from the non-varved section of core below 950 cm. The data differ slightly from those presented by Hughen et al. (2000): duplicates have not been averaged, and we have retained several results which appear anomalously young (possibly due to low level contamination), which we omitted from the earlier compilation. In addition, the floating varve chronology has been anchored to an updated and expanded tree-ring data set, with better estimates of uncertainty in the wiggle-match. Pending any further changes to the dendrochronology, these results represent the final 58PC calibration data set.

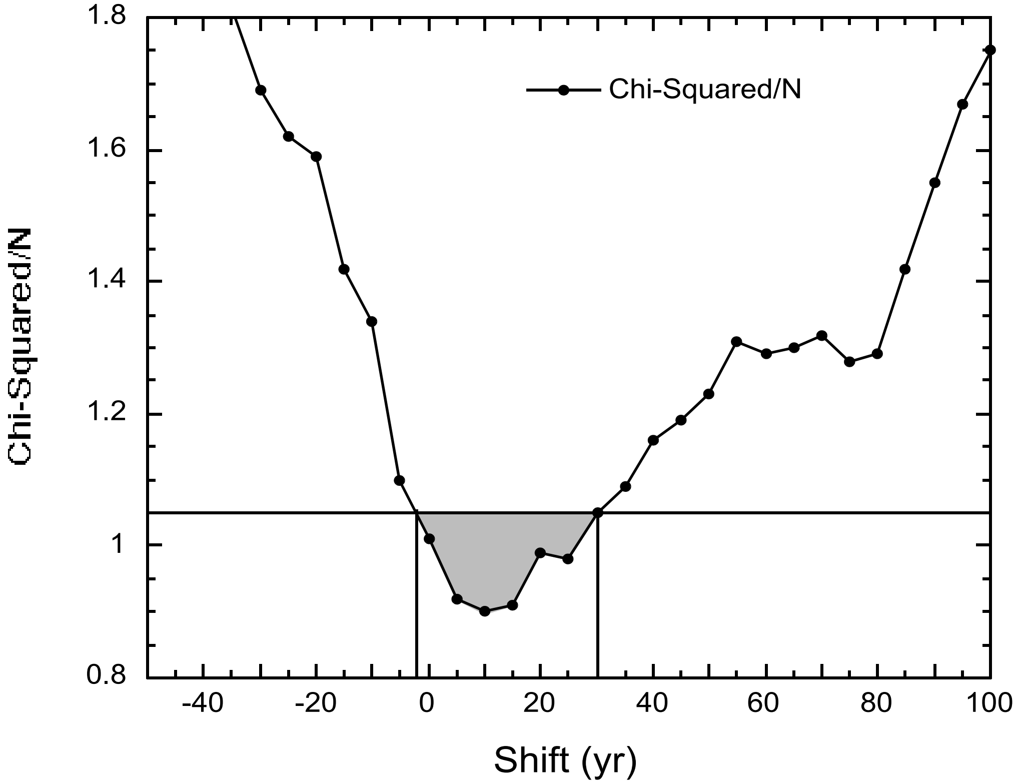

Figure 6 Results of stepped-correlation between floating Cariaco 58PC and anchored PPC ^{14}C data shown in Figure 5. The χ^2 value divided by degrees of freedom (N) is plotted versus shift in years of the Cariaco chronology relative to tree rings. Horizontal line marks the 1-σ cut-off limit for significance in the match (see text). Vertical lines mark the range of significant shifts between –2 and +30 yr, resulting in a best-fit for a Cariaco shift to older ages of 14 ± 16 yr.

ACKNOWLEDGMENTS

This work was supported by LLNL (97-ERI-009), DOE (W-7405-Eng-48), and NSF (ATM-9709563). This is WHOI contribution #11128.

REFERENCES

Bevington PR. 1969. *Data Reduction and Error Analysis for the Physical Sciences*. New York: McGraw-Hill. p 314–5.

Brown TA, Southon JR. 1997. Corrections for contamination backgrounds in AMS ^{14}C measurements. *Nuclear Instruments and Methods in Physics Research B* 123:208–13.

Clark JS. 1988. Stratigraphic charcoal analysis on petrographic thin sections: application to fire history in northwestern Minnesota. *Quaternary Research* 30: 81–91.

Donahue DJ, Linick TW, Jull AJT. 1990. Isotope-ratio and background corrections for accelerator mass spectrometry radiocarbon measurements. *Radiocarbon* 32(2):135–42.

Friedrich M, Remmele S, Kromer B, Hofmann J, Spurk M, Kaiser KF, Orcel C, Küppers M. 2004. The 12,460-year Hohenheim oak and pine tree-ring chronology from central Europe—a unique annual record for radiocarbon calibration and paleoenvironment reconstructions. *Radiocarbon*, this issue.

Guilderson TP, Southon JR, Brown TA. 2003. High-precision AMS ^{14}C results on TIRI/FIRI turbidite. *Radiocarbon* 45(1):75–80.

Holman KJ, Rooth CGH. 1990. Ventilation in the Cariaco Trench, a case of multiple source competition? *Deep-Sea Research* 37:203–25.

Hughen KA, Overpeck JT, Peterson LC, Anderson RF. 1996. The nature of varved sedimentation in the Cariaco Basin, Venezuela, and its palaeoclimatic significance. In: Kemp AES, editor. Palaeoclimatology and Palaeoceanography from Laminated Sediments. *Geological Society Special Publication* 116:171–83.

Hughen KA, Overpeck JT, Lehman SJ, Kashgarian M, Southon J, Peterson LC, Alley R, Sigman DM. 1998. Deglacial changes in ocean circulation from an extended radiocarbon calibration. *Nature* 391:65–8.

Hughen KA, Southon JR, Lehman SJ, Overpeck JT. 2000. Synchronous radiocarbon and climate shifts during the last deglaciation. *Science* 290:1951–4.

Hughen KA, Baillie MGL, Bard E, Bayliss A, Beck JW, Blackwell PG, Buck CE, Burr GS, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Herring C, Kromer B, McCormac G, Manning S, Bronk Ramsey C, Reimer PJ, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyhenmeyer CE. 2004a. Marine04 marine radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon*, this issue.

Hughen KA, Lehman SJ, Southon J, Overpeck JT, Marchal O, Herring C, Turnbull J. 2004b. ^{14}C activity and global carbon cycle changes over the past 50,000 years. *Science* 303:202–7.

Kirner DL, Burky R, Taylor RE, Southon JR. 1997. Radiocarbon dating organic residues at the microgram level. *Nuclear Instruments and Methods in Physics Research B* 123:214–7.

Kromer B, Friedrich M, Hughen KA, Kaiser F, Remmele S, Schaub M, Talamo S. 2004. Late Glacial ^{14}C ages from a floating, 1270-ring pine chronology. *Radiocarbon*, this issue.

Peterson LC, Overpeck JT, Murray DW. 1990. A high-resolution paleoenvironmental study of the Cariaco Basin, Venezuela: Late Quaternary to present. *Preliminary Report on R/V Thomas Washington Cruise Plume-07*. 5–26 June 1990.

Peterson LC, Haug GH, Murray RW, Yarincik KM, King JW, Bralower TJ, Kameo K, Rutherford SD, Pearce RB. 2000. Late Quaternary stratigraphy and sedimentation at Site 1002, Cariaco Basin (Venezuela). In: Leckie RM, Sigurdsson H, Acton GD, Draper G, editors. *Proceedings of the Ocean Drilling Program, Scientific Results* 165:85–99.

Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Blackwell PG, Buck CE, Burr GS, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Herring C, Hughen KA, Kromer B, McCormac G, Manning S, Bronk Ramsey C, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyhenmeyer CE. 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon*, this issue.

Schleicher M, Grootes PM, Nadeau M-J, Schoon A. 1998. The carbonate ^{14}C background and its components at the Leibnitz AMS facility. *Radiocarbon* 40(1):85–93.

Stuiver M, Reimer PJ, Bard E, Beck JW, Burr GS, Hughen KA, Kromer B, McCormac G, van der Plicht J, Spurk M. 1998. IntCal98 radiocarbon age calibration, 24,000–0 cal BP. *Radiocarbon* 40(3):1041–83.

Stuiver M, Polach HA. 1977. Discussion: reporting of ^{14}C data. *Radiocarbon* 19(3):355–63.

Vogel JS, Southon JR, Nelson DE. 1987. Catalyst and binder effects in the use of filamentous graphite for AMS. *Nuclear Instruments and Methods in Physics Research B* 29:50–6.