AGU PUBLICATIONS

Paleoceanography

REPLY

10.1002/2016PA003047

This article is a reply to a comment by *Bard et al.* [2016] doi:10.1002/2016PA002979.

Key Points:

- Evidence supports that Younger Dryas sea level slow stand and MWP-1B are reliably recorded by reef-crest coral Acropora palmata at Barbados
- Results indicate that Tahiti reefs reported in Bard et al. (2010) were unable to keep up with rapidly rising sea level during MWP-1B
- Tahiti SL error bars are greater than reported; a full error analysis shows Tahiti overlaps with the Barbados SL curve

Correspondence to:
R. A. Mortlock,
rmortloc@rci.rutgers.edu

Citation:
Mortlock, R. A., N. A. Abdul, J. D. Wright, and R. G. Fairbanks (2016), Reply to comment by E. Bard et al. on "Younger Dryas sea level and meltwater pulse 1B recorded in Barbados reef crest coral *Acropora palmata*" by N. A. Abdul et al., *Paleoceanography*, *31*, doi:10.1002/2016PA003047.

Received 12 OCT 2016
Accepted 20 NOV 2016
Accepted article online 1 DEC 2016

Reply to comment by E. Bard et al. on "Younger Dryas sea level and meltwater pulse 1B recorded in Barbados reef crest coral *Acropora palmata*" by N. A. Abdul et al.

Richard A. Mortlock[1], **Nicole A. Abdul**[1], **James D. Wright**[1], **and Richard G. Fairbanks**[2]

[1]Earth and Planetary Sciences, Rutgers, State University of New Jersey, Piscataway, New Jersey, USA, [2]Earth and Environmental Sciences, Columbia University, New York, New York, USA

Abstract Abdul et al. (2016) presented a detailed record of sea level at Barbados (13.9–9 kyr B.P.) tightly constraining the timing and amplitude during the Younger Dryas and Meltwater Pulse 1B (MWP-1B) based on U-Th dated reef crest coral species *Acropora palmata*. The Younger Dryas slow stand and the large (14 m) rapid sea level jump are not resolved in the Tahiti record. Tahiti sea level estimates are remarkably close to the Barbados sea level curve between 13.9 and 11.6 kyr but fall below the Barbados sea level curve for a few thousand years following MWP-1B. By 9 kyr the Tahiti sea level estimates again converge with the Barbados sea level curve. Abdul et al. (2016) concluded that Tahiti reefs at the core sites did not keep up with intervals of rapidly rising sea level during MWP-1B. We counter Bard et al. (2016) by showing (1) that there is no evidence for a hypothetical fault in Oistins Bay affecting one of the Barbados coring locations, (2) that the authors confuse the rare occurrences of *A. palmata* at depths $>$5 m with the "thickets" of *A. palmata* fronds representing the reef-crest facies, and (3) that uncertainties in depth habitat proxies largely account for differences in Barbados and Tahiti sea level differences curves with *A. palmata* providing the most faithful proxy. Given the range in Tahiti paleodepth uncertainties at the cored sites, the most parsimonious explanation remains that Tahiti coralgal ridges did not keep up with the sea level rise of MWP-1B.

1. MWP-1B—Not an Artifact of Local Tectonics

The basis for *Bard et al.*'s [2010] rejection of MWP 1B recorded at Barbados is its absence at Tahiti. *Bard et al.* [2010] proposed a tectonic explanation for MWP-1B, and *Bard et al.* [2016] further expanded on *Carlson and Clark* [2012] to argue that the MWP-1B sea level jump in Barbados is an artifact of an earthquake or variable uplift rates affecting coring location RGF 7 and 8 [*Abdul et al.*, 2016; *Peltier and Fairbanks*, 2006]. *Carlson and Clark* [2012] base their tectonic argument on an older section of the Barbados sea level curve presented in *Peltier and Fairbanks* [2006], noting a discrepancy or offset in sea level estimates between core RGF 9 and four dated samples from core RGF 15. *Carlson and Clark* [2012] attributed the apparent offset between core sites to higher uplift rates, more than twice the estimated rate [*Fairbanks*, 1989; *Peltier and Fairbanks*, 2006].

Our primary reason for dismissing the tectonic argument for MWP-1B is that we have determined that the water depth at coring location RGF 15 was incorrectly reported for the four RGF 15 *Acropora palmata* published in *Peltier and Fairbanks* [2006]. Core RGF 15 was drilled at the exact same coring stations as Cores RGF 13 and RGF 14 and at the same GPS coordinates and in the same four-point mooring spread. Based on the ship's location, the entry log for Core RGF 15 water depth should have been recorded as 269 ft (81.8 m) below mean sea level, exactly as the station entry entered for Cores RGF 13 and RGF 14. Instead, the Core RGF 15 Cruise Report lists the water depth as 248 ft (75.4 m) or 6.38 m, shallower, which we now believe to be in error. We apologize for the confusion caused by this logging error [*Peltier and Fairbanks*, 2006]. The corrected results (+6.38 m water depth correction) for the four RGF 15 sea level estimates reported in *Peltier and Fairbanks* [2006] overlap the published data from cores RGF 13 and RGF 9 [*Peltier and Fairbanks*, 2006]. Furthermore, in our forthcoming publication, we show that depth-corrected RGF 15 data overlap and are redundant with abundant *A. palmata* data obtained from two new drill cores (BBDS 11 and BBDS 14) both from the coring location corresponding to RGF 9. Therefore, there is no basis for the offsets between coring locations being caused by earthquakes or variable uplift rates. We consider replotting of Barbados sea level data with higher uplift rates [*Bard et al.*, 2016, Figure 1] to be unjustified.

One simple argument to be made against a hypothetical fault drawn in *Bard et al.* [2010] that extends offshore and through our array of drilling sites is that the supposed fault would cut through the prominent First High Cliff, a feature that has been extensively mapped and dated as the last interglacial reef [*Taylor*, 1974]. There are no significant changes in the elevation of the First High Cliff above present-day sea level in the area of Oistins Bay. The exposed reef terraces to the east of the Christ Church standard traverse are not affected by the Christ Church anticline, suggesting that uplift can be assumed to be small and relatively uniform to the west of South Point [*Radke and Schellmann*, 2006].

1.1. Coring Reef Strategy for Sea Level Reconstruction at Barbados and Tahiti: Sequence Stratigraphy Versus Lithostratigraphy

The different coring strategies employed at Barbados and Tahiti provide the clearest explanation as to why MWP-1B is recorded at Barbados but not at Tahiti. At Barbados, we targeted a series of parallel, submerged offshore constructional reefs, based on detailed bathymetry [*Macintyre*, 1967; *Macintyre et al*., 1991] and previous coring results [*Fairbanks*, 1989; *Peltier and Fairbanks*, 2006] for the sole purpose of extracting a deglacial sea level curve. The Oistins Bay region was selected for coring the deglacial sea level sequence based on the optimum growth conditions for the reef-crest coral, *A. palmata*, observed from kilometers of exposed uplifted Pleistocene reefs and dozens of onshore cores.

Previously, sea level studies in Barbados [*Fairbanks*, 1989] indicated that sea level jumped during MWP-1A and MWP-1B causing the keep-up reef in Barbados to drown and a new shallow water *A. palmata* reef-crest facies reestablished a coral reef landward of the drowned reef. A deep to shallow coring transect is required and predicted for melt water pulses and is the only way one can reconstruct the deglacial sea level curve at Barbados. This sequence stratigraphic strategy guided our core selection sites.

The “keep-up” *A. palmata* reef that recorded the Younger Dryas segment of the Barbados sea level curve became a “give-up” reef during MWP-1B. At those same drilling locations, the drowning event is documented by the *A. palmata* facies being replaced by deeper dwelling *Acropora cervicornis* fragments and cemented reef sands indicating that the sea level recorder is lost. A post-MWP-1B record can only be obtained from the dating of a new keep-up reef that established shoreward and in shallower water (and where we drilled), but only when sea level rise had slowed so that vertical accumulation of *A. palmata* was able to match sea level rise. We note that similar to MWP-1B, MWP-1A is also bracketed by *A. palmata* records obtained from deeper and shallower cores. We contend that no coral reef in the world can keep up with the +30 mm yr^{-1} sea level rise during MWP-1A and MWP-1B. To our knowledge, there is no radiometrically dated record of a coral reef that shows sustained vertical growth rates greater than 25 mm yr^{-1} [*Montaggioni*, 2005].

The coring strategy employed at Tahiti failed to recover MWP-1B because the redundant coring was conducted on the outer edge of the modern barrier reef flat for a variety of geologic purposes. Unlike Barbados, on Tahiti there is no opportunity for a coring sequence of younger reefs transgressing shoreward with rising sea level. The Tahiti coring strategy is classic lithostratigraphy (Figure 1). The dated material in Tahiti cores provides overlapping sea level estimates and suggests a reef that was largely keeping up with sea level rise up until the end of the Younger Dryas (Figure 2). After the Younger Dryas and through MWP-1B, Tahiti reefs accumulated close to the same rate as during the 14–12 kyr B.P. interval (Table S2 in supporting information) [*Bard et al*., 2010]. As shown at Barbados, a MWP greater than 30 mm yr^{-1} requires shoreward migration of the reef-crest facies and establishment of a new reef. One cannot record a MWP by dating coralgal assemblages at the same location, and thus, the Holocene Tahiti reef gives way to a “catch-up” reef as sea level data plot deeper compared to same age *A. palmata*. Evidence for MWP-1B at Tahiti can only come from drilling shoreward, but unfortunately, dating of material from the back reef zone indicates material that is of much younger (6 kyr) age [*Cabioch et al*., 1999]. We note that a core jumping approach was adopted at Tahiti where MWP-1A was captured only by coring in a shallower location [*Deschamps et al*., 2012].

2. *Acropora Palmata*, When Sampled From the Reef-Crest Facies—An Excellent Sea Level Proxy

In section 2, *Bard et al.* [2016] argues that *A. palmata* may have occupied water depths of 10–15 m during the last deglaciation. Figures 2 and S2 in *Abdul et al.* [2016] demonstrate that all *A. palmata* plot either with Tahiti

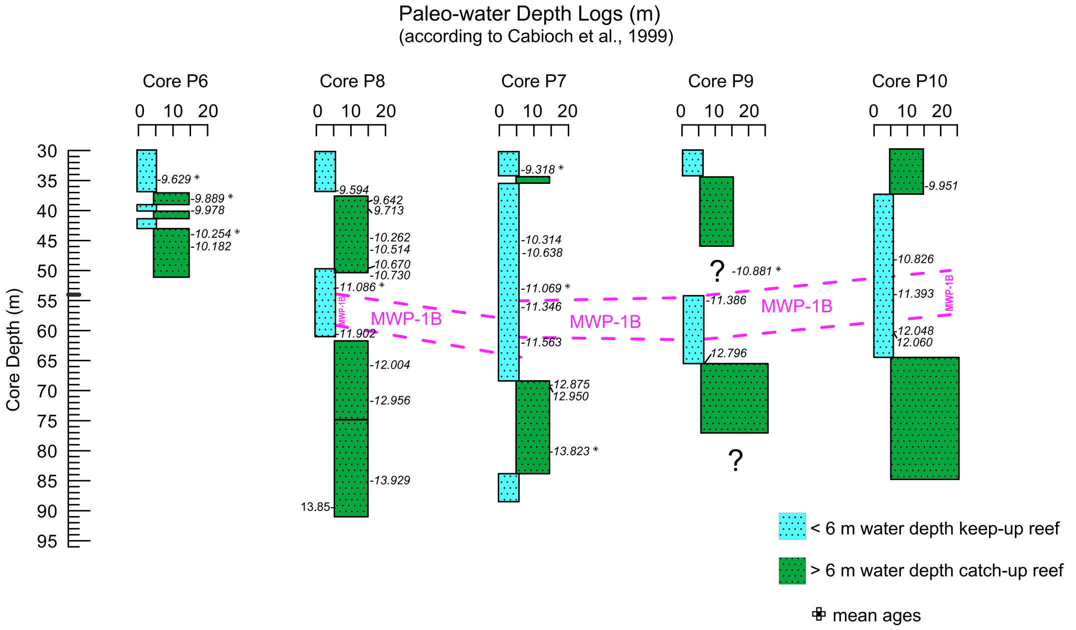

Figure 1. Core logs of estimated paleo-water depth for Tahiti drill cores (horizontal axis in meters) plotted against core depth (vertical axis in meters) reproduced from *Cabioch et al.* [1999]. Blue stippling illustrates shallow water coralgal communities (<6 m). Green stippling are deeper water communities (6–25 m paleo-water depth). The Younger Dryas and early to mid-Holocene interval is mostly represented by deeper water communities (green). Ages are from *Bard et al.* [2010] with crosses denoting mean ages of replicates. Pink dashed lines indicate the interpolated intervals that bracket MWP-1B as identified in the Barbados *Acropora palmata* sea level record [*Abdul et al*., 2016]. The interval is mostly represented by the shallow water community (blue stippling) but yielded only three dated samples that fall within MWP-1B. Cores P6, P8, and P9 were drilled at an angle between 30 and 33° from vertical adding to the uncertainty in depth assignments.

corals or at shallower depth and within the depth uncertainties assigned to corals in both records. At no time from 13.9 to 9 kyr B.P. is *A. palmata* found deeper than Tahiti corals. Therefore, a discussion of *A. palmata* depth habitat is irrelevant to the time interval and sea level curve presented in *Abdul et al.* [2016]. However, a reviewer and editor require that we address this point and thus the ensuing discussion.

Bard et al. [2016] identify a melt water pulse at Tahiti (14.65–14.31 kyr B.P) [*Deschamps et al*., 2012] that they claim is 500 years older than MWP-1A (14.04–13.63 kyr B.P.), the type section first defined at Barbados. *Bard et al.* [2016] and *Deschamps et al.* [2012] argue that these are the same global sea level event and that they should have the same ages and that Tahiti is correct. Therefore, *A. palmata* facies at Barbados must have been living deeper than its modern depth habitat of 0 to 5 m.

The *Abdul et al.* [2016] record has added nine new *A. palmata* data points spanning 13.9–13.6 kyr B.P. from drill cores BBDS 10 and RGF 12 that fill a 300 year and 7 m gap in the deglacial sea level record of *Peltier and Fairbanks* [2006]. The more detailed record now demonstrates, unequivocally, the “keep-up” reef reestablished at Barbados by 13.9 kyr B.P. at 81 m below sea level (bsl) and not 13.63 kyr B.P. and 74.5 m bsl as previously constrained by lower resolution records of *Fairbanks* [1989], *Bard et al.* [1990a, 1990b], and *Peltier and Fairbanks* [2006]. The update to the Barbados sea level record is important. Combining the revised post-MWP-1A record [*Abdul et al*., 2016] with *A. palmata* data recording the onset of MWP-1A [*Peltier and Fairbanks*, 2006] generates a sea level jump with a timing and amplitude more or less consistent with the Tahiti reconstruction. Therefore, in light of the new data published in *Abdul et al.* [2016] and our sea level curve in Figure 2, it can no longer be argued that differences between the Tahiti and Barbados record of MWP-1A are evidence of deeper living *A. palmata* facies [*Bard et al*., 2016; *Deschamps et al*., 2012].

While there are multiple assertions to modern *A. palmata* occupying water depths of up to 17 m [*Bard et al*., 2010; *Carlson and Clark*, 2012; *Deschamps et al*., 2012], the thick successions of U-Th dated reef crest facies *A. palmata* that plot with remarkable fidelity and redundancy [*Abdul et al*., 2016] should not be confused with isolated colonies, living depths in excess of 20 m, such as those reported in the Gulf of Mexico [*Zimmer et al*., 2006]. Based on the location, water depth, and photographs, the two coral specimens reported in *Zimmer*

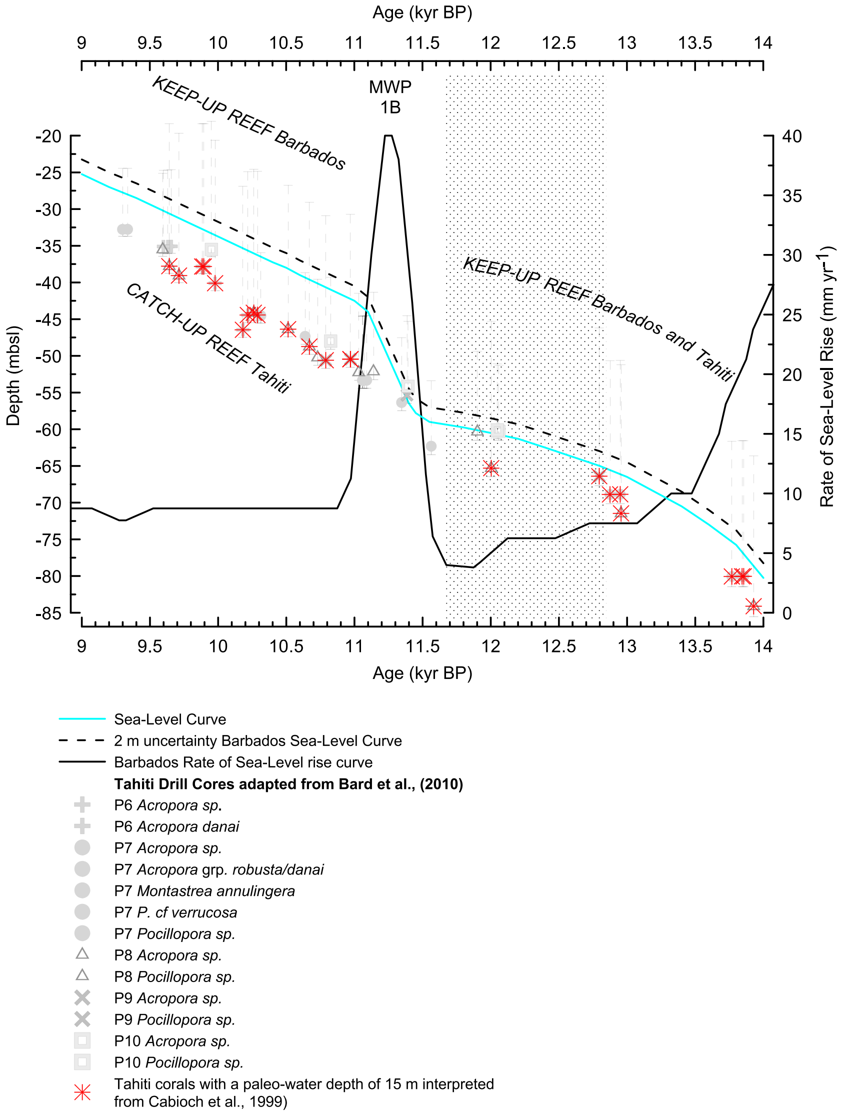

Figure 2. Tahiti data from *Bard et al.* [2010] plotted with the Barbados sea level curve. Cyan line is the Barbados sea level curve constructed from *Acropora palmata* corals with "best estimate "(dashed line) of its uncertainty [*Abdul et al.*, 2016]. Rate of sea level rise (black line) in mm yr^{-1} (right vertical axis) computed from the Barbados sea level curve. Tahiti data from *Bard et al.* [2010] (grayscale symbols) generated from coralgal assemblages *Acropora danai*, *A. gpe robusta*/danai, *Acropora* sp., *Montastrea annuligera*, *P. cf verrucosa*, and *Pocillopora* sp. and associated red algae encruster *Hydrolithon onkodes*. Red stars indicate coralgal samples in *Bard et al.* [2010] and interpreted by *Cabioch et al.* [1999] to have paleo-water depth >6 m bsl and up to 25 m bsl (see Figure 2). We estimate the paleodepth uncertainty for Tahiti data as the combined uncertainty due to paleo-water depth according to *Cabioch et al.* [1999], uncertainty due to estimates in subsidence rates (0.15 to 0.5 mm yr^{-1}), and uncertainty from inclined drilling for angles ranging from 30 to 33° from vertical (~2 m in P6, P8, and P9). Inclusion of the paleodepth uncertainty illustrates that there is complete overlap between the Tahiti data and the Barbados sea level curve.

et al. [2006] are more likely *Acropora prolifera*, a genetic hybrid between *A. palmata* and *Acropora cervicornis*. Only genetic testing can resolve the species identity of the isolated specimens at the remote Flower Garden Reef [*Zimmer et al.*, 2006]. There is no *A. palmata* facies (thickets) observed on Flower Garden Reef because the water depths are too deep.

Bard et al. [2016] take the argument further and suggest that the combined asexual and sexual reproductive strategies employed by *A. palmata* "lend it to being an unreliable indictor of extreme sea level change" because the fragmenting asexual strategy relies on transport of *A. palmata* fragments that could be transported downslope during rapid sea level rise. This is a moot point because all of the Barbados *A. palmata* sea level data reported in *Abdul et al.* [2016] are either shallower or at the same paleo-sea level as the Tahiti sea level estimates. To the contrary, the fragmenting of massive *A. palmata* fronds is exactly what leads to massive, monospecific *A. palmata* fossil beds occupying acres of surface area in the modern Caribbean reefs and Pleistocene reefs of Barbados.

Table 1. Comparison of Tahiti Subsidence Rate Estimates From Radiometric Dating, Geodetic Measurements, and Coral Reef Stratigraphy[a]

Tahiti Subsidence Rate Estimates		
Rate (mm yr^{-1})	Method	Reference[b]
0.21 to 0.25	K-Ar dating of subaerial lava in P7	1,2
0.15	Height and age of Holocene reefs	3
0.39	Open-system MIS 9 corals	4
0.5	Geodetic (GPS)	5

[a] The subsidence rate calculated based on the depth and age of a basalt layer subject to several critical variables: unknown elevation or water depth at time of basalt emplacement, erosion prior to coralgal colonization, and decreasing subsidence rates postbasalt emplacement. Using limited measurements on Holocene reefs to compute subsidence rates has its own particular sources of error. These include uncertainties in the paleowater depth of the Holocene coralgal ridges, the ages of the geomorphic features, and the true paleo-sea level at the age of the elevated Holocene coralgal ridges, and confusion with storm deposits due to the poor species identification success. The short time interval over which the Holocene reef has been subsiding also leads to larger uncertainties. Subsidence rate based on the open-system Uranium series dates for MIS 9 corals incorporate modeled ages and extrapolation of water depth from an imported sea level curve. Modern geodetic estimates using a variety of techniques including GPS, DORIS, and combined satellite altimetry and tide gauge sea level records led *Fadil et al.* [2011] to conclude that 0.5 ± 0.5 mm yr^{-1} is the best estimate, and therefore, Tahiti may be tectonically stable. We conclude that the best available estimates for Tahiti subsidence range from 0.15 to 0.5 mm yr^{-1} with a large uncertainty and include this source of uncertainty in the Tahiti data plotted in Figure 2.

[b] References: 1, *Le Roy* [1994]; 2, K-Ar age of 549 ± 11 ka (unpublished data, as referenced in *Bard et al.* [1996]); 3, *Pirazzoli et al.* [1985]; 4, *Thomas et al.* [2012]; 5, *Fadil et al.* [2011].

3. Barbados Corals Track Regional Sea Level

Geophysical models of the glacio-isostatic adjustment (GIA) predict that the sea level response at Barbados is reasonably close to the global sea level record [*Peltier and Fairbanks*, 2006]. Other models disagree; however, suggesting sea level at Barbados may be sensitive to local differences in mantle viscosity and mantle structure stemming from its location proximate to a subduction zone [*Austermann et al.*, 2013; *Lambeck et al.*, 2014]. *Clark et al.* [2002] argued that there should be a fast regional response due to gravitational changes between ice and water masses, the magnitude and timing of which will depend on the source of melting. Although *Abdul et al.* [2016] did not incorporate GIA corrections into the high-resolution Barbados sea level curve spanning 13.9–9 kyr B.P., data from our previous studies have been incorporated into numerous GIA models to reconstruct both the global (eustatic) and local responses to sea level [*Clark et al.*, 2002; *Lambeck et al.*, 2014; *Milne and Mitrovica*, 2008; *Peltier*, 2002, 2005; *Peltier and Fairbanks*, 2006]. While it might be tempting to ascribe differences between the Barbados and Tahiti sea level during melt water events to GIA or the gravitational response [*Bard et al.*, 2010; *Clark et al.*, 2002], the various sources of error and uncertainty in their respective sea level reconstructions must be considered. Collectively the sources of error in sea level reconstructions at Barbados and Tahiti include subsidence or uplift corrections, depth of habitat, and drill depth, among others.

Admittedly, the modeling results of *Austermann et al.* [2013] imply that the proximity to a subduction zone may complicate the Barbados estimate of the Last Glacial Maximum low stand. However, isostatic adjustments associated with deglaciation occur on much longer timescales (5–7 kyr postglacial decay times) [*Mitrovica et al.*, 2000] and cannot generate the magnitude or rapidity in the centennial-scale accelerations in the Barbados sea level record. Unfortunately, the sources of model error are highly controversial within the modeling community and cannot be rigorously evaluated at this time.

3.1. Subsidence Corrections

Tahiti subsidence rates are not well constrained with estimates ranging from 0.15 to 0.5 mm yr^{-1} with no published consensus within this range (Table 1). The uncertainties on these published subsidence rate estimates are very high. *Bard et al.* [1996, 2010] and *Deschamps et al.* [2012] chose 0.25 mm yr^{-1}, but the justification is not well explained, based on *Pirazzoli and Montaggioni* [1988], *Le Roy* [1994], and elsewhere (unpublished data, as referenced in *Bard et al.* [1996]). Applying the subsidence rate published by *Fadil et al.* [2011] and *Pirazzoli and Montaggioni* [1988], a 12 kyr B.P. sample could have a subsidence correction ranging from 2 m to 6 m.

Barbados is not immune from uncertainties in uplift rate corrections [*Bender et al.*, 1979; *Matthews*, 1973]. Our study area has a relatively low uplift rate, and the continuity and exposure of dated onshore and offshore Pleistocene reefs is the best evidence for relative constancy. Importantly, application of a ±50% uncertainty to a uniform correction of 0.34 mm kyr^{-1} would add just ±2 m uncertainty to our paleodepth estimates and would not change our interpretation of the Barbados sea level record including MWP 1B.

3.2. Depth Assignments

Cabioch et al. [1999] identify "four distinct but poorly diversified coralgal communities that can be delineated in the Tahiti postglacial reef succession and can be classified according to their depth range." They are described as "robust-branching *Acropora*" (0–6 m water depth), "tabular *Acropora*" (6–15 m), "domal *Porites*" (6–15 m), and "branching *Porites*" (5–30 m). However, the paleo-water depths of Tahiti dated coralgal assemblages as defined by *Cabioch et al.* [1999] are not used in *Bard et al.* [2010]. The deeper depth habitats can explain why the Tahiti coral data from cores P6–P10 fall on or below the Barbados sea level curve (Figure 2).

In comparison, the Barbados sea level record presented in *Abdul et al.* [2016] is based on 90 samples of a single species, *A. palmata*, a species that can generally be assigned a depth habitat of 5 m or less and which dominates the Caribbean reef crest community forming dense, high-relief monospecific thickets [*Goreau*, 1959; *Lighty et al.*, 1982; *Morelock et al.*, 2001; *Weil et al.*, 2002]. *A. palmata* is one of the fastest growing corals, and its massive size and density minimizes postdepositional transport. We obtained several hundred *A. palmata* samples from multiple coring locations with redundant drill cores, and many of the individually dated samples range between 10 and 20 cm in length. The Barbados offshore cores were obtained during three cruises using different drilling ships, drilling rigs, crews, and ship positioning systems. That adjacent, and often massive, *A. palmata* plot to within 1–5 m paleodepth of each other in the record presented in *Abdul et al.* [2016] is evidence that our drilling program captured *A. palmata* "thickets" that dominated the reef-crest zone and supports our assertion that the sea level curve in *Abdul et al.* [2016] has not been corrupted with data associated with allegedly deeper living *A. palmata*. We emphasize that though isolated specimens of *A. palmata* have been reported from deeper water, framework producing, reef crest faunas dominated almost exclusively by *A. palmata* must reflect water depths <5 m.

In summary, the collective sources of error in (i) subsidence corrections, (ii) water depth habitat of the dated specimens or surrounding sediments, and (iii) sample depth will lead to sea level error bars that are considerably greater than those reported by *Bard et al.* [2010, 1996]. Paleodepth error bars acknowledging any source of uncertainty are conspicuously absent in Figure 1 in *Bard et al.* [2016].

3.3. Meltwater Sourcing and GIA

Bard et al. [2016] are critical of the conclusion of *Abdul et al.* [2016] that MWP-1B was linked to the melting of the Laurentide (LIS) and Fennoscandian (FIS) ice sheets since it ignores GIA and that the conclusions conflict with recent reconstructions of ice sheet retreat [*Stroeven et al.*, 2016]. Multiple ice sheets of varying proportion contributed to deglacial sea level rise and to melt water pulses. Our hypothesis that melting of the LIS and FIS contributed to MWP 1B was based on the available marine and terrestrial physical evidence while *Bard et al.* [2016] choose to place more credence on model results. These most recent reconstructions of the FIS for the Younger Dryas and published subsequent to *Abdul et al.* [2016] suggest slow or no retreat with some readvancement along most of the ice sheets margins during the Younger Dryas and much faster retreat after the Younger Dryas [*Cuzzone et al.*, 2016; *Stroeven et al.*, 2016]. This is consistent with the observation of a slowdown or near-still stand in Barbados sea level curve [*Abdul et al.*, 2016]. In contrast, excluding lower rates of sea level rise during the Younger Dryas [*Bard et al.*, 2010], Tahiti corals show a relatively constant rate of sea level rise from 14 to 9 kyr B.P. which seems somewhat remarkable given the insolation and $p\mathrm{CO}_2$ changes and evidence for uneven retreat in the large ice sheets [*Cuzzone et al.*, 2016; *Gowan et al.*, 2016; *Stroeven et al.*, 2016]. That MWP-1B is an anomaly from the trend line in sea level rise is as much defined by the Younger Dryas slow stand as by a sea level jump. The slow stand is now resolved with remarkable clarity in the high-resolution *A. palmata* record [*Abdul et al.*, 2016] and generates a sea level deficit that distorts the sea level curve.

Barbados and Tahiti sea level reconstructions display remarkable overlap, except for the discrepancy during MWP-1B, when the combined uncertainties in paleodepth estimates are considered. That the records are so similar contradicts modeling simulations that predict large differences in the GIA response between Barbados and Tahiti during deglaciation.

4. Conclusion

The Tahiti coral data overlap the Barbados sea level curve when the assigned paleo-water depth uncertainty of the Tahiti coral specimens and additional uncertainties discussed above are plotted and taken into consideration (Figure 2). Honoring the blanket multispecies depth uncertainty assigned to their samples by *Bard et al.* [2010] and their colleagues *Cabioch et al.* [1999], there is virtually no basis for claiming a mismatch between the Barbados sea level record and the Tahiti coralgal data. Having determined that there was an error in reporting the water depth for four *A. palmata* samples from drill core RGF 15 [*Peltier and Fairbanks*, 2006], the discrepancies between paleodepths in RGF 15 and RGF 9 have been resolved. Therefore, there is no justification to call upon a hypothetical fault to explain the offset of Tahiti data from the Barbados sea level curve [*Bard et al*., 2010] during MWP-1B.

Acknowledgments
We thank K. Miller, two anonymous referees, and Editor E. Thomas for providing constructive comments that greatly assisted in preparing a more focused reply to the concerns and criticisms raised in the comment.

References

Abdul, N. A., R. A. Mortlock, J. D. Wright, and R. G. Fairbanks (2016), Younger Dryas sea level and meltwater pulse 1B recorded in Barbados reef crest coral *Acropora palmata*, *Paleoceanography*, *31*, 330–344, doi:10.1002/2015PA002847.

Austermann, J., J. X. Mitrovica, K. Latychev, and G. A. Milne (2013), Barbados-based estimate of ice volume at Last Glacial Maximum affected by subducted plate, *Nat. Geosci.*, *6*(7), 553–557.

Bard, E., B. Hamelin, and R. G. Fairbanks (1990a), U-Th ages obtained by mass spectrometry in corals from Barbados: Sea level during the past 130,000 years, *Nature*, *346*(6283), 456–458.

Bard, E., B. Hamelin, R. G. Fairbanks, and A. Zindler (1990b), Calibration of the ^{14}C timescale over the past 30,000 years using mass spectrometric U-Th ages from Barbados corals, *Nature*, *345*, 405–410.

Bard, E., B. Hamelin, M. Arnold, L. Montaggioni, G. Cabioch, G. Faure, and F. Rougerie (1996), Deglacial sea-level record from Tahiti corals and the timing of global meltwater discharge, *Nature*, *382*(6588), 241–244.

Bard, E., B. Hamelin, and D. Delanghe-Sabatier (2010), Deglacial meltwater pulse 1B and Younger Dryas sea levels revisited with boreholes at Tahiti, *Science*, *327*(5970), 1235–1237.

Bard, E., B. Hamelin, P. Deschamps, and G. Camoin (2016), Comment on "Younger Dryas sea level and meltwater pulse 1B recorded in Barbados reef crest coral Acropora palmata" by N. A. Abdul et al., *Paleoceanography*, doi:10.1002/2016PA002979.

Bender, M., R. G. Fairbanks, F. W. Taylor, R. K. Matthews, J. G. Goddard, and W. S. Broecker (1979), Uranium-series dating of the Pleistocene reef tracts of Barbados, West Indies, *Geol. Soc. Am. Bull.*, *90*(6), 577–594.

Cabioch, Camoin, and Montaggioni (1999), Postglacial growth history of a French Polynesian barrier reef tract, Tahiti, central Pacific, *Sedimentology*, *46*(6), 985–1000.

Carlson, A. E., and P. U. Clark (2012), Ice sheet sources of sea level rise and freshwater discharge during the last deglaciation, *Rev. Geophys.*, *50*, RG4007, doi:10.1029/2011RG000371.

Clark, P. U., J. X. Mitrovica, G. A. Milne, and M. E. Tamisiea (2002), Sea-level fingerprinting as a direct test for the source of global meltwater pulse IA, *Science*, *295*(5564), 2438–2441.

Cuzzone, J. K., P. U. Clark, A. E. Carlson, D. J. Ullman, V. R. Rinterknecht, G. A. Milne, J.-P. Lunkka, B. Wohlfarth, S. A. Marcott, and M. Caffee (2016), Final deglaciation of the Scandinavian Ice Sheet and implications for the Holocene global sea-level budget, *Earth Planet. Sci. Lett.*, *448*, 34–41.

Deschamps, P., N. Durand, E. Bard, B. Hamelin, G. Camoin, A. L. Thomas, G. M. Henderson, J. Okuno, and Y. Yokoyama (2012), Ice-sheet collapse and sea-level rise at the Bolling warming 14,600 years ago, *Nature*, *483*(7391), 559–564.

Fadil, A., L. Sichoix, J.-P. Barriot, P. Ortéga, and P. Willis (2011), Evidence for a slow subsidence of the Tahiti Island from GPS, DORIS, and combined satellite altimetry and tide gauge sea level records, *C. R. Geosci.*, *343*(5), 331–341.

Fairbanks, R. G. (1989), A 17,000-year glacio-eustatic sea level record: Influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation, *Nature*, *342*(6250), 637–642.

Goreau, T. F. (1959), The ecology of Jamaican coral reefs I. Species composition and zonation, *Ecology*, *40*(1), 67–90.

Gowan, E. J., P. Tregoning, A. Purcell, J.-P. Montillet, and S. McClusky (2016), A model of the western Laurentide Ice Sheet, using observations of glacial isostatic adjustment, *Quat. Sci. Rev.*, *139*, 1–16.

Lambeck, K., H. Rouby, A. Purcell, Y. Sun, and M. Sambridge (2014), Sea level and global ice volumes from the Last Glacial Maximum to the Holocene, *Proc. Natl. Acad. Sci. U. S. A.*, *111*(43), 15,296–15,303.

Le Roy, I. (1994), Evolution des volcans en système de point chaud: île de Tahiti, Archipel de la Société (Polynésie Française): Université de Paris 11, Orsay, France, p. 272.

Lighty, R. G., I. G. Macintyre, and R. Stuckenrath (1982), *Acropora palmata* reef framework: A reliable indicator of sea level in the Western Atlantic for the past 10,000 years, *Coral Reefs*, *1*(2), 125–130.

Macintyre, I. G. (1967), Submerged coral reefs, west coast of Barbados, West Indies, *Can. J. Earth Sci.*, *4*(3), 461–474.

Macintyre, I. G., K. Rützler, J. N. Norris, K. P. Smith, S. D. Cairns, K. E. Bucher, and R. S. Steneck (1991), An early Holocene reef in the western Atlantic: Submersible investigations of a deep relict reef off the west coast of Barbados, W.I, *Coral Reefs*, *10*(3), 167–174.

Matthews, R. K. (1973), Relative elevation of late Pleistocene high sea level stands: Barbados uplift rates and their implications, *Quat. Res.*, *3*(1), 147–153.

Milne, G. A., and J. X. Mitrovica (2008), Searching for eustasy in deglacial sea-level histories, *Quat. Sci. Rev.*, *27*(25–26), 2292–2302.

Mitrovica, J. X., A. M. Forte, and M. Simons (2000), A reappraisal of postglacial decay times from Richmond Gulf and James Bay, Canada, *Geophys. J. Int.*, *142*(3), 783–800.

Montaggioni, L. F. (2005), History of Indo-Pacific coral reef systems since the last glaciation: Development patterns and controlling factors, *Earth Sci. Rev.*, *71*(1–2), 1–75.

Morelock, J., W. Ramírez, A. Bruckner, and M. Carlo (2001), Status of coral reefs southwest Puerto Rico, *Caribbean J. Sci.*, *4*, 1–57.

Peltier, W. R. (2002), On eustatic sea level history: Last Glacial Maximum to Holocene, *Quat. Sci. Rev.*, *21*(1–3), 377–396.

Peltier, W. R. (2005), On the hemispheric origins of meltwater pulse 1a, *Quat. Sci. Rev.*, *24*(14-15), 1655–1671.

Peltier, W. R., and R. G. Fairbanks (2006), Global glacial ice volume and Last Glacial Maximum duration from an extended Barbados sea level record, *Quat. Sci. Rev.*, *25*(23-24), 3322–3337.

Pirazzoli, P. A., and L. F. Montaggioni (1988), Quaternary coastal changes Holocene sea-level changes in French Polynesia, *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, *68*(2), 153–175.

Pirazzoli, P. A., L. F. Montaggioni, G. Delibrias, G. Faure, and B. Salvat (1985), Late Holocene sea-level changes in the Society Islands and in the northwest Tuamotu Atolls: Proceedings of the Fifth International Coral Reef Congress, v. Vol. 3: Symposia and Seminars (A). p. 131-136.

Radke, U., and G. Schellmann (2006), Uplift history along the Clermont Nose traverse on the west coast of Barbados during the last 500,000 years—Implications for paleo-sea level reconstructions, *J. Coast. Res.*, *22*(2), 350–356.

Stroeven, A. P., et al. (2016), Deglaciation of Fennoscandia, *Quat. Sci. Rev.*, *147*, 91–121.

Taylor, F. W. (1974), The uplifted reef tracts of Barbados, West Indies: Detailed mapping and radiometric dating of selected areas [M.Sc. dissert.]: Brown University, Providence, R.I., 235 p.

Thomas, A. L., et al. (2012), Assessing subsidence rates and paleo water-depths for Tahiti reefs using U-Th chronology of altered corals, *Mar. Geol.*, *295-298*, 86–94.

Weil, E., E. A. Hernández-Delgado, A. Bruckner, L. Ortoz, O. Nemeth, and H. Ruiz (2002), Distribution and status of Acroporid coral (Scleractinia) populations in Puerto Rico, Conference: NOAA-NMFS and NCORE Potential Application of the US Endangered Species Act (ESA) as a Conservation Strategy, Volume 1: RSMAS, Miami, Fla. USA, p. 71-92.

Zimmer, B., W. Precht, E. Hickerson, and J. Sinclair (2006), Discovery of *Acropora palmata* at the Flower Garden Banks National Marine Sanctuary, northwestern Gulf of Mexico, *Coral Reefs*, *25*(2), 192–192.