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HOLOCENE HISTORY OF THE MANGROVE ISLANDS OF TWIN CAYS, BELIZE, CENTRAL AMERICA

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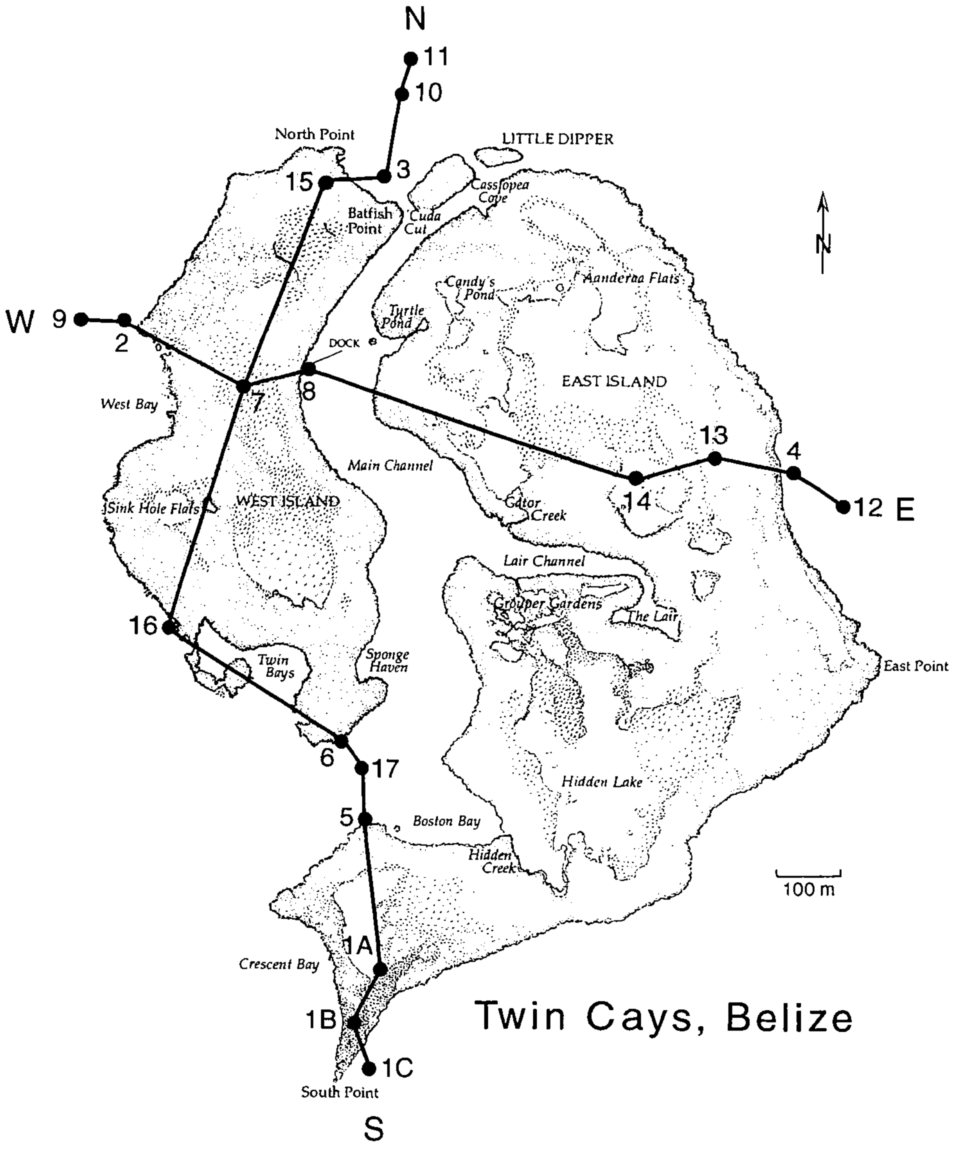

Figure 1. Location Map of Twin Cays showing Main Channel, N-S and E-W cross sections and core locations.

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ABSTRACT

Nineteen vibracores collected along north/south and east/west transects across Twin Cays, Belize indicate that these two mangrove islands have been formed by accumulations of mangrove peat and sediment that are almost 9 m thick. Mangrove communities were established on a Pleistocene limestone substrate about 8,000 calendar (cal) years ago and kept pace with the late Holocene transgressing seas. At several stages lagoonal sands invaded the mangrove communities and commonly were subsequently overgrown by the mangroves. The initiation of the main channel that separates these two cays was established early in the history of these islands and appears to be related to the topography of the underlying limestone. Radiocarbon dates of peat and sediment from this study were calibrated and plotted with respect to mean sea level and were shown to be in agreement with the corrected western Atlantic sea-level curve (Toscano and Macintyre, 2003).

INTRODUCTION

Mangrove communities were rapidly established on the Pleistocene surface of the Belize Barrier Reef Platform after it was flooded about 8,000 cal years ago by the rising seas of the Holocene Transgression (Purdy, 1974; Purdy et al., 1975; Ebanks, 1975; Halley et al., 1977; Shinn et al., 1982; Macintyre et al., 1995). The majority of these mangrove communities subsequently were drowned on the deeper Pleistocene surfaces and covered by calcareous lagoonal deposits. In the south-central area of the Belize Barrier Reef Platform, however, mangrove communities that were established on high relief on the underlying Pleistocene limestone kept pace with the rising seas and formed very thick accumulations of peat, particularly at Tobacco Range (Macintyre et al., 1995) and Twin Cays.

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We investigated the Holocene history of the mangrove islands of Twin Cays and show the changing patterns of development of these islands as they kept pace with advancing sea level. In addition, calibrated radiocarbon dates on mangrove peat, mangrove wood and *Halimeda* sand are used to demonstrate that the Toscano and Macintyre (2003) corrected sea-level curve for the western Atlantic is valid for the Belize area.

PREVIOUS WORK

Purdy (1974) was the first to report radiocarbon dates for peat samples taken from sediment cores collected in the inner Southern and Northern Shelf Lagoons. As he was mainly interested in establishing the rates of deposition of sediment accumulations, he did not report the water depths of his core sites. We recently obtained this information from him (E.G. Purdy, November 2002) and have discovered that peat samples ranging from depths of 1 m to 24 m yielded uncalibrated ^{14}C dates of 5,600 ± 140 yrs BP to 10,075 ± 210 yrs BP.

Thin accumulations of basal mangrove peat overlying a terrigenous clay deposit on the eroded Pleistocene limestone surface have been reported at Ambergris Cay (about 130 km north of Twin Cays) where they were patchy in distribution and undated (Ebanks, 1975). Similar thin peat deposits were found around Boo Bee Patch Reef in the Southern Shelf Platform Lagoon, 3 km south of Twin Cays, where they were only 0.3 m thick and yielded an uncalibrated ^{14}C date of 8,780 ± 100 yrs BP at a depth of 18 m below sea level (Halley et al., 1977).

Shinn et al. (1982) sampled peat from vibracores collected along a transect that started at Carrie Bow Cay and extended west to the mainland. The peat was generally at the base of five cores. On the Barrier Reef Platform they were less than 1 m thick at depths of 9.5 m and 16 m below sea level. These peats were not ^{14}C-dated, but the three vibracores collected in the Southern Shelf Lagoon encountered peat shallowing shoreward at depths below sea level of about 15 m, 7 m and 5 m. A total of five ^{14}C dates for these peats ranged (uncalibrated) from 8,808 ± 600 yrs BP to 2,861 ± 190 yrs BP.

Some of the thickest accumulations of mangrove peat ever reported were documented in vibracores and in samples taken with Macauly and Davis soil-sampling probes along a northwest-to-southeast transect across Tobacco Range (Macintyre et al., 1995). Almost all of the sections sampled were entirely mangrove peat, both from the island and offshore. This peat, which was established on terrigenous basal mud on Pleistocene limestone, was up to 10 m thick and gave a maximum uncalibrated ^{14}C date of 6,920 ± 100 yrs BP. We are now reporting that Twin Cays, which is only 5 km south of Tobacco Range, has very similar thick accumulations of mangrove peat overlying Pleistocene limestone.

METHODS

Field Work

A total of 19 vibracores were collected along north/south and east/west transects across Twin Cays (Fig. 1). The first 6 cores were collected by a team led by R.G. Lighty in 1984. In the following year, I.G. Macintyre's group collected an additional 13 cores. Continuous sediment and peat sections were vibracored using 9 m-long, 7.6 cm-diameter aluminum core tubes, each fitted with a core catcher (Fig. 2). Offshore work was relatively easy compared with the movement of this heavy equipment into the interior (Fig. 3).

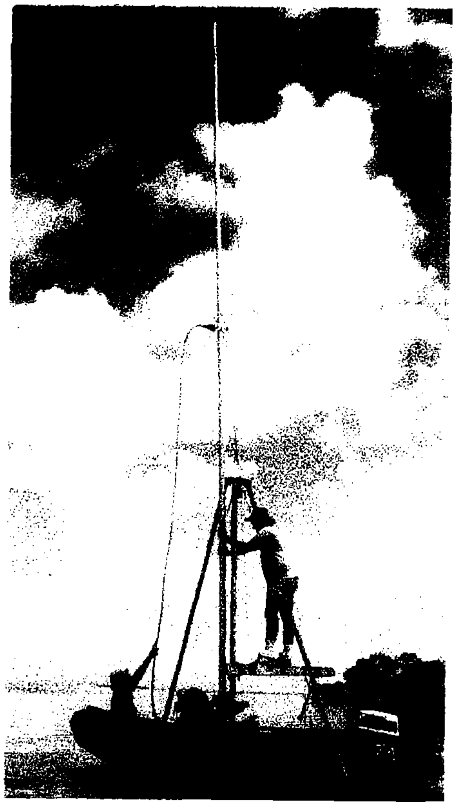

Figure 2. Collecting vibracore 16 off the west coast of Twin Cays with the aid of a Zodiac (inflatable boat).

Figure 3. Crossing Hummingbird Pond (between cores 13 and 14 on Figure 1) with vibracore unit. The tripod can be seen at site 14 in the background.

Core recovery and depth of penetration were recorded at each site so that corrections could be made for sample compaction (primarily of peat) that occurred during coring. In addition, a record was made of the elevation of each core site with respect to mean sea level. Cores were left in their aluminum tubes, cut in 3 m sections, capped and shipped for laboratory analyses.

Radiocarbon dates were determined by the former Smithsonian Institution Radiocarbon Laboratory, using the Libby half-life of 5568 years; 95% of the activity of the National Bureau of Standards oxalic acid was used as the modern standard. The peat samples were studied under the microscope to remove rootlets that appeared noncontemporaneous, and all carbonate material was removed by acid pretreatment.

Radiocarbon Date Calibration

Uncalibrated ^{14}C dates on intertidal mangrove peat (*Rhizopora mangle* and related species) were determined using the Libby ^{14}C half life of 5568 years (rather than the true ^{14}C half life of 5730 years) and neither analyzed nor corrected for ^{13}C; thus they are not valid calendar ages. Standard ^{14}C dates therefore are not consistent with the more accurate temporal framework available from high-precision U-Th-dated coral records for tracking sea level.

Calibration data, which account for temporal variations in atmospheric $^{14}C/^{12}C$ over time, are now widely used to arrive at the true (calendar) ages of radiocarbon-dated samples (Stuiver et al., 1998a; b). For peat samples, correction for ^{13}C and atmospheric calibration shifts the original ^{14}C data to older values, with the offset increasing as the samples get older (Bard et al., 1990). It is important to calibrate ^{14}C data from intertidal mangrove peat deposits because they are believed to accumulate in a specific facies having a well-defined relationship to tidal range and hence to sea level (e.g. Scholl et al., 1969; Robbin, 1984; Boardman et al., 1988; Digerfeldt and Hendry, 1987). As such, mangrove peats can provide essential upper-limit information for the actual position of sea level above the elevation of contemporaneous coral-reef crest growth.

None of the mangrove samples presented and referenced in this paper had originally been analyzed for ^{13}C fractionation. Peat dates were calibrated with the CALIB program (Stuiver and Reimer, 1993) as nonconventional radiocarbon ages using a $^{13}C_{PDB}$ value of $27\pm0.2^{o}/_{oo}$ (Smith and Epstein, 1971) and the atmospheric calibration dataset A (CALIB Manual version 4.1; Stuiver and Reimer, 1993; Stuiver et al., 1998 a; b).

Toscano and Macintyre (2003) synthesized and calibrated all available peat and coral ^{14}C age data to construct a sea-level curve for the western Atlantic. This curve included the peat samples taken from Twin Cays cores and discussed herein, as well as 23 peat samples from the Tobacco Range group of mangrove islands in the Central Belize Lagoon (Macintyre et al., 1995). This calibrated coral-peat sea-level curve is presented in relation to the Twin Cays data to understand the sea-level history of the Central Belize Lagoon.

RESULTS

Subsurface Facies

The two cross sections based on vibracore transects (Figs. 4 and 5) indicate that mangroves were established on an elevated section of the erosional surface of the Pleistocene limestone substrate (Macintyre and Toscano, this volume) about 8,000 cal years ago. The maximum thickness of the mangrove peat is about 9 m, which is slightly less than that of the peat sections recovered from Tobacco Range (Macintyre et al., 1995), which is about 5 km north of Twin Cays.

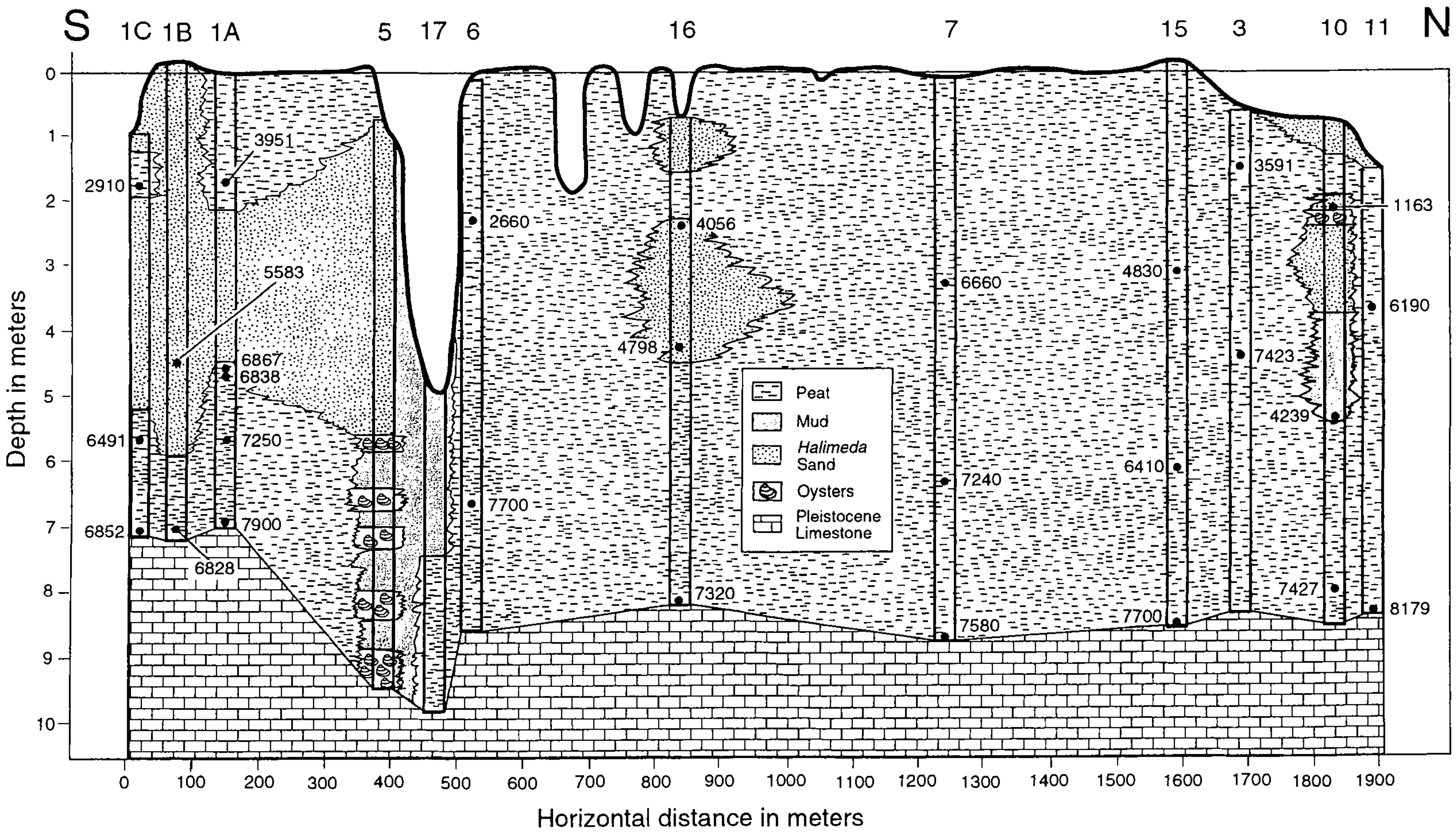

Figure 4. N-S vibracore cross section across Twin Cays, showing distribution of dominant mangrove facies and locations of radiocarbon-dated samples. All ages are in calendar (cal) years.

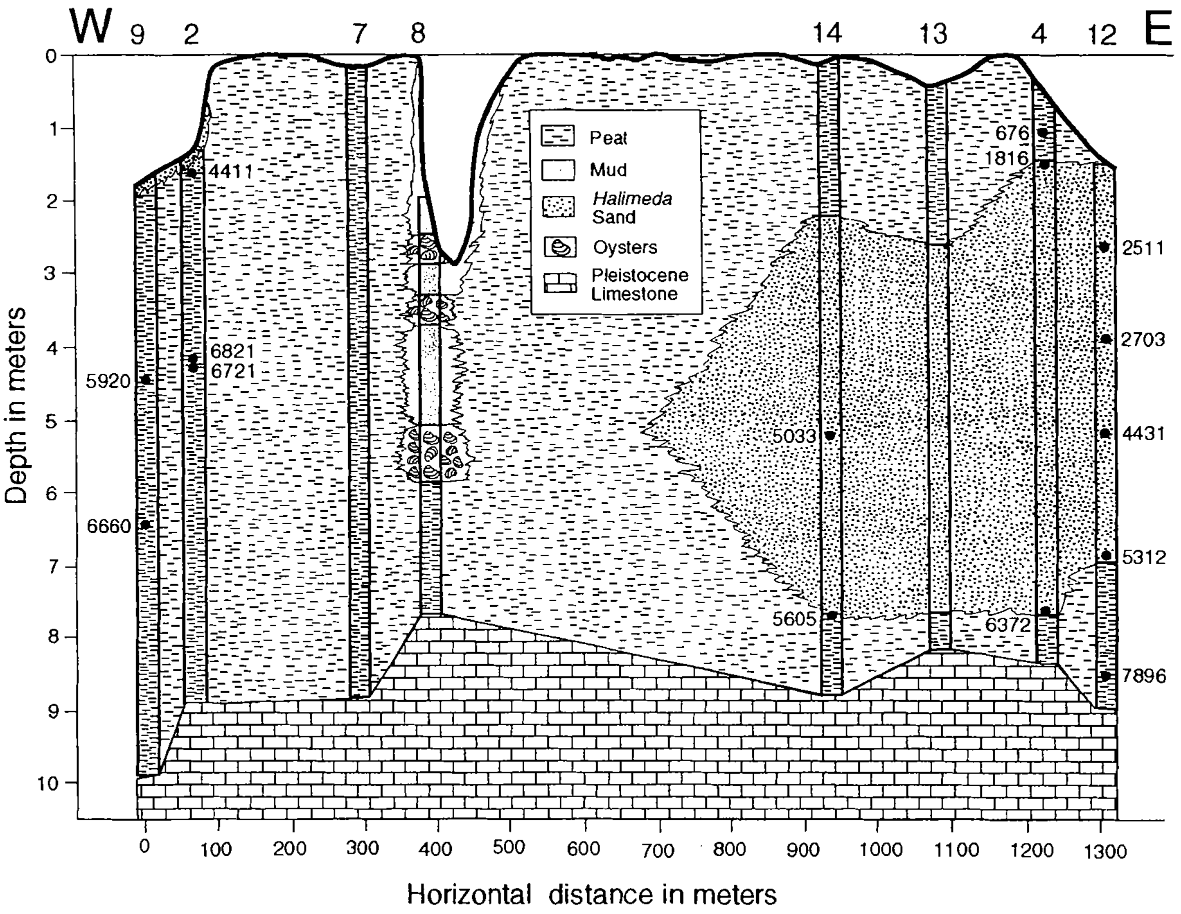

Figure 5. W-E vibracore cross section across Twin Cays, showing distribution of dominant mangrove facies and locations of radiocarbon-dated samples. All ages are in calendar (cal) years.

Four basic facies were recognized in the Twin Cays cores:

Mangrove Peat Facies. The mangrove peat, like the peat from Tobacco Range (Macintyre et al., 1995), was composed of two types that are related to stages of peat preservation. The uppermost sections were dominated by well-preserved "broad-fibered peat", which ranged in color from brown to reddish brown and generally had a spongy texture of coarse-fibered roots and rootlets. In contrast, the "fine-fibered peat" was usually found in lower sections of the cores and ranged in color from dark brown to black and consisted of a pasty dense texture of fine fibers. This decomposed early peat usually lacked identifiable plant remains. All stages of alteration of peat were found along with a common intermixing with both sand and mud deposits.

Halimeda Sand Facies. This facies consisted of a calcareous sand dominated by *Halimeda* grains in varying amounts of carbonate mud matrix. Molluscs were common and consisted of a wide variety of bivalves and gastropods. Other constituent grains included branching *Porites* fragments, echinoid spines, and worm tubes.

Mud Facies. These grey calcareous muds contained scattered grains of molluscs, including bivalves and gastropods, *Halimeda* plates and echinoid spines. The mud section found in Core 10 differed significantly from the other muds. It contained mostly benthic foraminifer tests with traces of gastropods, bivalves, and echinoid spines, and was probably a mangrove pond deposit.

Oyster Bed Facies. This facies, which is always found interbedded with the mud facies, was dominated by oyster valves (*Isognomon alatus*) with minor amounts of other molluscs, *Halimeda* grains and barnacles.

Calibrated Radiocarbon Dates

Calibration of ^{14}C dates from Twin Cays peat, wood, and *Halimeda* sand samples (Table 1) pushes the ages back by 100 to 900 years over the approximately 700-8,200-year time frame. Toscano and Macintyre (2003) presented similar calibration age shifts for their larger western Atlantic coral and peat database.

Plots of calibrated radiocarbon dates of Twin Cays samples with respect to mean sea level are shown in Figure 6. The sea-level curve in Figure 6 is the western Atlantic sea-level curve based on the combined calibrated coral and peat dataset of Toscano and Macintyre (2003). This curve keeps most of the Twin Cays mangrove peat and wood samples above it and the subtidal *Halimeda* sands below.

As can be seen in Figure 6, a few subtidal *Halimeda* sand samples plot above this curve and probably represent transported deposits. Two peat dates that plot slightly below this curve can likely be explained by younger root contamination (age shift) or compaction that occurred during coring (elevation shift). The elevations of peat dates well above the curve are more problematic as discussed at length by Toscano and Macintyre (2003).

Age calibration provides an improved temporal component to the curve; however, elevation issues still exist in the large (up to 4 meters) vertical range of the peat samples. Figures 4 and 5 (cross sections across depositional environments) indicate that several mangrove environments exist across these islands. As these facies likely shifted over time, vertical sections in particular cores may not contain consistent peat compositions throughout. Given the lack of identifiable macroscopic remains in the peat, the assumption that intertidal *Rhizopora mangle* dominates all vertical sections is not verifiable. Unfortunately, the actual elevation range of the modern surface environments is less that 0.5 m (this study as well as Tobacco Range; Macintyre et al., 1995) making it difficult to assume that the elevation range of the geologic peat samples in the sea-level curve is related to topographic changes in facies preserved in the cores. In addition, the elevation of wood samples higher in the section with the elevated peats might be an indication that a number of peats represent preserved canopy-level deposits. Another possibility includes the need to factor out tidal or storm-surge variability from the elevations, which is not possible to quantify in a geologic context. Lastly, glacio-hydro-isostatic 3D earth model predictions (Lambeck et al., 2002) may eventually provide some downward correction which is site-specific; however, the 4 m elevation range of the peat database may also be indicative of age errors possibly caused by contamination of peat by older carbon from pre-Holocene substrate and/or terrestrial sources.

Table 1. Calibrated radiocarbon dates for Twin Cays samples plotted in Figures 6 and 8. Type MP is Mangrove Peat, W is Wood, HS is *Halimeda* Sand.

Location	**Sample Type**	**Core ID**	**Elevation, m MSL**	**^{14}C Date yrs BP**	**±**	**CalBP Years**
Twin Cays	MP	1A-128	-1.76	3655	80	3951
Twin Cays	MP	1A-355	-4.59	6065	75	6867
Twin Cays	MP	1A-350	-4.73	6030	105	6838
Twin Cays	MP	1B-360	-7.06	6070	110	6828
Twin Cays	MP	1C-60	-1.77	2835	130	2910
Twin Cays	MP	1C-425	-5.76	5745	150	6491
Twin Cays	MP	1C-555	-7.19	6040	145	6852
Twin Cays	MP	2-15	-1.55	3960	95	4411
Twin Cays	MP	2-210	-4.25	5915	90	6721
Twin Cays	MP	3-90	-1.53	3400	105	3591
Twin Cays	MP	3-260	-4.50	6520	160	7423
Twin Cays	MP	4-55	-1.05	800	70	676
Twin Cays	MP	6-200-216	-2.31	2490	60	2660
Twin Cays	MP	6-620-640	-6.75	6920	110	7700
Twin Cays	MP	7-250-270	-3.30	5870	100	6660
Twin Cays	MP	7-500-520	-6.35	6310	90	7240
Twin Cays	MP	7-693-713	-8.71	6730	90	7580
Twin Cays	MP	9-200-220	-4.45	5210	90	5920
Twin Cays	MP	9-350-370	-6.43	5870	90	6660
Twin Cays	MP	11-190-210	-3.71	5420	70	6190
Twin Cays	MP	15-250-270	-3.08	4270	80	4830
Twin Cays	MP	15-500-520	-6.15	5670	80	6410
Twin Cays	MP	15-690-709	-8.49	6920	90	7700
Twin Cays	MP	16-630-644	-8.12	6450	90	7320
Twin Cays	W	1A-420	-5.70	6340	60	7250
Twin Cays	W	1A-518	-7.02	7080	110	7900
Twin Cays	W	2-204	-4.18	6050	100	6821
Twin Cays	HS	1B-237	-4.58	4815	55	5583
Twin Cays	HS	4-95	-1.48	1810	40	1816
Twin Cays	HS	10-115-125	-2.20	1190	90	1163
Twin Cays	HS	12-90-100	-2.63	2390	70	2511
Twin Cays	HS	12-190-200	-3.89	2490	100	2703
Twin Cays	HS	12-290-300	-5.15	3920	70	4431
Twin Cays	HS	14-490-500	-5.20	4380	70	5033
Twin Cays	HS	16-138-148	-2.39	3620	70	4056
Twin Cays	HS	16-300-310	-4.27	4150	80	4798

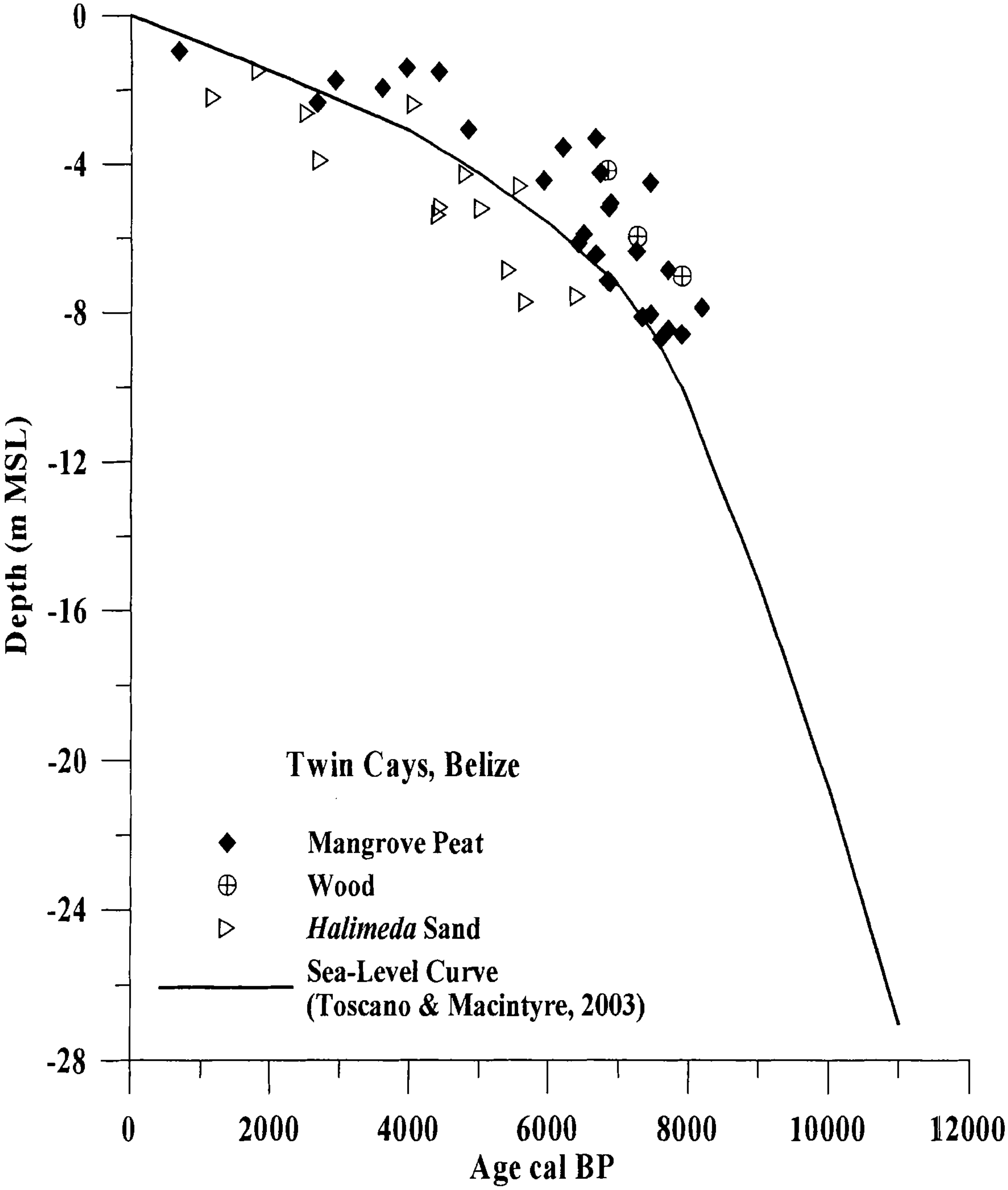

Figure 6. Calibrated age data from peat, wood, and *Halimeda* sand taken from Twin Cays cores in relation to the corrected western Atlantic sea-level curve of Toscano and Macintyre (2003).

DISCUSSION

Holocene History

It can be seen on the two cross sections (Figs. 4 and 5) that mangrove peat at Twin Cays started to accumulate about 8,000 cal years ago on an erosional Pleistocene limestone surface at depths of 9 to 10 m below present sea level. Unlike Tobacco Range (Macintyre et al., 1995), where basal clay deposits were found in both vibracore and sediment-probe samples, this residual soil deposit was only recovered at the base of Core 11 at Twin Cays. This material, which represents the soil that accumulated on the exposed Pleistocene limestone, also was reported below peat deposits in northern Belize (High, 1975; Ebanks, 1975) and Belizean offshore atolls (Gischler, 2003). Basal clays were either lost during the coring on Twin Cays or washed off the Pleistocene surface prior to the establishment of the mangrove communities.

Oysters are commonly found in large quantities on mangrove roots exposed at the edges of channels or ponds (Fig. 7). Therefore, the presence of interlayered mud and oyster beds (Cores 5 and 17) above the Pleistocene surface in the main channel at the southern section of Twin Cays (Fig. 4) indicates that this channel existed during most of the Holocene history of these islands. In this area the position of the channel appears to be related to a topographic low point in the underlying Pleistocene limestone surface. At the north end of this S-N cross section (Fig. 4), the interlayered mud, sand, and oysters in the middle portion of Core 10 suggests the existence of a mangrove pond that was eventually closed off by mangroves and later submerged by rising sea level. Further north on the E-W cross section (Fig. 5), the main channel (seen in Figure 4, cores 5 and 17) developed or extended into that area about 2,000 years later, independent of the Pleistocene substrate relief (Fig. 5, core 8).

Major transgressions of lagoonal *Halimeda* sands occurred around 5,000 to 6,000 cal years ago off both the east and south coasts (Figs. 4, 5). This sand was overgrown by mangrove communities off the east coast about 2,000 cal years ago but off the south coast the sand has maintained its position and presently forms South Point (Fig. 1). Off both the west and north coasts, similar but considerably smaller incursions of lagoonal *Halimeda* sands have occurred at later dates, around 4,000 to 5,000 cal years ago. This indicates that the north and west

Figure 7. Modern *Isognomon alatus* (oyster) growth on exposed mangrove roots at Twin Cays analagous to the oysters cored in tidal channel deposits. Field drawing by Mary Parrish (2002).

coasts of the smaller island (Figs. 1, 4, 5) have had more stable mangrove development during the formation of these islands than have the east and south coasts of the larger island. This could be related to more exposure to hurricane damage and the resultant retreat of mangroves off the seaward-facing southern and eastern coasts.

Holocene Sea-Level History of Belize

Our calibrated sea-level database consisting of ^{14}C-dated mangrove peat and associated *Halimeda* sands from Twin Cays basically agrees with the Toscano and Macintyre (2003) corrected western Atlantic sea-level curve (Fig. 6). However, a publication by Gischler and Hudson (2004) introduced a sea-level curve for Belize that is considerably elevated above the western Atlantic sea-level curve. This contrast in

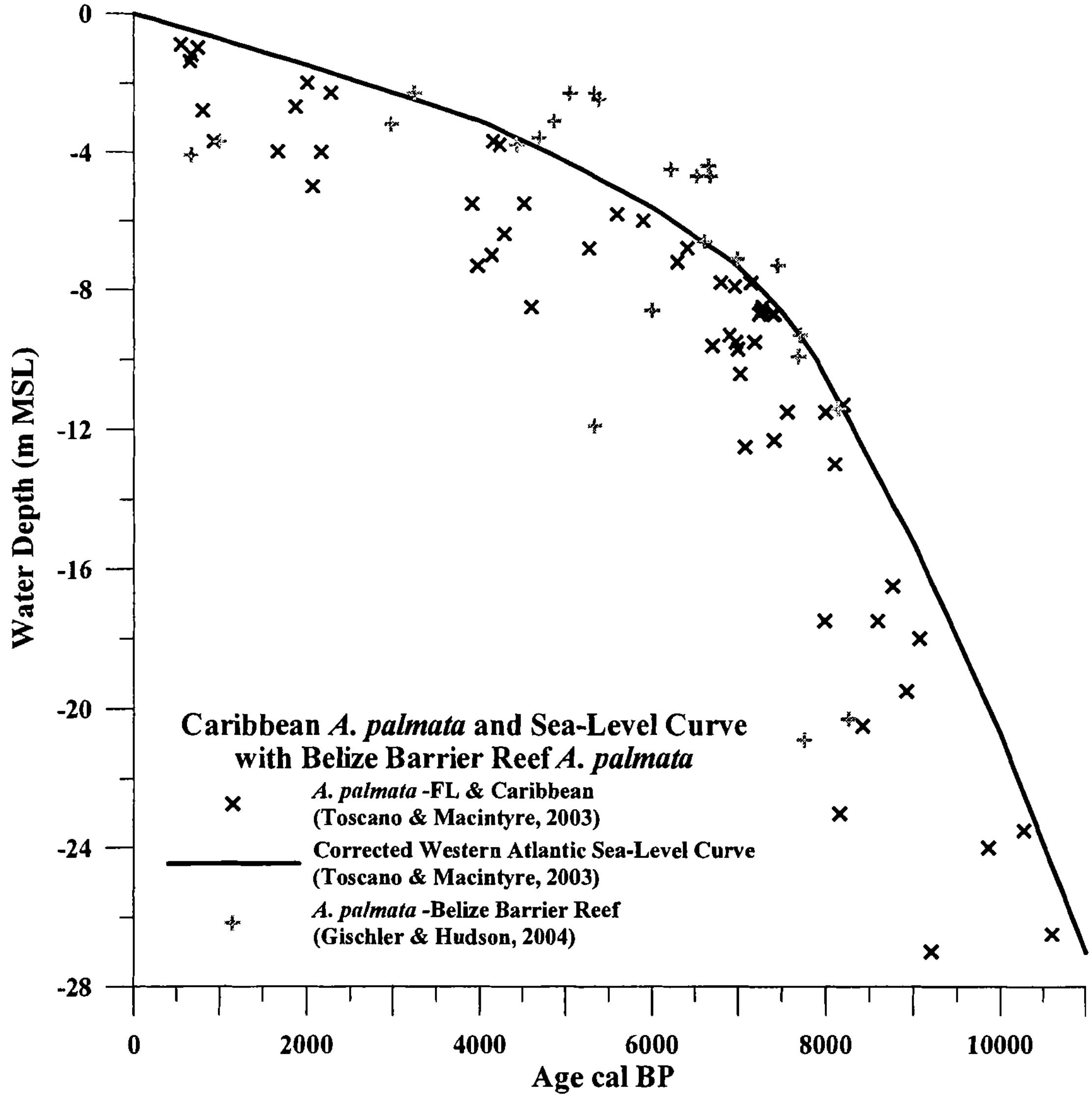

Figure 8. Western Atlantic sea-level curve (Toscano and Macintyre, 2003) with plots of calibrated age dates of *A. palmata* used in the construction of this curve and calibrated dates of *A. palmata* from Gischler and Hudson (2004).

our understanding of Belizean sea-level history over the last 10,000 years is based, for the most part, on a number of *Acropora palmata* dates that plot well above the western Atlantic sea-level curve.

In Figure 8 we show the western Atlantic sea-level curve with plots of the 51 calibrated *A. palmata* samples that were used in the construction of this curve (Toscano and Macintyre, 2003). We have also plotted the 23 *A. palmata* dates from Gischler and Hudson (2004). Although as many as 13 of their dates from the shallow-water *A. palmata* agree with the western Atlantic curve, those contrast with 10 plots (forming two distinct clusters and 1 outlier) that are located significantly above the curve (Fig. 8). With the overall history along the Belize barrier-reef complex being one of subsidence progressively increasing southward (Purdy, 1974; Choi and Ginsburg, 1982; Choi and Holmes, 1982; Lara, 1993; Purdy et al., 2003), and the fact that many of Gischler and Hudson's (2004) coral dates agree with (lie on or below) the western Atlantic curve, it is not possible to relate the elevated dates to tectonic uplift. In addition, the elevated, clustered coral plots are geographically limited largely to three cores (BBR2, BBR10, BBR11) taken on a Pleistocene high on the Belize shelf, according to Gischler and Hudson's (2004) cross section (their Figure 2). In addition, these three cores contain a high percentage of cemented coral debris. The age range represented by the corals on this Pleistocene high (-7m to –5 m MSL) is too old when compared with the depths of the same age range of samples taken from the other cores, both to the north and the south of the high area (- 21m to -7m). Given that Gischler and Hudson (2004) state that they are unable to determine if these corals are in place, we suggest that the 10 elevated *A. palmata* are corals that have been transported during multiple episodes of severe storm activity and concentrated on the topographic high. The high area containing these cores is also located in a "window" between the south ends of Turneffe and Lighthouse atolls and the north end of Glovers atoll; therefore it is open to direct wave action. This pattern of coral storm deposits plotting well above previous sea levels is well demonstrated in cores from the Holandes Cay storm ridge off the Caribbean coast of Panama (Macintyre et al., 2001).

The same situation holds true for an earlier manuscript on the Holocene history of the reefs on atolls off Belize (Gischler and Hudson, 1998). In this case six radiocarbon-dated *A. palmata* samples plotted well above the western Atlantic sea-level curve (Toscano and Macintyre, 2003), in contrast to the 10 other coral dates that plot in agreement with (i.e. on or under) this sea-level curve. As with the Belize Barrier Reef samples, the elevated *A. palmata* samples from the offshore atolls all came from cores containing "well-cemented grainstone-rudstone" (p. 338), which is indicative of high wave energy deposits. As expected, these cores were collected on the windward sides of the atolls, all sites where modern storm deposits are accumulating---most recently the extensive storm ridge system that formed on the windward side of Glover's Reef after Hurricane Mitch passed over this atoll in 1998 (Macintyre, personal observation, 1999).

Other authors have also presented elevated sea-level curves for Belize, but these were based on very few and highly questionable elevated peat dates. Davies and Montaggioni (1985) went so far as to suggest an early attainment of near-present sea levels (less than 2 m below present sea level) about 5,000 to 6,000 years ago with a slow continuous rise to present sea level (p. 497). However, in a later figure they show their Belize sea-level curve catching up with present sea level 5,000 years ago and compared it to sea-level patterns recorded in the Pacific (p. 504). Likewise, the sea-level curve for Belize presented by Westphall (1986) shows a sharp rise in sea level until reaching about -2 m approximately 5,000 years ago followed by a gradual rise to present sea level.

The comprehensive western Atlantic sea-level curve effectively combines calibrated data from Caribbean-wide peats (including Twin Cays data), and the shallow-water coral *Acropora palmata*, which bracket and define this sea-level curve (Toscano and Macintyre, 2003). We therefore do not accept any premise suggesting that Belize has had a significantly different isostatic history in comparison to the rest of the western Atlantic, particularly because the sea-level curve proposed by Gischler and Hudson (2004) places most of the Twin Cays peat at unrealistic depths below sea level. As our Twin Cays radiocarbon dates of mangrove peat and subtidal *Halimeda* sand also closely bracket this western Atlantic curve, we propose that this sea-level curve represents the valid late Holocene history of sea-level rise in Belize.

CONCLUSIONS

The 19 vibracores collected along two transects across Twin Cays reveal that these islands were initiated as mangrove communities about 8,000 cal years ago. These mangrove communities accumulated at rates that allowed them to keep pace with the rising late Holocene seas. There were several periods when lagoonal *Halimeda* sands replaced the mangroves, but in most areas the mangroves reestablished over those sand deposits. The main channel that separates the two cays was established early in the history of the islands and was probably related in part to the relief of the underlying Pleistocene limestone.

When calibrated radiocarbon dates from Twin Cays mangrove peat, wood, and *Halimeda* sands are plotted with respect to mean sea level, they establish a record for the rise of sea level in Belize for the last 8,000 cal years that agrees with the Toscano and Macintyre (2003) sea-level curve for the western Atlantic. Other sea-level curves proposed for Belize (Davies and Montaggioni, 1985; Westphall, 1986; Gischler and Hudson, 2004) are elevated above this western Atlantic curve and are considered invalid because they are based in large part on problematic peat and coral data.

ACKNOWLEDGMENTS

The vibracores for this study were originally collected by Ian G. Macintyre and Robin G. Lighty in a cooperative agreement to study the internal structure and Pleistocene substrate of Twin Cays, Belize. Vibracores collected in 1984 and 1985 (with the help of Anne Raymond, Gregor B. Bond, Karen L. Russell, Daniel Covington, Scott Cross and Keith Bowers) were shipped to Texas A&M University where Robin Lighty was a staff member. He and his student, Greg Bond, described the cores and Bond included a limited description of the history of Twin Cays in his Masters Thesis (Bond, 1987), which was originally intended to be a study of the surface sediments around Twin Cays. This is an effort to present a comprehensive account of this work that was largely supported by Smithsonian funds and facilities. We present, for the first time, core logs and cross-sectional reconstructions that are corrected for compaction and calibrated radiocarbon dates for both the peat and carbonate samples. We thank Eberhard Gischler for comments on the manuscript. We especially thank Mary Parrish for her art work and graphics and W.T. Boykins for text and photographic layouts. (CCRE Contribution Number 676).

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