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RADIAL GROWTH RATES OF MICROATOLLS ON A REEF FLAT ON ABAIANG, REPUBLIC OF KIRIBATI

BY

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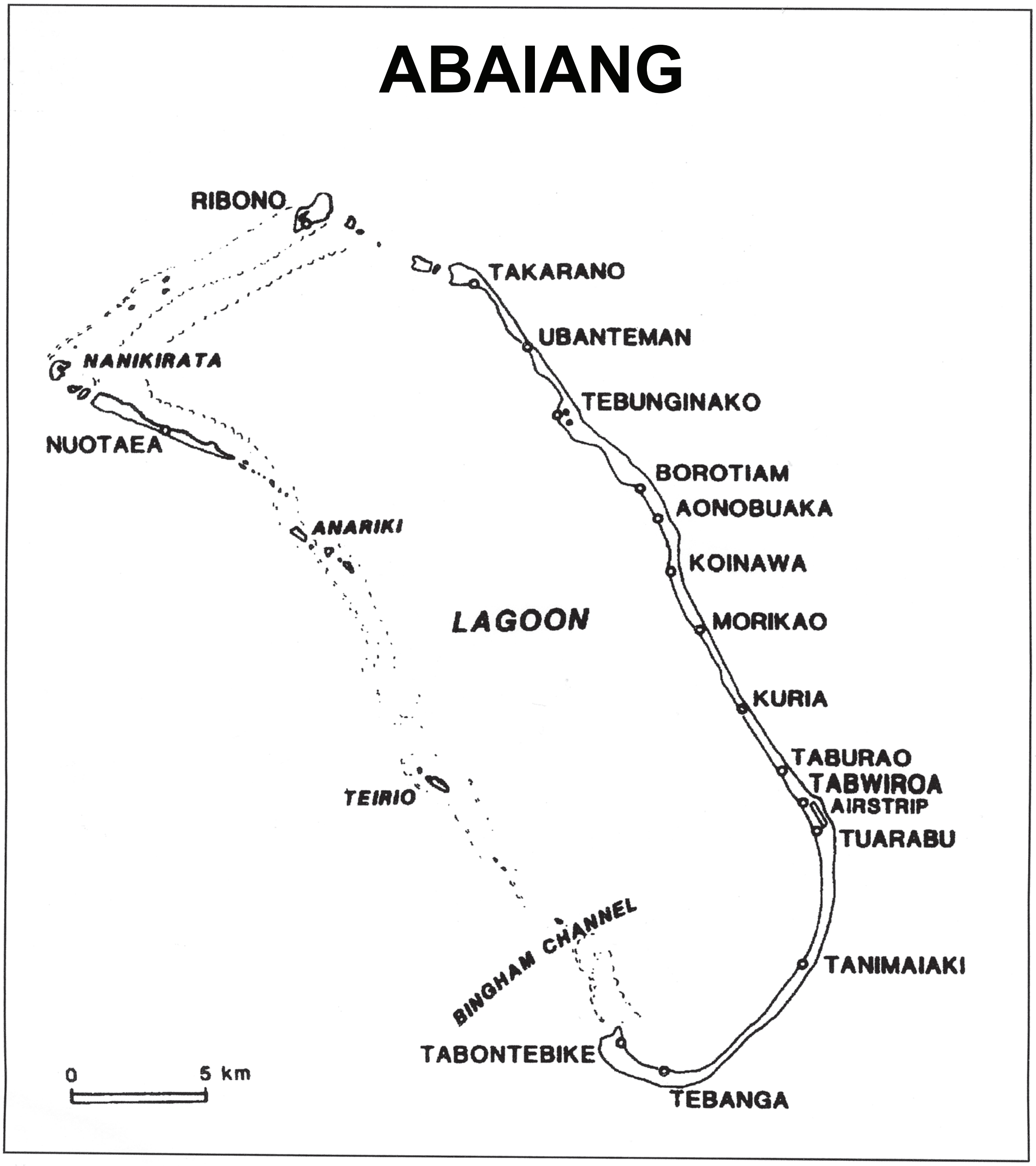

Figure 1. The letter T in TABWIROA stands on the study site. Abaiang is located in the Central Pacific, 1° 48' N by 173° E.

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ABSTRACT

Disk-shaped coral colonies called microatolls have live coral tissue on their outer edges and nonliving centers. The upward growth of these structures is limited by the level of lower low water and the yearly outward growth in at least one species, *Porites lutea*, is recorded in the upper surface of the disks in the form of annuli. From March 1998 until August 2005, we used two different methods to assess radial growth rates of *Porites lutea* microatolls on the ocean reef flat of Abaiang Atoll, Republic of Kiribati . We found that annual growth rates varied substantially during the 7.9 years of observation, from 0.7 to 2.6 cm/yr, with a mean of 1.6 cm/yr.

INTRODUCTION

Information concerning the definition, structure, diversity and formation of microatolls (MAs) has been reviewed elsewhere (e.g., Flora and Ely, 2003), and data concerning growth rates of several MAs of *Porites lutea* were presented for the period March 1998 to October 2000 (op cit). A separate paper focusing upon the use of these same heads for assessing sea-level changes is under preparation, but this current note deals only with additional information on growth rates.

Our study site for this project is located on the ocean reef flat of Abaiang (Fig. 1). It is a large conglomeration, or patch, of about 630 microatolls (Fig. 2). The patch is about 30 m wide by 100 m long with the long axis vertical to the reef crest and is located on the ocean reef flat less than 1 mile NNE of the village of Tabwiroa (Fig. 1). The southern-most point of land on Abaiang is slightly less than 7 miles north of Tarawa, the capital of the Republic.

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Figure 2. Looking toward the ocean, this view shows the patch of microatolls in which our observations were made. We have estimated the number of heads of *Porites lutea* in this patch to be between 600 and 700. Photo taken July 27, 2005.

METHODS

MAs can be measured accurately only when completely exposed during spring low tides. We found the Tarawa tide tables as published by the Kiribati Shipping Services, Limited to be quite adequate for planning our work on Abaiang. In 1997, the mean of all higher high waters for January was 1.77 m and for lower lows was 0.34 m. Thus the range was 1.43 m. The month of July was quite similar. Of course numbers vary with season and lunar cycles.

The species of coral forming these microatolls was identified through microscopic examination of calyx features as given by Veron (1986), including a fused triplet, five palli, and five radii. A representative head is shown in Figure 3.

The growth rates were calculated in two different ways: (1) by measuring increases in diameter of nine specific MAs on five separate occasions over the course of approximately 7.3 years, and (2) by measuring growth in 14 MAs, in August 2005, using the distinctly more prominent elevated ridge or annulus (Figure 4) as a baseline. It was formed during the 1997 El Niño Southern Oscillation (ENSO) event. This event is discussed at greater length in Flora and Ely (2003).

Figure 3. A *Porites lutea* microatoll on the Tabwiroa Village ocean reef flat of Abaiang Atoll, Kiribati. Annuli are visible. July 27, 2005.

Figure 4. The ENSO annulus is the ridge which rests beneath the numbers 5 and 6 on the instrument.

The microatolls in the patch numbered more than 600 which meant returning to the same head each time over the years was a matter of concern. Not only did many look much alike but shapes changed over time for many reasons (weather, waves, local people in search of food, etc.). Accordingly, we used a map (Fig. 5), compass bearings, distances between the different MAs and photographs of each head to assure our return to the same sites each time. The caption for Figure 5 gives more detail.

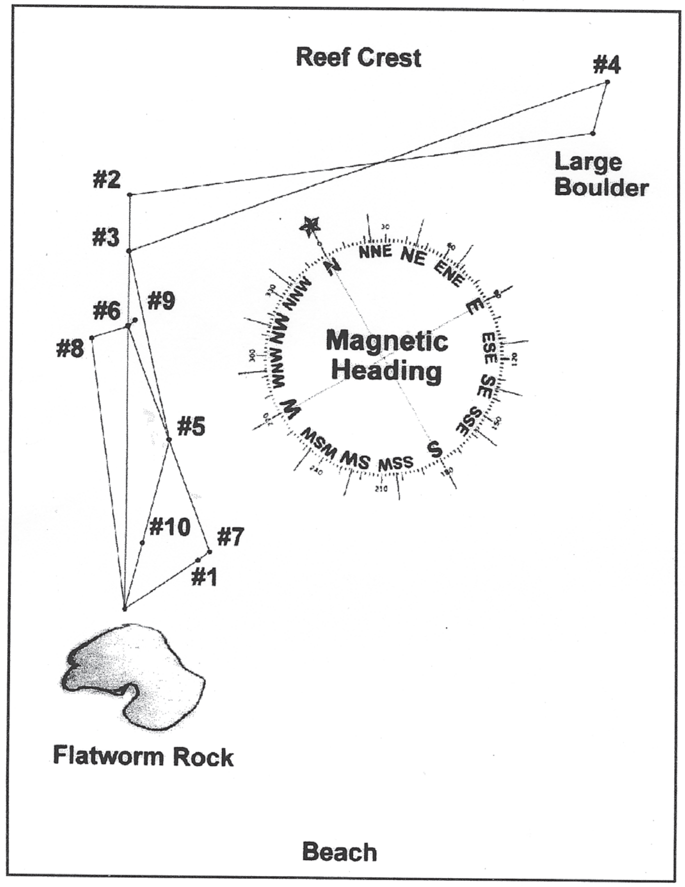

Figure 5. Map as drawn on our first visit to the Microatoll Patch. Flatworm Rock was always the reference point. Directions and distances were recorded from it and among the various heads. We carried photographs from previous trips. The heads added in 2005 are not included but their locations are recorded.

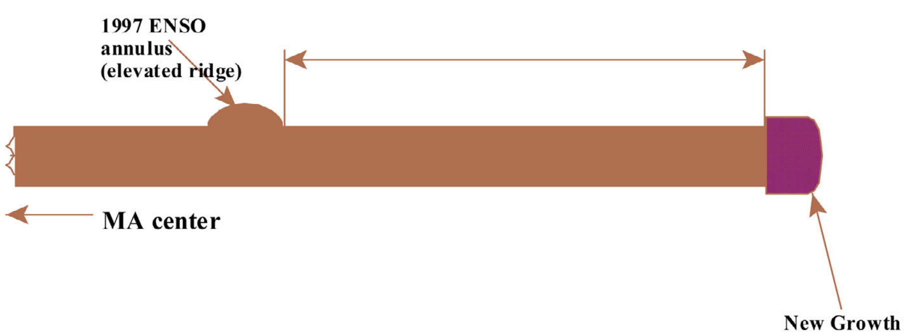

Figure 6. Schematic showing the place of measurement (upper double arrow) for growth assessment using the ENSO annulus approach.

Method One: Increases in Diameter

In this method, the distance, in centimeters (to an accuracy of one-tenth of a centimeter) from the inside edge of the living growth through the MA center to the opposite inside edge, was determined for each of nine MAs on five separate occasions: March 1998, May 1999, October 2000, September 2002, and August 2005. The differences between subsequent measurements were used to calculate growth rate for each interval. In all cases more than one diameter was measured (except for 2002 when two heads were omitted because of misidentification). These, and the mean for each head, are given in Table 1.

Method Two: Growth Since the 1997 ENSO Event

The distance from the outer edge of the 1997 ENSO annulus to the inner edge of the living coral ring (the new growth) at the perimeter was measured as shown in Figure 6. Measurements at four places, i.e., at the ends of diameters vertical to and parallel to the reef crest were taken on each head. Because this method did not require remeasuring MAs that had previously been measured (as in Method One), we were able to expand our sample population from 9-to-14 MAs.

RESULTS

Growth rate data as determined by Method One are provided in Table 1. Growth rate data from Method Two are in Table 2. MA # 1 was excluded from both tables because it was removed in 1998 for X-ray analysis of growth rings (Flora and Ely, 2003)

Table 1 shows that during the period from earliest to most recent measurements (7.3 yrs), the mean overall diameter growth was 25.3 cm (i.e., 92.4 - 67.1), which is 3.5 cm of diameter growth and 1.7 cm of radial growth per year. It also seems that annual growth was asymmetric during that period; thus, mean radial growth rate varied as follows:

March 1998 - May 1999, 2.6 cm/yr
May 1999 - October 2000, 2.0 cm/yr
October 2000 - September 2002, 0.7 cm/yr
September 2002 - August 2005, 2.1 cm/yr

Table 2 shows that during the 7.9 years since the 1997 ENSO elevated ridge was formed, mean radial growth was 1.5 - 1.7 cm/yr.

Taken together, these data show that the radial growth measured during the period 1997 to 2005, ranged from 0.7-to-2.6 cm/yr and the mean rate of growth was 1.6 cm/yr.

The fact that some diameter measurements show a decrease (Table 1) reflects variability in growth due to a variety of environmental influences such as water quality, disturbance by other reef organisms, wave action and even human intervention. Locals frequently lift microatolls in search for food, and this can modify MA growth patterns by changing positions relative to currents etc. and by direct damage to portions of the rim of living coral.

Table 1. MA Diameter Measurements (cm) for Various Years
(All measurements rounded to the nearest 10th).

MA #	March 98	May 1999	Oct 2000	Sept 2002	Aug 2005
	Diameter	Diameter	Diameter	Diameter	Diameter
2	76.2	81.2	89.5	---	104.5
	80	88	85.3	---	110.9
	85.3	90.6	96	---	
3	65	70.6	72.2	---	93
	64	70.5	75	---	80
	55.4	59.9	69	---	
4	79.6	85	89.5	98.4	105
	80.1	77.8	90.5	96.6	109
	72.6	80.2	87	92.7	
5	101.3	97.5	111.5	106.5	124
	96	104.1	110	113.4	127.5
	100	106.5	109	115.5	
		105.5			
		103.2			
6	62	65.2	75.1	73.7	89
	60.3	64	74.6	72.9	89
	62	65	72.6	78	
7	73.5	74.2	81	88.5	93.5
	81	72.9	91.3	96	89.5
	79.5	76.5	89.5	93.9	
		72.1			
8	62.5	67.1	73.9	70.5	88.3
	59.2	66.3	75.5	63.2	86.3
	61.5	67.8	70.5	67.2	
9	44.7	48.4	56.3	65.9	71.8
	45.2	52.2	56.2	71.3	74
	44	48.2	56.5	66.5	
10	43.3	45	53.5	57.2	57
	40.5	46.2	53.5	52.9	71
	37.4	43.9	46	50.4	
Mean	67.1	73.2	78.2	80.6	92.4
Change		+6.1	+5	+2.4	+11.8
Period		1.2 yrs	1.3 yrs	1.9 yrs	2.9 yrs
Growth rt	diameter	5.1	3.9	1.3	4.1
(cm/yr)	radius	2.6	2.0	0.7	2.1

Table 2. Outer Edge of the 1997 ENSO Annulus (Elevated Ridge) to the Inner Edge of New Growth (cm), August 2005. (All measurements rounded to the nearest 10th)

MA #	Hor Rt	Hor Lft	Vert Top	Vert Bot	Mean
2	15.5	13.5	18	14	15.3
3	14.5	14	8	8	7.5
4	19.5	18.9	15	14	16.9
5	12.5	12.5	12	13.8	12.7
6	15.5	13	16.5	13	14.5
7	11.7	11	10	10.7	10.9
8	14	11	12	13	12.5
9	15.5	13	16	13.5	14.5
10	8.8	10.8	11.3	10.8	10.4
11	13.5	8.8	9	10	10.3
12	13.5	10.8	15	5.2	11.1
13	11	10.2	12	12	11.3
14	11	10.5	12	12	11.4
15	12.5	11	10.5	12	11.5
Mean	13.5	12.1	12.7	11.6	12.2
Radial	1.7	1.5	1.6	1.5	1.5

CONCLUSION

Microatolls have the potential to grow upward as rapidly as outward as constrained by the level of lower low water. Thus, the upper surfaces of microatoll annuli should be expected to grow higher than usual during ENSO years and indeed that has been our observation on the Tabwiroa flat. It is well known that in near-equatorial areas of the Central Pacific, the sea surface rises during ENSO events as the prevailing westerly winds reverse and water that has been held in the west flows eastward raising the level. The 1997 event was massive and produced a distinctly higher annulus than usual. The authors resided on Abaiang Atoll during 1997 and 1998 and were able to feel the strong shift in winds and to observe the annulus as it formed over time.

Should sea-levels rise at a rate less than the mean growth rates reported here, the microatolls in the patch should grow upward apace and match the rising sea thus contributing to the upward growth of the reef. The often-mentioned rise of 2.2 mm/yr [e.g] (Cazenave and Nerem, 2004) should not by itself inhibit the upward growth of these coral heads. It is clear they contribute to the ability of the reef to match rising seas and thus play a part in reducing the dangers faced by Central Pacific atoll residents.

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