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COMPARATIVE GROWTH RATES OF SOME REEF CORALS IN THE CARIBBEAN.(U)
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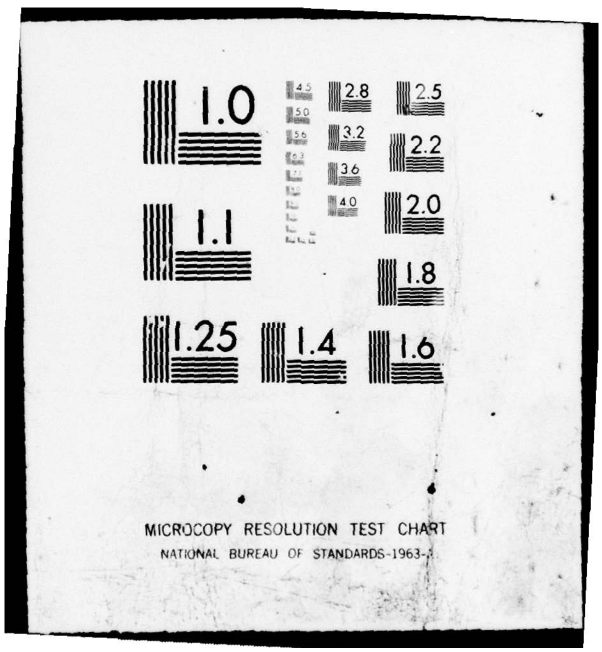
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MARINE SCIENCES CENTRE

McGILL UNIVERSITY MONTREAL

COMPARATIVE GROWTH RATES OF SOME REEF CORALS IN THE CARIBBEAN

Final rept.

by

John B. Lewis[1], *Fritz Axelsen*[2], *Ivan Goodbody*[3], *Cynthia Page*[4] [redacted] *Geoffrey Chislett*[5]

MS-10

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FINAL REPORT

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COMPARATIVE GROWTH RATES OF SOME REEF
CORALS IN THE CARIBBEAN

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Prepared by

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Geoffrey Chislett

INTRODUCTION

The first references to growth of corals from the tropical western Atlantic were reviewed by Dana (1872) who reported observations made on *Acropora* in Haiti and on *Montastrea* in the Bahamas. Le Conte (1875) studied the growth of *Acropora* in Florida. Agassiz (1890) measured the growth of *Montastrea* in Florida and Vaughan (1915) made an intensive study of the growth rates of more than twenty species of corals on the Florida and Bahamas reef tracts. Recently, Hoffmeister and Multer (1964) investigated growth of *Montastrea* in Florida, while Shinn (1966) studied the growth of *Acropora* in the same area. Goreau and Goreau (1959) investigated rates of calcium deposition in corals in Jamaica.

Measurements of growth rates of corals in the tropical western Atlantic have thus been largely confined to the northern areas, in Florida and the Bahamas. The purpose of the present study was to investigate latitudinal variations in growth rates in the Caribbean at Barbados and Jamaica and to compare these with coral growth on reefs from Florida and the Bahamas.

MATERIALS AND METHODS

In previous growth rate studies of corals by Mayor (1924), Edmondson (1929), Stephenson and Stephenson (1933) and Vaughan (1915), the colonies were removed from the water and then cemented to tiles or concrete blocks. Vaughan (1915), whose work on Atlantic corals is of particular interest, removed the specimens from the water each time they were measured. In the present study both the transplanting of colonies and the length measurements were carried out entirely under water.

Four species were selected for study; Acropora cervicornis (Lamarck), Porites porites (Pallas), Madracis asperula (Milne - Edwards and Haime) and Montastrea annularis (Ellis and Solander).

The basic method adopted for studying growth rates of corals in both Jamaica and Barbados, was simply to attach branches and colonies of coral to suitable anchoring devices. Concrete blocks, measuring 12 in. by 12 in. by 2 in. were cast in moulds. In each of them five galvanized pipes, 5 inches long, were embedded, one at each corner and one in the centre. A number was impressed on the block at the base of each pipe for easy identification when measuring. Pieces of thick rubber hose, 7 inches long, were fitted tightly into the pipes. The inside diameters of the hose, chosen according to selected samples of corals, were .5 inches for Acropora cervicornis and Porites porites, .25 inches for Madracis asperula, and 2.0 inches in the case of Montastrea annularis. Five branches of suitable size of each species were then carefully inserted into the rubber hose. Two blocks were constructed for each species.

The instruments used for measuring were a transparent mm scale, a pair of straight calipers to measure length, a curved pair of calipers to measure diameter, a lead pencil and a plastic slate for recording the results.

Whenever possible, growth increments were measured each month. Lengths of the stems of Acropora cervicornis, Porites porites, and Madracis asperula, were measured from the upper edge of the rubber hose to the tip of the corallum. Side-branches which appeared during later growth were measured from their bases on the main stem to the growing tip. In the case of M. annularis, the height and diameter was measured for each individual colony. When colonies were found dead, they were replaced by healthy ones.

In order to determine the growth rate of the four species, it was essential that they should be placed in an area where the corals were already growing vigorously in order to be as certain as possible that there were no unfavourable environmental conditions to retard growth.

The area chosen for the growth rate study in Barbados was similar to the deep water community of Lewis (1960). It was an area with extensive beds of Madracis asperula (mixed with Porites porites), large colonies of Montastrea annularis (some measuring up to 8 feet in height and several feet across), and many stands of Acropora cervicornis, measuring 2-3 feet in height. Pure stands of Madracis asperula and Porites porites were observed at greater depths (15-20 meters) where Montastrea annularis was the dominant massive coral species and Madracis asperula the dominant branching form.

In Jamaica the site chosen was near the mouth of Kingston Harbour at Port Royal. The coral communities in this area are not as extensive as those from Barbados and it is not regarded by Goreau (1959) as an area of prolific reef development. However, all the species studied were abundant at the chosen site and, in respect to depth and other environmental parameters, it was apparently similar to the Barbados location.

The experiments were begun in July of 1965 in Barbados and continued until October of 1967. In Jamaica the corals were set out in December of 1965 and the experiment was terminated in November of 1967.

RESULTS AND DISCUSSION

Monthly measurements of the four species of coral from Barbados are shown in Tables I to V and from Jamaica in Tables VI to X. Mean monthly growth increments have been calculated and are included in the tables.

Mean monthly growth increments for Montastrea annularis, for Madracis asperula and for Porites porites were very similar in Jamaica and Barbados. Montastrea and Madracis had mean monthly increments of 0.2 cm in both areas, while mean monthly increments of Porites were 0.3 cm in both localities. There was a notable difference however in the monthly growth rates of Acropora cervicornis between the two sites. The mean monthly increment for branches of Acropora in Barbados was 1.2 cm, while in Jamaica it was 2.2 cm.

The results thus show a very rapid growth for Acropora cervicornis, followed by Porites porites, Madracis asperula and Montastrea annularis. This is not surprising since a branched species such as Acropora would be expected to grow more rapidly than a massive form such as Montastrea (Vaughan, 1915).

The total annual growth rates of Acropora cervicornis of approximately 14 cm in Barbados and 26 cm in Jamaica are the highest recorded from the Atlantic area and the growth is more than twice that reported by Vaughan (1915). He recorded an annual growth rate of 40 mm at Dry Tortugas, Florida, and 45 mm at Golding Cay, Bahamas. More recently, however, Shinn (1966) recorded an annual increase of 100 mm, the hitherto highest known growth rate for Acropora cervicornis from Florida and the West Indies. There are still, however, marked differences in growth rates between Barbados, Jamaica and Florida.

TABLE I. MONTHLY HEIGHT MEASUREMENTS IN CM OF MONTASTREA ANNULARIS. BARBADOS

Branch No.	1965 Oct.	Nov.	Dec.	1966 Jan.	Feb.	Mar.	Apr.	May	June	July	Sept.	Oct.	Dec.	1967 Jan.	Feb.	May	July	Sept.	Oct.
1	4.0	4.1	4.2	4.4	4.3	4.5	4.6	4.7	-	4.1	6.2	6.2	6.4	6.3	6.7	*2.4	2.6	2.6	2.8
2	5.7	6.0	6.3	6.3	6.3	6.8	6.7	7.1	7.1	7.3	7.5	7.8	7.8	8.0	8.3	8.4	8.6	*5.8	6.0
3	4.6	4.8	4.9	*4.8	*5.7	5.5	*4.6	5.0	5.0	5.1	5.2	5.3	5.7	5.7	6.1	6.0	6.3	6.5	6.0
4	4.8	5.1	5.4	*5.0	*5.3	6.4	6.3	6.8	6.8	6.9	6.9	7.1	7.2	7.7	7.6	7.8	8.0	8.3	8.5
5	6.7	7.0	7.0	7.3	7.2	7.3	7.2	7.5	7.6	7.7	7.6	8.0	8.2	8.2	8.7	8.8	9.1	9.4	9.5
6	7.5	8.2	*7.8	7.8	*7.5	*7.8	*5.5	*6.0	6.2	6.4	6.6	6.7	*5.0	5.2	5.3	5.7	5.8	6.1	6.3
7	7.6	7.7	7.8	8.1	8.1	8.4	8.4	8.6	8.6	8.9	9.0	9.2	9.3	9.6	9.8	10.2	10.0	10.8	10.9
8	3.1	3.3	3.5	3.5	3.7	3.9	3.9	4.1	4.2	4.5	4.6	4.8	5.0	5.0	5.2	5.5	4.7	4.8	5.0
9	6.2	6.2	6.3	6.6	6.5	6.8	*6.0	6.0	6.3	6.2	6.3	6.5	*4.4	4.5	4.5	5.1	5.2	5.6	5.6
10	8.1	8.1	8.3	8.3	8.4	8.5	8.7	9.0	8.9	9.3	9.3	9.4	9.5	9.7	9.8	9.7	10.1	10.3	10.5
Mean growth increments		0.2	0.2	0.1	0.1	0.3	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.2

* new branch

mean monthly increment - 0.2 cms.

TABLE II. MONTHLY DIAMETER MEASUREMENTS IN CM OF MONTASTREA ANNULARIS. BARBADOS

Branch No.	1965 Oct.	Nov.	1966 Jan.	Feb.	Mar.	Apr.	May	June	July	Sept.	Oct.	Dec.	1967 Jan.	Feb.	July	Sept.	Oct.
1	2.4	2.7	2.9	2.8	2.8	2.7	2.8	3.3	3.3	*2.6	2.9	2.9	3.1	3.1	*2.5	2.5	2.6
2	3.2	3.9	4.0	4.3	4.3	4.3	4.5	4.6		4.6	4.7	4.8	5.0	5.0	5.8	*3.3	3.4
3	3.5		3.5	3.2	3.3	3.5	3.7			3.7	3.7	3.6	3.7	3.8	4.6	5.3	5.3
4	3.3	3.5	3.6	*2.4	2.6	3.0	3.2	3.2	3.2	3.4	3.3	3.3	3.4	3.5	3.7	4.0	4.1
5	5.0	5.0	4.9	5.3	5.2	5.1	5.5	5.8	5.8	5.9	5.9	5.9	5.9	6.0	7.4	7.6	7.6
6	3.1	3.3	4.4	*3.7	3.8	*3.2	3.3	3.1	3.5	3.7	3.7	*3.3	3.5	3.5	3.8	4.3	4.3
7	4.4	4.4	4.5	4.6	4.6	4.7	4.6	4.6	4.5	4.8	4.9	4.9	5.0	5.1	6.0	6.1	6.4
8	3.0	3.2	3.5	3.4	3.6	3.8	4.2	4.4	4.3	4.5	4.6	4.7	4.8	4.9	4.8	4.9	5.0
9	2.7	2.7	3.1	3.1	3.0	*2.9	3.0	3.2	3.0	3.2	3.3	3.5	3.6	3.6	3.7	4.1	4.2
10	4.4	4.9	5.0	5.4	5.4	5.3	5.7	5.8	5.9	5.9	6.0	5.9	6.2	6.3	6.6	7.0	7.2
Mean growth increments		0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1

* new branch

mean monthly increment - 0.1 cm.

TABLE III. MONTHLY GROWTH MEASUREMENTS IN CM OF MADRACIS ASPERULA. BARBADOS

Branch No.	1965 July	Sept.	Oct.	Nov.	Dec.	Dec.	1966 Jan.	Feb.	Mar.	Apr.	Apr.	May	June	July	Sept.	Oct.	Dec.	1967 Jan.	Feb.	May	July	Sept.
1	5.5	*5.7	6.0	6.1	6.5		6.7	7.1	7.3	7.4		7.6	7.7	7.9	8.3	8.4	9.0		9.3	*2.3	4.5	4.7
2	7.3	5.7	6.0	6.1	6.4		6.5	6.6	6.9	7.2		7.3	7.5	7.8	8.1	8.3	8.5		9.0	*3.3	2.6	3.0
3	5.2	5.7	6.0	6.2	6.4		6.4	6.7	6.9	7.0		7.3	7.5	7.6	*4.1	4.3	3.8		4.2	*3.4	3.8	4.2
4	4.1	5.7	5.9	5.9	5.9		5.9	6.0	6.2	6.4		6.5	6.6	7.0	7.4	7.6	8.0		3.1	*3.8	3.9	4.5
5	5.4	5.9	6.0	6.1	6.4		6.6	6.5	6.9	7.3		*4.7	*4.8	5.1	5.6	5.7	6.1		6.2	*4.2	4.5	5.2
6	5.4	5.8	6.1	6.1	6.2	*4.6	4.9	5.1	5.3	5.6	*4.5	4.7	5.0	5.4	5.7	6.2	6.0	6.1				
7	3.9	*5.7	5.9	5.8	6.1	*3.1	3.2	3.4	3.6	3.9	*6.1	6.3	6.5	6.7	7.1	7.1	7.5	7.8				
8	4.5	4.8	5.3	5.4	5.6	*3.6	3.7	3.9	4.1	4.4	*4.0	4.1	4.3	4.5	4.8	4.9	5.2	5.4				
9	3.5	4.3	4.8	4.8	5.0	*4.2	4.2	4.3	4.5	4.8	*6.8	7.1	7.5	7.5	5.1	5.7	6.0	6.3				
10	3.2	3.6	3.9	4.1	4.2	*4.2	4.5	4.7	4.8	5.0	*4.6	4.9	5.6	5.8	5.8	6.0	6.3	6.8				
Mean growth increments		0.2	0.3	0.1	0.2		0.1	0.2	0.2	0.3		0.2	0.3	0.2	0.3	0.2	0.3	0.3		0.1	0.3	0.2

* new branch   mean monthly increment - 0.2 cms.

TABLE IV. MONTHLY GROWTH MEASUREMENTS IN CM OF PORITES PORITES. BARBADOS

Branch No.	1965 July	Sept.	Oct.	Nov.	Dec.	1966 Jan.	Feb.	Mar.	Apr.	May	June	July	Sept.	Oct.	Dec.	1967 Jan.	Feb.	May	July	Sept.
1	6.6	7.3	7.9	*7.5	7.8	8.0	*5.2	*5.5	*5.2	6.0	6.2	6.6	6.9	7.2	8.9		9.8	*6.0	6.4	*7.3
2	5.8	7.2	7.5	7.7	8.2	8.8	9.0	9.4	*5.2	5.5	5.7	6.2	7.0	7.3	7.8		8.7	*4.2	4.8	*6.4
3	7.2	8.7	8.9	8.9	*8.4	8.6	8.9	9.0	9.5	9.7	10.2	10.5	11.0	11.3	11.8		12.5	*4.6	5.3	*3.0
4	7.1	7.5	7.6	8.1	8.2	8.5	8.4	8.7	9.2	9.6	10.4	10.4	*5.1	5.3	5.7		6.6	*4.8	6.2	*5.5
5	6.6	7.8	8.7	8.8	9.1	*8.7	9.0	9.0	9.5	9.7	10.1	10.5	11.6	11.7	12.1	12.4	12.9	*4.2	4.0	6.7
6			10.0	10.6	10.7	10.8	10.7	11.0	11.2	11.8	11.9	12.3	13.2	13.2	14.4	14.3	14.6			
7			8.7	9.1	9.4	9.7	9.7	9.7	10.4	10.3	10.7	*7.5	*6.6	6.9	7.3	7.3	7.9			
8			6.8	7.5	7.8	8.2	8.5	9.0	9.4	9.5	9.6	10.2	*8.8	9.0	9.5	9.7	10.0			
9			7.3	7.7	7.8	8.1	8.6	8.7	9.2	9.7	9.9	10.1	*7.5	7.8	8.1	8.5	8.9			
10			7.1	7.6	7.8	8.4	*5.0	5.2	5.6	5.9	6.4	6.7	*6.9	*4.0	4.8	5.2	5.7			
Mean growth increments		0.5	0.4	0.4	0.2	0.3	0.2	0.2	0.5	0.3	0.3	0.3	0.4	0.2	0.3	0.2	0.4		0.2	

* new branch

mean monthly increment - 0.3 cms.

TABLE V. MONTHLY GROWTH MEASUREMENTS IN CM OF ACROPORA CERVICORNIS. BARBADOS

Branch No.	1965 July	Sept.	Oct.	Nov.	Dec.	1966 Jan.	Feb.	Mar.	Apr.	May	June	July	Sept.	Oct.	Dec.	1967 Jan.	Feb.
1	8.7	11.1	11.9	12.5	13.5	15.0	16.3	17.7	18.9	19.7	21.3	22.6	24.4	26.2	31.6	31.7	32.7
2	5.9	7.7	8.5	9.2	10.5	11.2	12.4	13.4	14.2	15.5	16.8	18.7	21.5	22.6	23.7	23.7	23.5
3	8.5	9.9	10.7	11.5	12.8	13.3	14.5	15.6	17.1	18.3	18.8	19.9	21.7	22.9	24.5	24.7	25.8
4	8.5	9.8	10.9	11.5	12.7	13.3	14.5	15.4	16.4	18.0	19.3	20.2	23.2	24.1	26.0	26.0	26.7
5	7.8	9.5	10.7	11.7	12.7	13.6	15.2	16.5	18.0	19.0	20.0	21.8	24.8	25.0	25.5	25.2	25.2
6					3.9	5.5	6.1	7.3	8.4	9.7	11.1	12.2	14.7	16.5	18.4	18.5	19.6
7					3.9	5.2	6.0	7.0	8.4	9.6	11.0	12.1	14.8	15.7	17.6	18.5	20.1
8					3.1	4.4	5.3	5.8	7.2	8.9	9.5	10.5	12.4	12.9	16.5	16.8	18.4
9					3.3	3.9	4.9	5.5	6.8	7.5	9.5	10.9	13.8	14.1	15.5	16.5	17.8
10					2.2	3.5	4.6	4.8	6.4	7.7	8.5	9.7	12.0	12.0	12.3	*11.5	*10.9
Mean growth increments		1.7	1.0	0.7	1.2	1.1	1.1	1.0	1.3	1.2	1.2	1.3	2.4	0.9	2.0	0.3	1.0

* new branch

mean monthly increment - 1.2 cms.

TABLE VI. MONTHLY HEIGHT MEASUREMENTS IN CM OF MONTASTREA ANNULARIS. JAMAICA

Branch No.	1965 Dec.	1966 Jan.	Feb.	March	May	July	Sept.	Nov.	1967 Jan.	Apr.	June	Aug.	Oct.
1	6.2	6.3	6.1	6.3	6.5	6.5	*5.5	5.5	5.7	5.7	6.0	6.0	6.0
2	7.3	7.5	*7.0	7.5	*5.5	5.5	5.9	5.9	6.2	6.3	6.5	6.9	6.9
3	8.4	8.5	8.6	8.8	9.0	9.2	9.3	9.2	9.2	9.5	9.5	9.5	9.5
4	4.0	4.3	*3.8	3.9	4.2	4.2	4.3	4.8	4.8	4.8	5.1	5.4	5.9
5	6.9	7.0	6.9	6.9	7.0	6.8	7.4	7.5	7.5	8.0	8.3	8.3	8.3
6	7.1	7.1	*6.4	6.4	6.6	6.8	6.8	7.3	7.4	7.5	7.8	7.8	7.8
7	6.0	6.2	6.2	6.2	6.1	6.1	6.2	6.4	6.5	6.5	6.8	7.1	7.1
8	6.2	6.3	7.1	9.8	9.8	10.0	10.2	10.8	10.8	10.8	10.8	10.9	10.9
9	5.5	6.5	7.2	7.5	7.8	7.9	9.3	9.3	7.5	8.2	8.3	8.4	8.4
10	6.8	7.6	*7.1	7.1	7.3	7.5	7.5	7.5	7.7	8.0	8.1	8.4	8.7
Mean growth increments		0.3	0.2	0.4	0.2	0.1	0.3	0.2	0.1	0.2	0.2	0.2	0.1

* new branch mean monthly increment - 0.2 cms.

TABLE VII. MONTHLY DIAMETER MEASUREMENTS IN CM OF MONTASTREA ANNULARIS. JAMAICA

Branch No.	1965 Dec.	1966 Jan.	Feb.	March	May	July	Sept.	Nov.	1967 Jan.	Apr.	June	Aug.	Oct.
1	4.7	5.0	5.0	5.0	5.3	5.2	5.2	5.2	5.2	5.5	5.5	5.5	5.6
2	4.2	4.6	4.6	4.6	*4.0	4.3	4.4	4.4	4.4	4.8	4.8	4.8	5.2
3	3.4	3.6	3.8	3.9	*3.4	4.0	4.1	4.3	4.3	5.0	5.1	5.5	5.5
4	3.6	3.6	3.7	3.8	3.8	3.8	3.8	4.0	4.1	4.1	4.5	4.5	4.6
5	4.7	4.9	4.9	5.0	5.0	5.0	5.0	5.3	5.5	5.8	5.9	6.1	6.2
6	4.5	4.7	4.6	4.6	4.8	4.6	4.7	5.0	5.1	5.4	5.9	6.0	6.0
7	4.5	5.2	*4.8	4.8	4.7	4.7	4.7	4.7	*3.3	3.5	3.6	3.9	3.9
8	4.8	4.8	*5.0	6.6	6.7	6.7	6.9	*7.6	7.6	7.8	8.1	8.4	8.5
9	4.8	4.8	8.0	8.1	8.1	8.3	*4.6	5.0	5.5	5.5	5.9	6.0	6.3
10	5.0	5.8	6.4	6.5	6.4	6.4	6.4	6.5	6.7	7.0	7.3	7.5	7.5
Mean growth increments		0.3	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.5	0.2	0.2	0.1

* new branch

mean monthly increment - 0.2 cms.

TABLE VIII. MONTHLY LENGTH MEASUREMENTS IN CM OF MADRACIS ASPERULA. JAMAICA

Branch No.	1965 Dec.	1966 Jan.	Feb.	March	May	July	Sept.	Nov.	1967 Jan.	Apr.	June	Aug.	Oct.
1	1.8	1.8	1.8	1.6	1.6	1.7	1.7	1.9	2.1	2.5	2.5	2.8	2.8
2	2.6	3.2	3.5	3.5	3.6	3.8	4.1	4.2	4.4	4.8	5.0	5.9	6.1
3	4.1	4.2	4.7	4.6	4.6	5.0	5.0	5.1	5.6	5.9	6.0	6.6	7.4
4	2.0	2.0	2.0	2.0	1.9	2.0	2.2	2.2	2.4	2.8	2.8	3.2	3.8
5	2.4	3.2	3.0	3.0	4.1	4.1	4.3	4.6	4.6	4.6	4.8	5.5	5.5
6	1.8	2.1	2.1	2.1	2.1	2.3	2.5	2.5	2.8	2.9	2.9	3.0	3.3
7	2.4	2.8	2.8	*1.2	1.6	2.0	2.3	2.7	*1.5	1.6	1.6	1.7	-
8	3.6	3.6	*1.2	1.4	1.6	1.7	1.7	1.7	1.9	2.2	2.4	2.4	-
9	1.5	1.5	1.3	1.4	*1.1	1.1	1.3	1.3	1.6	2.2	2.4	2.6	3.0
10	2.8	3.2	*1.2	1.8	1.9	1.9	2.1	2.3	2.6	2.6	2.6	3.2	3.3
Mean growth increments		0.3	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.3	0.1	0.4	0.3

* new branch

mean monthly increment - 0.2 cms.

TABLE IX. MONTHLY LENGTH MEASUREMENTS IN CM OF PORITES PORITES. JAMAICA

Branch No.	1965 Dec.	1966 Jan.	Feb.	March	May	July	Sept.	Nov.	1967 Jan.	Apr.	June	Aug.	Oct.
1	4.6	4.9	5.2	5.3	5.6	5.6	5.6	5.6	5.7	6.0	6.5	6.9	7.2
2	5.0	5.5	5.7	6.9	6.7	*4.5	4.8	4.8	5.4	5.5	5.5	5.5	5.6
3	7.5	7.9	7.9	7.9	*2.6	2.9	3.5	3.6	[illegible]	4.5	4.5	5.0	-
4	5.5	5.5	6.2	6.2	6.4	6.7	7.4	8.2	8.7	8.7	9.0	9.7	10.0
5	4.7	5.2	5.3	5.3	6.3	6.5	*6.2	*4.6	4.9	5.0	5.4	5.4	6.0
6	4.0	4.2	4.5	4.6	4.8	5.1	*4.8	5.6	5.8	5.8	6.4	7.0	8.2
7	4.5	4.6	*3.9	4.1	4.5	5.2	5.1	5.5	5.9	6.2	6.4	6.8	6.9
8	5.5	6.0	6.0	6.2	*4.3	4.5	5.2	*4.0	4.7	5.0	5.0	5.6	5.7
9	5.7	5.6	5.6	6.0	*5.3	5.5	6.2	*4.1	4.5	5.0	5.2	5.6	5.8
10	3.7	4.3	4.4	4.7	5.4	5.8	6.2	6.7	7.8	8.2	8.6	9.4	9.6
Mean growth increments		0.3	0.2	0.3	0.4	0.3	0.4	0.4	0.5	0.3	0.3	0.4	0.3

* new branch   mean monthly increment - 0.3 cms.

TABLE X. MONTHLY LENGTH MEASUREMENTS IN CM OF ACROPORA CERVICORNIS. JAMAICA

Branch No.	1965 Dec.	1966 Jan.	Feb.	March	May	July	Sept.	Nov.	1967 Jan.	Apr.	June	Aug.	Oct.
1	7.4	8.2	9.5	10.3	11.3	12.3	14.6	17.5	*11.7	16.0	20.8	23.6	26.0
2	5.7	7.5	9.0	10.0	11.3	11.7	12.6	15.2	*9.2	13.3	15.7	20.5	21.9
3	6.6	6.6	7.9	9.8	10.0	11.0	13.9	16.3	*10.7	12.8	14.0	16.8	18.6
4	6.4	6.5	7.6	8.8	9.2	9.3	9.8	14.5	*9.6	13.4	18.3	23.1	
5	7.1	8.9	10.7	12.1	12.3	12.0	12.2	13.7	*9.9	12.2	16.4	18.9	22.0
6	5.7	7.2	8.6	9.9	*7.5	9.5	12.3	14.8	19.7	22.8	27.0	29.5	
7	6.4	6.4	6.7	6.9	8.5	9.4	11.2	13.2	15.7	18.0	20.2	26.8	30.0
8	7.5	8.5	10.0	10.1	12.7	15.0	17.3	19.6	24.3	27.1	30.1	31.2	36.3
9	6.7	7.8	9.2	10.3	12.6	14.5	17.0	18.7	22.0	27.0	31.4	31.4	37.3
10	7.0	7.8	9.0	10.2	13.0	14.3	16.6	19.5	22.2	25.0	29.0	32.0	33.5
Mean growth increments		0.9	1.3	1.0	1.4	1.1	1.7	2.6	3.6	3.3	3.5	3.1	3.1

* new branch

mean monthly increment - 2.2 cms.

The results of Shinn (1966) and of the present study are higher than those suggested by Weinland (Dana, 1872) in Haiti and by Le Conte (1875) in Florida, but in the last two cases the results are only approximate because in no single case was the actual growth period of any of the measured specimens known.

The previous records obtained by other investigators for Acropora are briefly summarized below:

Species	Gain in Height in mm per year	Locality	Author
Acropora (species?)	94	Cocos-Keeling Island (Indian)	Guppy (1889)
Acropora (species?)	27.4 (100 days)	"	Wood-Jones (1910)
Acropora cribripora) Cropora pulchra) Acropora haimii)	120	Samoa (Pacific)	Mayor (1924)
Acropora abratanoides	125-130	Yapp Island (Pacific)	Tamura and Hada (1932)
Acropora pulchra	101-172	"	"

It appears that the growth rate of branching Acropora species with loosely arranged calcareous skeleton is nearly the same for the Atlantic, Pacific and the Indian Oceans. This is also the case for the branching species of Porites.

As for Porites porites, it was found that the average monthly gain in height was 0.3 cm. The growth rates of branching species of Porites were determined by Vaughan (1915) in Florida and the Bahamas. His results and those of other investigators from other localities are briefly summarized below:

Species	Gain in Height in mm per year	Locality	Author
branching *Porites* (sp?)	38.1	Cocos-Keeling Island (Indian)	Guppy (1889)
Porites (open branches)	30.3	Maldives (Indian)	Gardiner (1903)
branching *Porites*	30.0	Samoa (Pacific)	Mayor (1924)
Porites nigrescens (short irregular branches)	18.5	Yapp Island (Pacific)	Tamura and Hada (1932)
Porites clavaria	20.45	Florida (Atlantic) On tiles.	Vaughan (1915)
Porites clavaria	20.20	Florida	"
Porites clavaria	20.25	Bahamas (Atlantic) On tiles.	"
Porites clavaria	8.33	Bahamas	"

Porites clavaria (Lamarck) is synonymous with *Porites porites* (Pallas) (Smith, 1948). Vaughan (1915) states that the specimen referred to *Porites clavaria* may include more than one species of similar growth facies. His figures are appreciably lower than the ones obtained from the present study from both Barbados and Jamaica.

Madracis asperula showed an average monthly increase in height of 0.2 cm. Since this species is very abundant, its contribution to the mass of the reef must be very considerable. The transplanted specimens adopted a highly branching form and eventually gave rise to arborescent-shaped colonies. This is a growth form which was not observed on the reef, where the species is a stout-branched form. Under natural conditions, the colonies are so close together that the branches grow upward, having little space in which to extend laterally. On the blocks, on the other hand, they had free space all around and could grow in any direction.

The growth of Madracis asperula has never before been investigated, although Goreau and Goreau (1959) determined the calcification rate of a related species, Madracis decactis, in Jamaica.

Montastrea annularis, although occurring as larger colonies, showed a similar rate of growth, in terms of height, as the other species, except for Acropora. It is interesting to note that Goreau and Goreau (1959) found that the amount of calcium deposited per unit time on the basis of tissue mass as expressed by the nitrogen content was less in the massive corals than in the branching species. It is, however, possible that the calcification powers of massive forms may be as great or even greater per unit surface area of the basal calicoblastic epidermis which is the organ of skeletogenesis in corals. The mean monthly upward growth in Montastrea was on the average more than one and a half times as fast as that of the diameter. This differential growth gives the coral colony a columnar shape, very characteristic of the reefs in Barbados where the species is the chief structural element of the reefs (Lewis, 1960). Vaughan (1915) considers Montastrea annularis the reef species "par excellence" of Florida and the West Indies. Smith (1948) and Newell (1958) note the importance of this species as a reef builder, and Goreau (1959) describes it as the chief element of the seaward growth of the reef in Jamaica.

The earliest reference on growth of Montastrea annularis was given by Dana (1872). Two specimens were taken from a 64-year old wreck, near "Silver Bay" off Turks Islands. The thickness of two corals at the centre was 203.2 mm and the width 381.0 mm. If the corals commenced their growth immediately after the wreck, the annual increase would be 3.17 mm in height and 5.95 mm in width. But these figures might be higher since we do not know when the specimens started growing. The same applies to the results obtained by Alexander Agassiz (1890). He measured two specimens of Montastrea annularis which had grown upon a telegraph cable between Key West and Havana at a depth of 11-13 meters for a period of 7 years or less. The greatest height above the cable for the two colonies was 63.5 mm and 57.1 mm; this would mean an annual increase of at least 9.0 mm and 8.1 mm respectively. Vaughan (1915) recorded the highest figures for naturally attached specimens on Loggerhead Reef (Fort Jefferson, Florida), 6.8 mm a year in height and for colonies on tiles, 5.28 mm per annum. He obtained an average annual increase in height of 5.6 mm for Golding Cay, Bahamas. However, Hoffmeister and Multer (1964) did growth experiments on the Florida reef tracts, which were similar in many respects to those of Vaughan (1915). They obtained much higher figures (a mean of 10.7 mm per year); this represents more than one and a half times as fast a growth as that determined by Vaughan.

The average growth increment from month to month varied considerably for each species, and the question arose whether these variations corresponded to variations in water temperature or other environmental factors. Shinn (1966) demonstrated seasonal changes in growth rate of Acropora cervicornis in Florida and showed that the maximum and minimum growth rates corresponded to maximum (30.5°C) and minimum (20°C) temperatures of the sea. Such a wide variation in temperature during the year does not occur in either Barbados or Jamaica where the temperature in 1966-1967 varied by only about 3°C. Reef corals can survive a minimum temperature of 18.5°C but the optimum temperature lies between 25°C and 29°C (Vaughan and Wells, 1943).

Although there were seasonal changes in sea temperatures and salinity at both Jamaica and Barbados (Figures 1-4) nevertheless no marked seasonal variations in growth rates were observed. It would appear that the magnitude of the environmental changes was not enough to affect growth.

Mayor (1914) studied the temperatures at which many reef animals at Tortugas (Florida) live and determined the limits of toleration for a number of species. He found that "tropical marine animals commonly live within 5°C of their temperature of maximum activity and they are, relatively speaking, poorly adjusted in a physiological sense to their temperature environment". The minimum temperature endurable by a vigorous growth of reef corals is 18.5°C although at this temperature they will not survive long. He showed that at about 16°C most of the reef corals of the West Indies would be unable to capture food, and that a sustained exposure to such low temperatures would be fatal. A species such as Montastrea is killed by exposure to 14-15°C for 9 hours. In view of this fact, it may not be surprising that Vaughan (1915) recorded low figures on growth rates of corals from Tortugas (growth period, 1912-1914). In the year from June 1, 1912 to May 31, 1913, the air temperature at Tortugas ranged from 35 to 18.6°C. The air temperature at Tortugas commonly ranges from a maximum of 36.6°C in summer to about 15.5°C in winter. These relatively cold air temperatures in winter appear to reduce the temperature of the water over the reef to about 17.2°C (Mayor, 1914).

The growth rate of corals is greater in regions where the annual average sea temperature is higher (Vaughan and Wells, 1943), and it could be suggested that the higher annual growth rate of corals in Barbados and Jamaica, as compared with those in Florida, is due in great part to the fairly steady and high sea temperatures throughout the year. The higher growth rate of Acropora in Jamaica is however not readily explainable.

High sea temperature is not the only condition necessary for vigorous coral growth. Salinity is an important factor. Salinity tolerated by reef corals lies between 27^{o}/oo and 40^{o}/oo. Reef corals attain their maximum development where the salinity of the surface water in tropical regions is about 36^{o}/oo (Vaughan and Wells, 1943). The salinity recorded in Barbados (Fig. 2) fluctuated between 32^{o}/oo and 35.7^{o}/oo, concentrations favourable to coral growth. In Jamaica there was a wider range between 22 and 36^{o}/oo. The periodic low salinities at Port Royal (Goodbody, 1966) may be the reason for the lack of well developed reef in the area. As temperature and salinity were the only two variables measured, the influence of other environmental factors, such as food supply, cannot be evaluated.

The observations of Wood-Jones (1910), Mayor (1924), Edmondson (1929) and Stephenson and Stephenson (1933) showed that corals do not necessarily grow at constant rates. Wood-Jones (1910) showed that a coral colony might grow rapidly for a time and hardly make any further progress in the succeeding period, while another colony of the same species and size, which had shown no activity at the time when the first was active, would suddenly enter on a period of unusually active growth. It is apparent from this study that the growth of the individual branches was not very variable in either Barbados or Jamaica.

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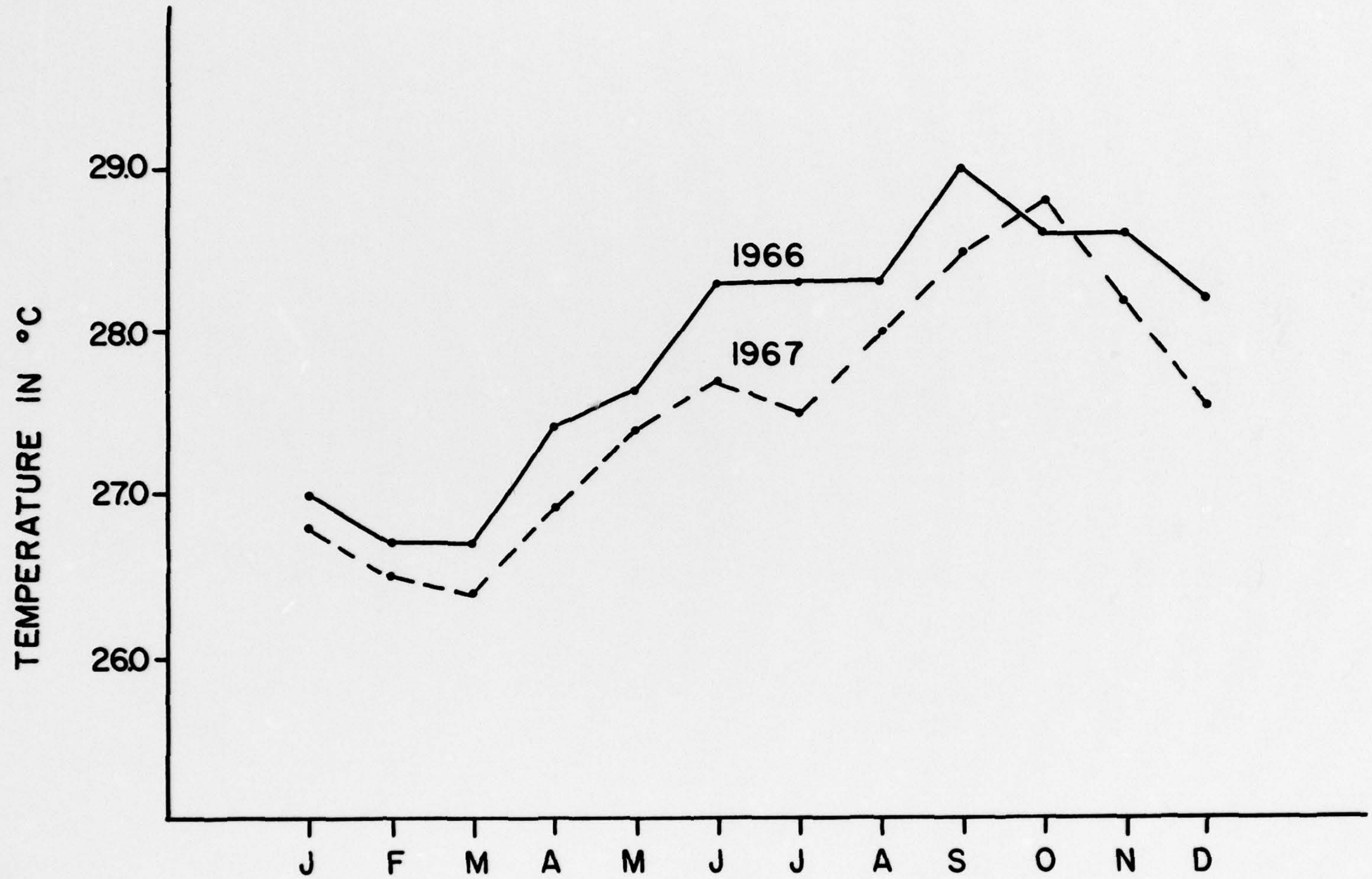

FIGURE I. MEAN MONTHLY SEA SURFACE TEMPERATURE AT WEST COAST OF BARBADOS.

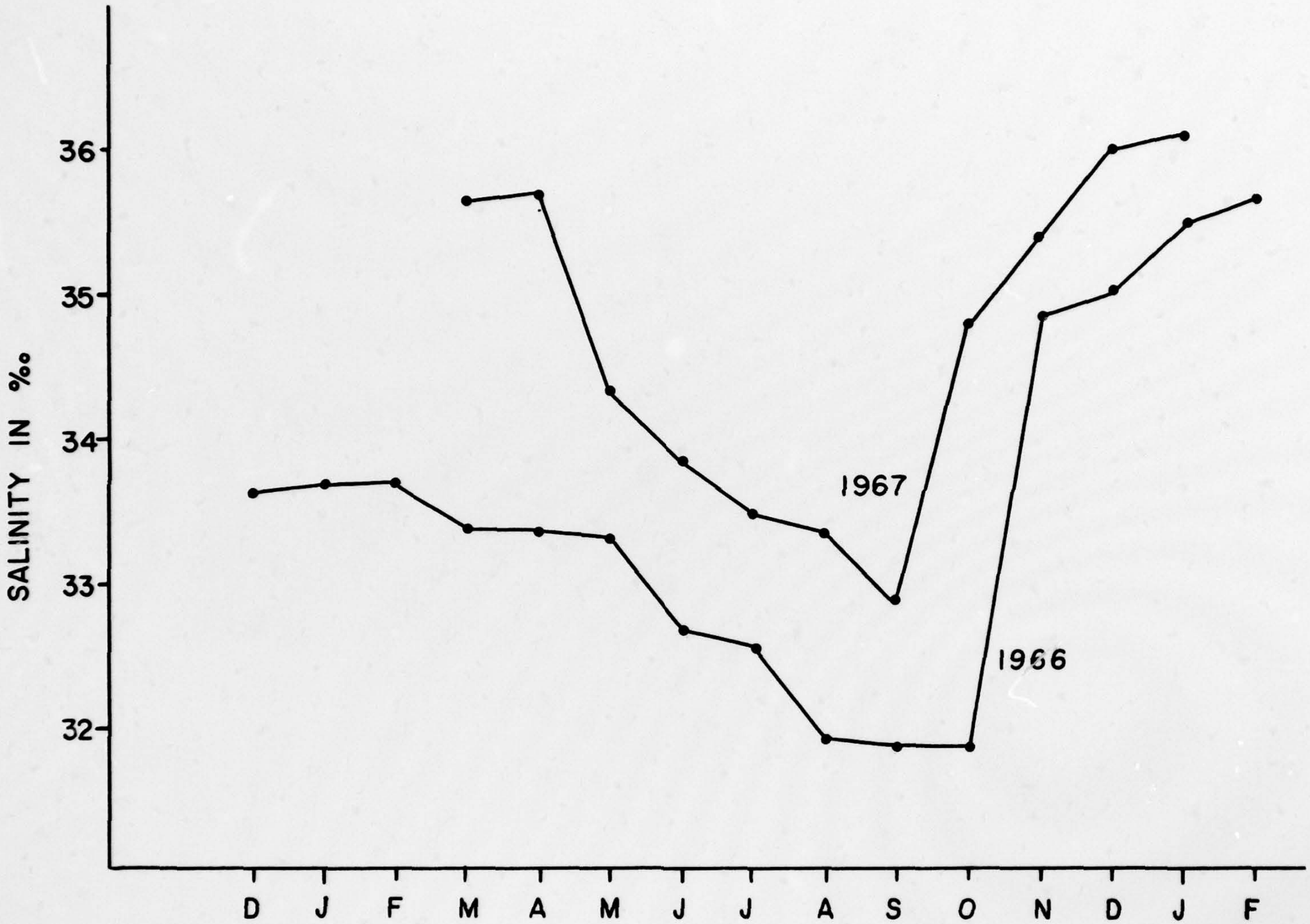

FIGURE 2. MEAN MONTHLY SALINITIES AT WEST COAST, BARBADOS (AT 10 M DEPTH).

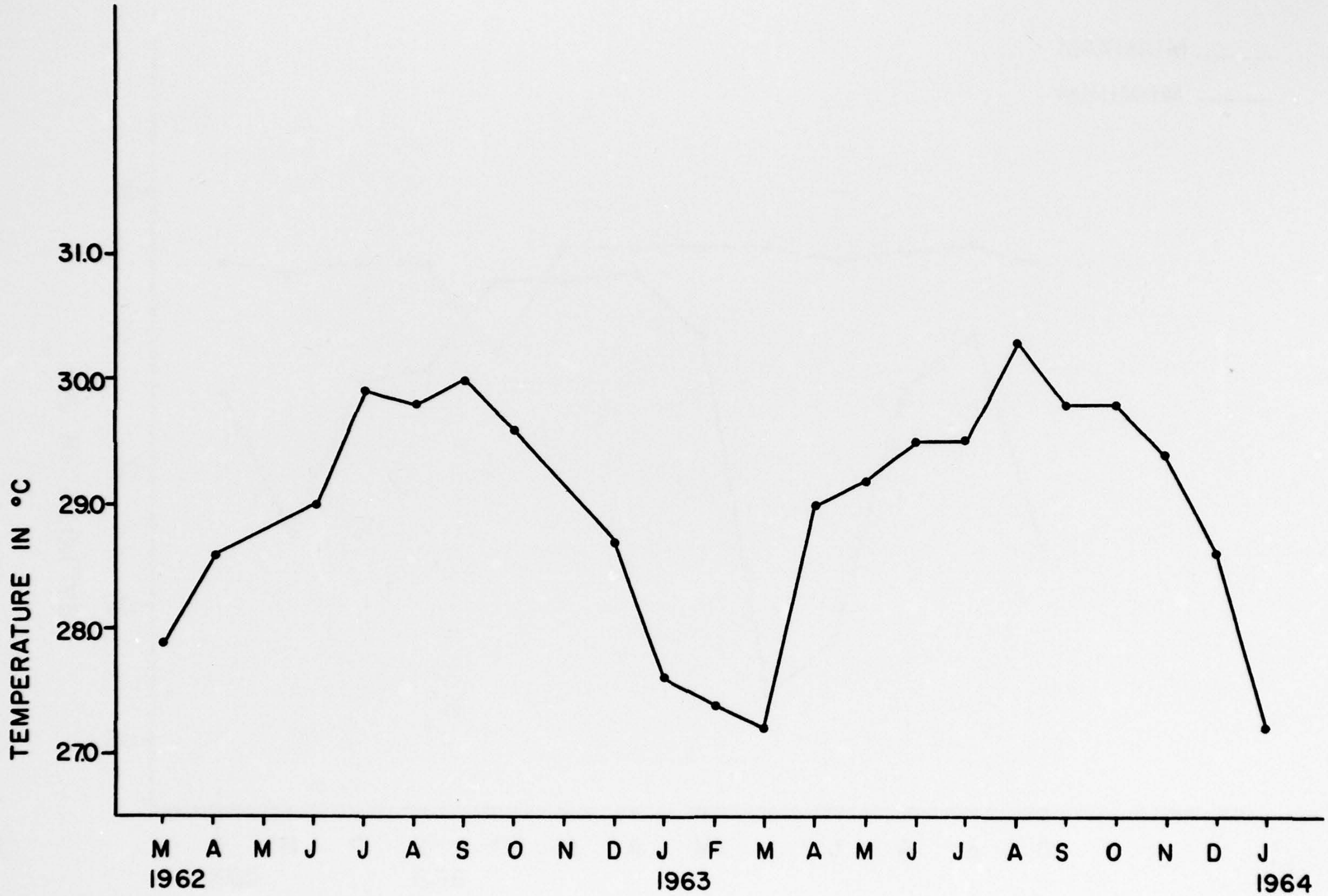

FIGURE 3. MEAN MONTHLY SEA TEMPERATURES AT PORT ROYAL, JAMAICA.

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13. ABSTRACT

The growth rates of four species of corals, Acropora cervicornis (Lamarck), Porites porites (Pallas), Madracis asperula (Milne-Edwards and Haime) and Montastrea annularis (Ellis and Solander) were determined at Barbados and Jamaica. These were compared with growth rates of the same species elsewhere in the Caribbean.

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