Ecological Observations of *Halimeda macroloba* Decaisne (Chlorophyta) on Guam[1]

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Abstract

Halimeda macroloba is a green alga in the Order Siphonales. This species, abundant on Guam, is found usually in water less than a meter in depth at MLLT. It was found that this species grows best in fine, compact sand on the shallow reef flats in areas washed regularly by mild currents. When water movement lags, epiphytes are more pronounced.

According to data collected during this investigation the greatest amount of growth occurs during the first month of development. Growth in the field averages 5.8 cm the first month and 1.5 to 3.0 cm per month after. The life span of *H. macroloba* is calculated to be four months. Fruiting specimens were observed in the field every month during this study. Fruiting is periodic but the conditions that trigger fruiting are still unknown. Fruiting and fusion were observed in the laboratory.

The most important feature of *H. macroloba* is its deposition of calcium carbonate. Segments of the average mature specimen contain 8.5 grams of calcium carbonate. Using this information it is possible to estimate the amount of $CaCO_3$ contributed to sand formation in a given area by counting the mature plants/meter^2 and multiplying by 8.5. Repopulation of *H. macroloba* was also studied.

Introduction

Information on the genus *Halimeda* is limited to a few scattered papers. Yamada (1941) described seven species found in the South Seas. Hillis (1959) revised the genus, and Colinvaux *et al.* (1965) described growth of *Halimeda* and other marine algae in laboratory culture. Colinvaux (1968a) briefly explained vegetative reproduction and in (1968b) described the growth of calcareous marine algae in laboratory culture. Kanda (1940) to date, has published the only paper on a particular species of this genus. His notes contain valuable descriptions of *Halimeda macroloba* Decaisne, however, ecological information is at a minimum.

Due to the lack of ecological information on this genus, an investigation was undertaken on the habitat preference, growth rate, repopulation and calcium car-

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bonate production of *Halimeda macroloba* Decaisne on the reef flats of Guam from September 1968 to June 1969. Of the fourteen species of *Halimeda* found on Guam, *H. macroloba* is by far the most abundant species in terms of standing crop on shallow reef flats.

Materials and Methods

The major reef areas of Guam were surveyed to determine the distribution of *Halimeda macroloba.* Once locations were determined it was then possible to investigate the preferred habitat of this species. Data on water depth, sand depth, current, temperature, and salinity were collected as part of habitat preference investigation. Growth rate and fruiting behavior were studied to obtain information on the life cycle and repopulation of this species. Once this information was available, investigations followed to establish the percentage of calcium carbonate present in the alga. Estimates were then made on the amount of calcium carbonate contributed by *H. macroloba* to sand formation at selected localities on the reefs of Guam.

Other areas in the Pacific where *Halimeda macroloba* is abundant are given in Fig. 1. Information was obtained from the IBM listing of Pacific marine benthic algae compiled by M. S. Doty and R. T. Tsuda, University of Hawaii.

Description of Guam

Guam (Fig. 2) is a volcanic island with limestone formations that date to the Miocene Age. The *Halimeda* group found in Sumay limestone dates to the Pliocene Age. Guam is nearly encircled by fringing reefs which vary from cut benches to coral reef flats nearly 650 meters wide. Most of the sand deposits on the benches and reef flats are composed of calcium carbonate, but some volcanic sand beaches are found near river channels. (Tracey *et al.,* 1964)

Observations

Habitat

Halimeda macroloba was observed (Fig. 2) along western shores from 13° 32′ north latitude (Tumon Bay) to 13° 13′ north latitude (Cocos Island). This species is also found on the northern part of the island at Ritidian Point and Tarague Beach. The seven areas examined along Guam's western shores had an abundance of *H. macroloba.* On the eastern side of Guam, five areas were examined from 13° 26′ north latitude (Pago Bay) to 13° 16′ north latitude (Inarajan Bay). Three surveys were made of reef areas between Inarajan Bay and Cocos Island but no *H. macroloba* was observed. Pago Bay on the eastern side of Guam and Tumon Bay and U.S.O. Beach on the western side have the most abundant stands of *H. macroloba.*

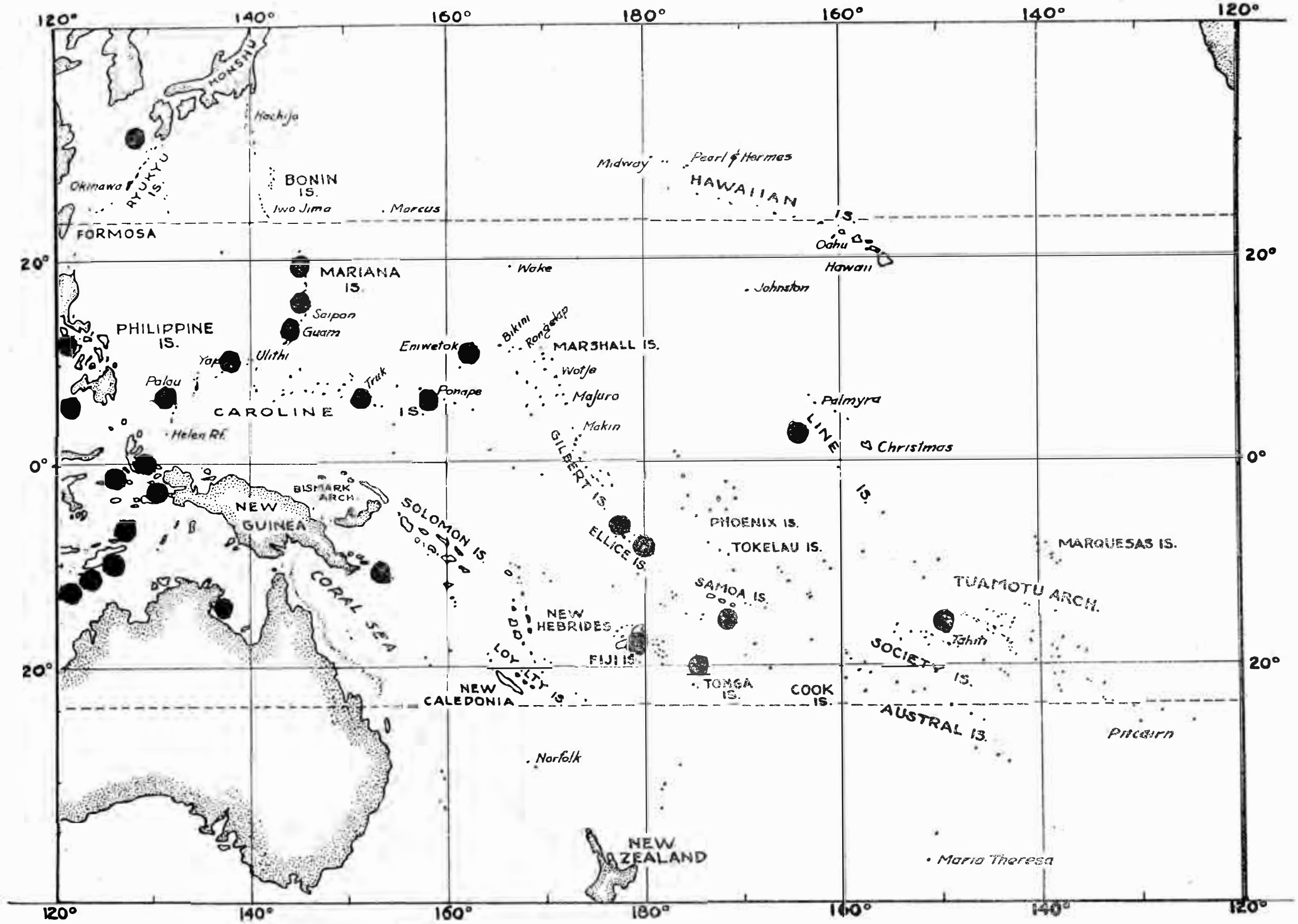

Fig. 1. Pacific distribution of *Halimeda macroloba*.

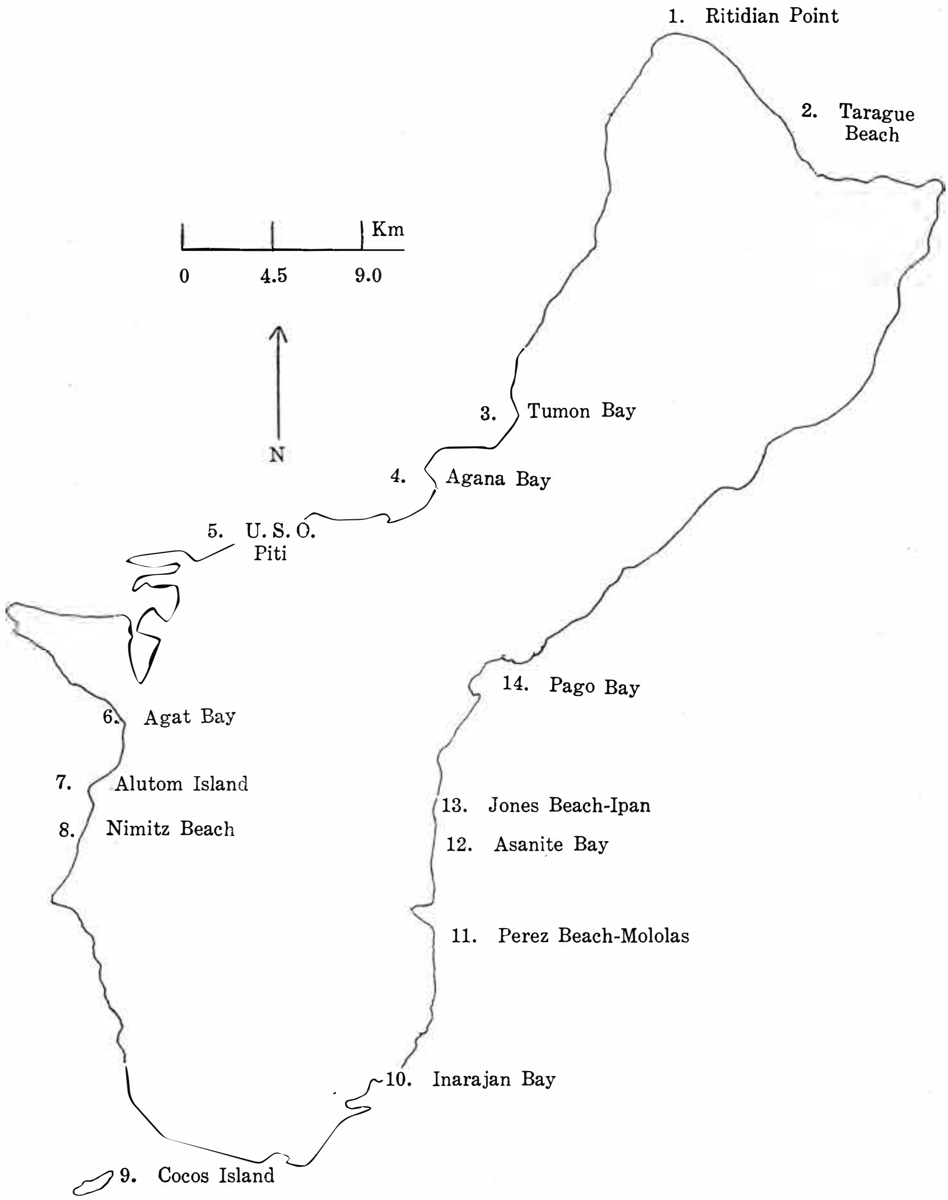

Fig. 2. Geographic distribution of *Halimeda macroloba* on Guam.

Substratum

Halimeda macroloba grows on Guam's shallow inner reef flats on sandy substratum. The minimum depth of sand required by *H. macroloba* to grow successfully is 6 to 10 cm. The richest stands occur in areas having more than 10 cm of sand. The importance of suitable sand depth and water depth is evident at

U.S.O. (United Service Organization) Beach where the majority of the *H. macroloba* thalli is found on the sides of the sandy channel where the sand is over one-half meter deep.

To date, fifty-five *H. macroloba*, representing less than 1% of all thalli observed, have been observed growing on coral. These algae range in height from 0.5 cm to 10 cm but none has been observed in the mature or fruiting stage. It may be that this alga is unable to survive until maturity on a coral substratum.

The rhizoids of specimens growing on coral or in 2 cm of sand average 0.5 cm to 2 cm in length, respectively, while rhizoids from specimens growing in deeper sand average 7.9 cm. The rhizoids form an intricate network of siphons which bind the sand particles together and anchor the alga firmly in the sandy substratum. With the aid of its very large rhizoid, *H. macroloba* endures the rough, almost turbulent currents of high tide and may even endure the violence of typhoons. One-half of the stand of *H. macroloba* at Asanite Bay withstood the typhoons of October and November, 1968.

In an effort to determine the type of sand preferred by *H. macroloba* 25 samples (three samples from each of seven selected areas and four samples from Tumon Bay, San Vitores Beach) were taken from eight sites where *H. macroloba* grows abundantly. The sand was collected from these areas and dried thoroughly. The sand was then analyzed by means of sieving. The metal sifter consisted of a series of five cylindrical screens which fit upon each other forming one large cylinder. The uppermost sieve had the largest pores which were 5 mm in diameter. Below this the sieves had pores of 3 mm, 2 mm, 1 mm, and 0.5 mm respectively. The sand was placed in the uppermost sieve and gently shaken until the sand sorted out by size. The sand left in each individual sieve was weighed on a balance. The individual weights were recorded and size percentages (Fig. 3) were calculated. Examination showed that all particles larger than 3 mm consisted mainly of broken coral, shells, crabs, and other invertebrates as well as *Halimeda* particles. It is apparent from this study that *Halimeda macroloba* prefers fine, compact sand.

Population counts of mature *H. macroloba* at sites where sand was analyzed were: 30 thalli/m^2 at U.S.O. Beach, south of the channel; 22/m^2 at San Vitores, Tumon Bay; 20/m^2 at Pago Bay, south of the channel; 18/m^2 at Nimitz Beach; 15/m^2 at both Asanite Bay and Perez Beach, Mololas; 10/m^2 at both U.S.O., north of the channel and Pago Bay, north of the channel.

Both Pago Bay areas mentioned above, as well as Nimitz Beach have abundant stands of *H. macroloba* growing in mud-sand which has a characteristic sulfide odor. Mature specimens from Nimitz Beach area were consistently three to four centimeters shorter and had three to four fewer branches than specimens from other areas.

The relatively clean sand north of the channel at Pago Bay (150 meters from shore), Tumon Bay, and U.S.O. Beach have the richest stands of *H. macroloba.*

Plant Association

The sand inhabiting plants usually associated with *H. macroloba* are the

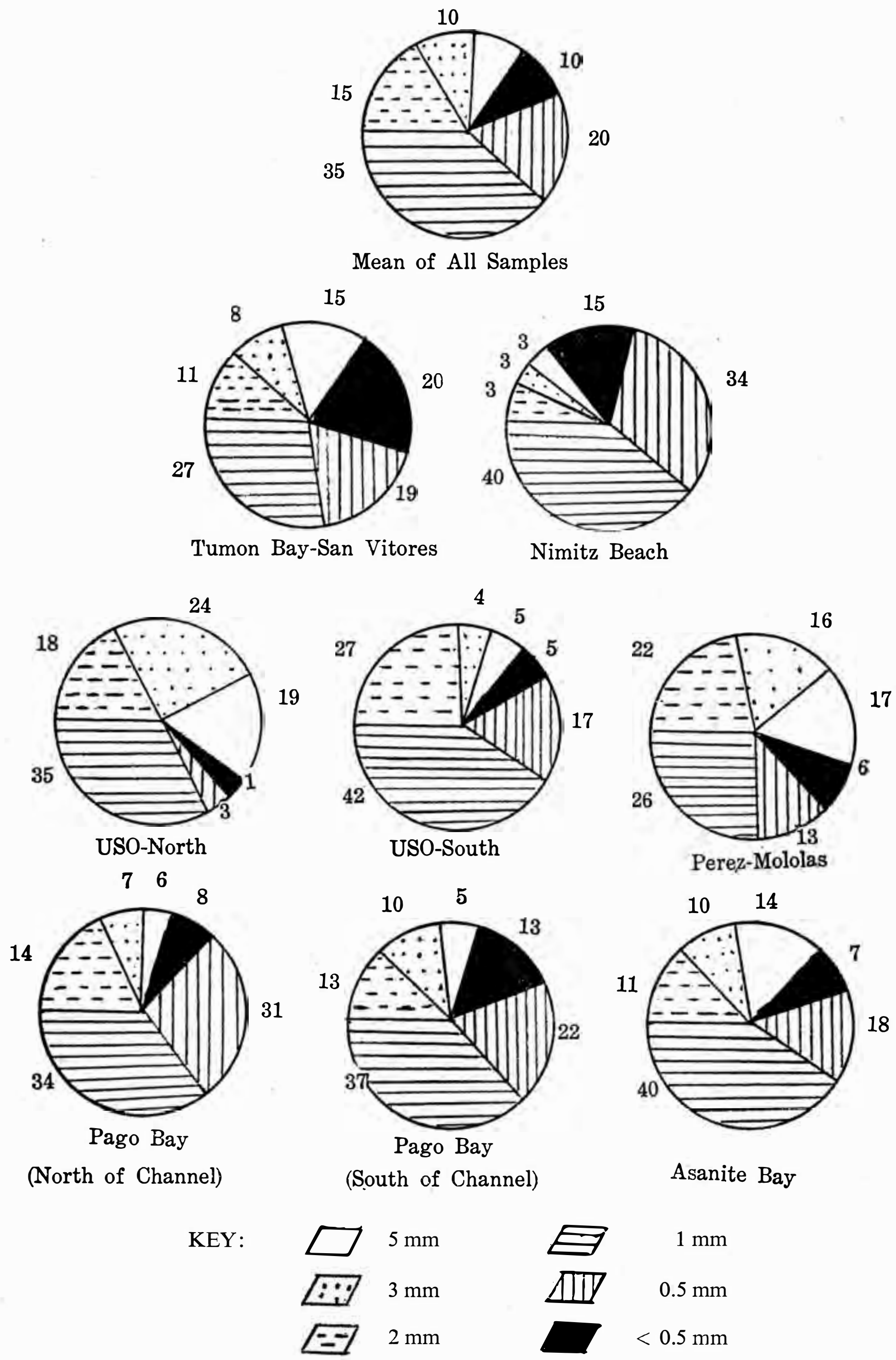

Fig. 3. Particle sizes of sand samples according to percentage.

spermatophytes, *Enhalus acoroides* (L. F.) Rich., *Halodule uninervis* (Forskal) Ascherson, *Halophila minor* (Zoll.) Hartog, as well as the green algae, *Caulerpa sertularioides* (Gmelin) Howe and *Avrainvillea obscura* J. Ag. Although *Halimeda opuntia* (L.) Lamx. is not a sand plant (it grows on coral) it can be found frequently adjacent to *H. macroloba*. Of the 14 species of *Halimeda* known from Guam these are the only species commonly found on the inner reef flats.

Enhalus acoroides accumulates and binds sand, and as such provides *H. macroloba* protection in areas where the currents are strong. Emery (1962) considers *Enhalus* an important geologic agent because it traps and holds the sand that is swept across the reef. *Enhalus* mounds are easily recognized and very often *H. macroloba* can be found associated with these beds. Epiphytes, especially *Hypnea esperi* Boerg., were prevalent on *Enhalus* and *H. macroloba* at Pago Bay and at Nimitz Beach.

In addition to *Hypnea esperi*, both *Padina minor* Yamada and *Dictyota cervicornis* Kütz, as well as *Caulerpa sertularioides* (Gmel.) Howe, were observed growing on *H. macroloba*. *Fosliella* sp. and other coralline algae partially cover several segments of the thalli.

Another observation to be included here is that forty out of fifty *H. macroloba* collected at Pago Bay and Nimitz Beach had a distinctive yellow substance on the segments. This powdery substance became evident when the specimens dried. Microscopic examination showed this to be *Calothrix confervicola* (Roth) Ag. The *H. macroloba* collected from other areas did not have *Calothrix* evident on the thalli. Chemical analysis indicated that a sulfur compound was present in the yellow substance.

Water Depth

The average depth of water at MLLT in the areas where the majority of *H. macroloba* grows is 30–45 cm. *Halimeda macroloba* has been observed on Saipan in 4 meters of water but never seems to occur any deeper (R. T. Tsuda, personal communication). Extreme exposure during spring tides results in white-edged segments, which die and are eventually shed. Observations at Asanite Bay and U.S.O. Beach reveal that the entire thallus decomposed prematurely after overexposure during spring tides.

Current

Most of the *H. macroloba* stands studied on Guam are in areas washed regularly by mild currents. Those stands growing in quiet areas have a black hydrogen sulfide sand substratum and possess more epiphytes. At Asanite Bay *H. macroloba* is washed continuously by swift currents. Here epiphytes are few and the life span is two to three weeks shorter than in areas where the water is less active. In the more quiet areas of Pago Bay and Nimitz Beach mature *H. macroloba* is usually covered with various epiphytes which limit the amount of light to the *Halimeda* thereby hindering growth. This appears to be the case since specimens with many epiphytes averaged a height of 11.0 cm compared to the usual 12.5 cm for mature *Halimeda*. In the laboratory aquaria also, epiphytes are most evident during periods of over exposure to the sun. Regardless of this situation, the majority of these epiphyte-laden specimens fruited. Colinvaux (1968b) reports on the problem of epiphytes on *Halimeda* specimens in aquaria culture.

Amphipods, crabs, opistobranchs, hermit crabs, and foraminifera were prevalent on the thalli of *H. macroloba* growing in areas where the currents were stronger.

Temperature

According to temperatures recorded, *Halimeda macroloba* can tolerate a wide range of temperature. Daily temperature variation on the reef flat shows an extreme of 33.3°C in pools during low spring tides and 27.4°C during high spring tides. The mean temperature, however, at MLLT was 31°C while at high tide the mean was 27.7°C.

Salinity

Water samples taken from areas where *H. macroloba* is found were analyzed for salinity by the University of Guam's Division of Biosciences and Marine Studies. The mean salinity from 11 sites was 34.0‰. In the laboratory aquarium, the salinity was 38.5‰ at the time of determination and this higher rate of salinity did not appear to have any harmful effects on the specimens in the aquarium. Additional samples were analyzed to determine the difference in salinity between surface water and bottom water where *H. macroloba* grows. Salinity of surface water was 33.5‰ while bottom samples had a mean salinity of 33.9‰. San Vitores Beach, however, showed an extreme difference of 2.1‰ in salinity at MLLT 30 meters from shore. The surface water was less saline than the bottom water during low tide because of freshwater runoff from shore. At high tide the difference was negligible. *H. macroloba* is known to occur in brackish water as well as in the Red Sea (Hillis, 1959) which has a salinity of 37–40‰.

Growth Rate

To determine the growth rate of *Halimeda macroloba*, over 200 plants were tagged and measured between September, 1968 and June, 1969. Three generations at Asanite Bay and one generation at two different sites at Pago Bay were observed.

Lengths of colored electrical wire, each with a 1×3 cm adhesive tape tag bearing consecutive numbers written with India ink, were used to tie around the bases of the *Halimeda* thalli. The tagged plants on the reef were examined biweekly for growth rate and fruiting.

In September, 1968 over 100 *H. macroloba* from Pago Bay were transplanted near an *Enhalus* bed in Asanite Bay as an experimental project. Asanite Bay was completely void of this species previously. Typhoons in November washed away half of the original *H. macroloba* transplanted there. Since the November typhoons, those specimens of *H. macroloba* which withstood the storms matured and fruited. By April, 1969 there were over 118 *H. macroloba* in the original site. Two juveniles were well established on a sandy substrate over 30 meters from the original site by February. By March two more juveniles were found 10 meters away from the first site and in April ten juveniles were five meters away.

Within a month of the replanting at Asanite Bay three new plants were observed. Examination showed no evidence of vegetative reproduction (Colinvaux, 1968a) and therefore it is assumed that these new plants originated from zygotes. If this assumption is correct the time from zygote formation to appearance of the first segment is approximately one month. The greatest amount of growth occurred during the first month after the appearance of the first segment. Growth rate studies commenced with development of the first segment. The thalli grew an average of 5.8 cm the first month and then growth slowed down. The average rate of growth after that was 1.5 cm to 3.0 cm per month. At maturity the average thallus growing on the reef measured 11.0 cm in height. Fig. 4 shows the rate of growth based

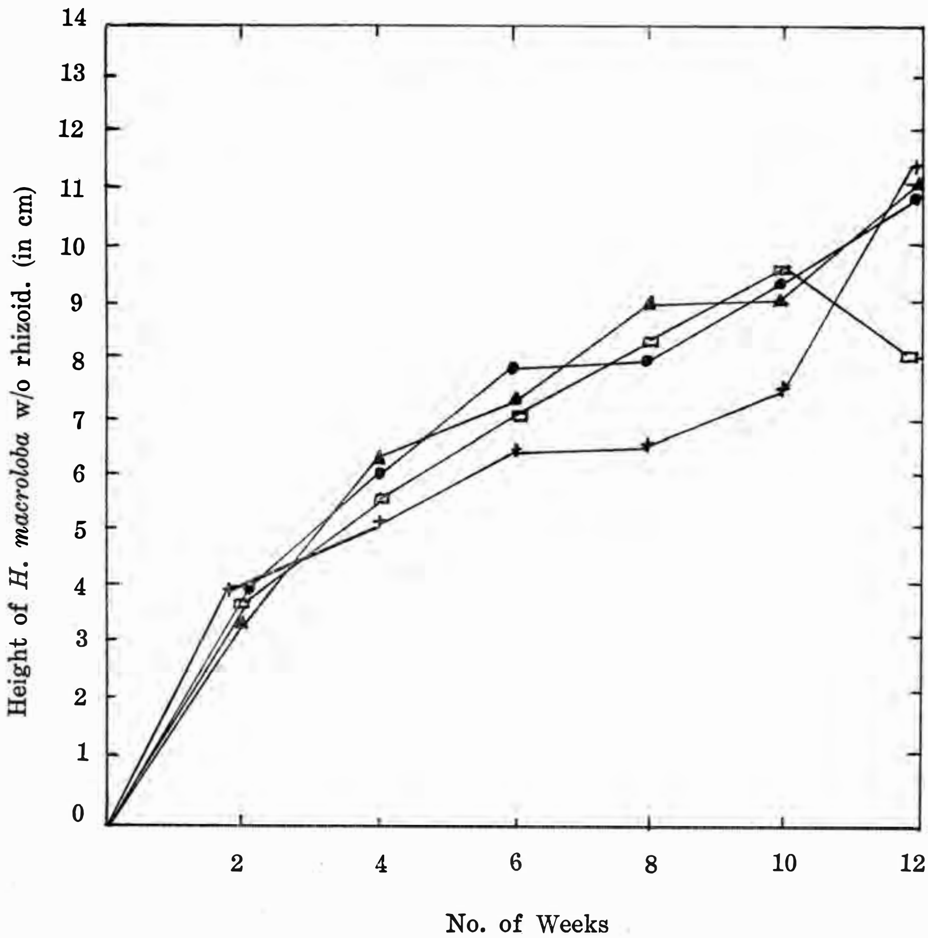

Fig. 4. Rate of growth with development of first segment. Aquarium specimens (▲), Pago Bay near shore (●), Pago Bay 150 m from shore (□), and Asanite Bay (+).

on fertile specimens of tagged *H. macroloba* for both Pago Bay areas, Asanite Bay, and the laboratory aquaria. The rate of growth after appearance of first segment is based on the mean growth of 50 aquarium specimens (▲), 35 specimens from Pago Bay near shore (●), 25 specimens from Pago Bay 150 meters from shore (□), and 33 specimens from Asantite Bay (+). It must be noted that *H. macroloba* was first introduced to Asanite Bay in September, 1968. *H. macroloba* at this site is exposed to extreme wave action as well as lack of sufficient sand substratum.

The growth rate in the laboratory aquaria appears to be very similar to the growth rates for Pago Bay, but the specimens in the aquaria had three to four fewer branches and irregular segment growth dominated. Colinvaux *et al.* (1965) shows this irregular segment growth on Plate 3. Irregular segment growth is an exception on the reef. In the aquaria it is possibly the result of inadequate light exposure and insufficient water movement.

Growth rate was also recorded in terms of new segments added (Table 1). During the first month a range of three to eight new segments were added. During the second month three or less segments developed and during the third month two or less segments developed. Microscopic examination of developing segments after ten hours' growth showed that they consisted mainly of transparent siphons which originated from the segment directly below. Growth was rapid and within two days the segment was 1.1 cm long (nearly its normal size).

Table 1. Growth rate of *H. macroloba* in laboratory aquaria in terms of new segments added.

No. of Tagged *H. macroloba*	Segments Added: 10/15/68 Original Segments	11/15/68 Additional Segments	12/17/68 Additional Segments
1.	7	1	1
2.	5	0	0
3.	6	0	0
4.	7	1	2
5.	6	2	2
6.	3	3	2
7.	8	1	0
8.	6	2	1
9.	5	2	2

Colinvaux *et al.* (1965) reports that the stalks with main axis could act as perennial structures. However, *H. macroloba* rhizoids without branches disintegrate. This was observed in both laboratory and field experiments. Seventy-two rhizoids were placed in the aquaria between December and Febraury in an effort to determine whether or not they would give rise to segments but none did. Similar observations were made on the reef with similar negative results. However, rhizoids of *Avrainvillea obscura* J. Ag. served as perennial structures and in all instances produced new thalli within a week.

A comparative study of thalli height and breadth was made using 35 mature specimens from Pago Bay. The mean height was 9.3 cm while the mean breadth was 16.6 cm giving a difference of 7.3 cm. Rhizoids averaged 7.9 cm in length but the accuracy here is debatable, since they break very easily during removal from the substratum. The rhizoids showed a mean of 1.4 cm less than the mean thallus examined. However, two other studies were made comparing rhizoid length to thallus height indicating a difference of 2.9 cm and 3.5 cm, respectively (Table 2).

Fig. 5 shows the maturity stages of typical specimens according to data collected during this study. Fig. 5–D fruited exactly one week after the photo was taken.

Table 2. Specific data on typical mature specimens of *H. macroloba*. Measurements are in cm.

No. of Specimen	Height of thallus	Breadth of thallus	Length of rhizoid	No. of segments per branch	Length of Av. segment	Width of Av. segment	Branches per thallus
			Pago Bay				
1.	11.5	18.5	8.6	9	1.3	2.9	16
2.	11.0	21.0	8.5	10	1.5	2.3	21
3.	9.5	16.5	5.6	10	1.3	1.9	17
4.	10.2	16.0	6.8	9	2.0	1.5	18
5.	11.0	17.0	9.0	10	2.0	2.3	17
6.	11.5	24.1	6.8	10	1.7	2.0	18
7.	11.5	20.5	8.5	10	1.4	2.4	18
8.	10.5	19.5	8.0	10	1.5	2.0	19
9.	11.0	20.1	8.5	9	1.5	2.1	17
10.	10.1	19.0	8.9	9	1.7	2.1	18
Mean:	10.8	19.2	7.9	9.6	1.6	2.2	17.9
			U.S.O.				
1.	10.0	21.5	8.0	9	1.5	2.1	18
2.	14.2	24.1	8.1	10	1.6	1.9	21
3.	9.5	19.6	7.8	9	1.2	1.6	20
4.	8.0	20.2	7.5	9	1.6	1.8	15
5.	11.0	24.5	8.4	10	1.2	2.0	18
6.	9.5	22.7	8.0	10	1.4	1.9	16
7.	8.5	22.5	7.9	9	1.9	2.5	17
8.	9.0	19.1	8.0	8	1.2	2.1	21
9.	13.9	23.5	7.9	9	1.4	1.9	16
10.	11.0	19.5	8.5	7	1.5	2.3	14
11.	11.7	28.0	8.0	8	1.9	2.2	18
12.	12.0	22.1	7.9	9	1.5	2.3	14
13.	15.0	25.2	8.0	10	1.5	2.6	16
14.	10.0	22.2	8.2	8	1.6	2.0	15
15.	11.4	26.1	7.9	10	1.2	2.3	14
Mean:	11.0	22.7	8.0	9.4	1.5	2.1	17.1

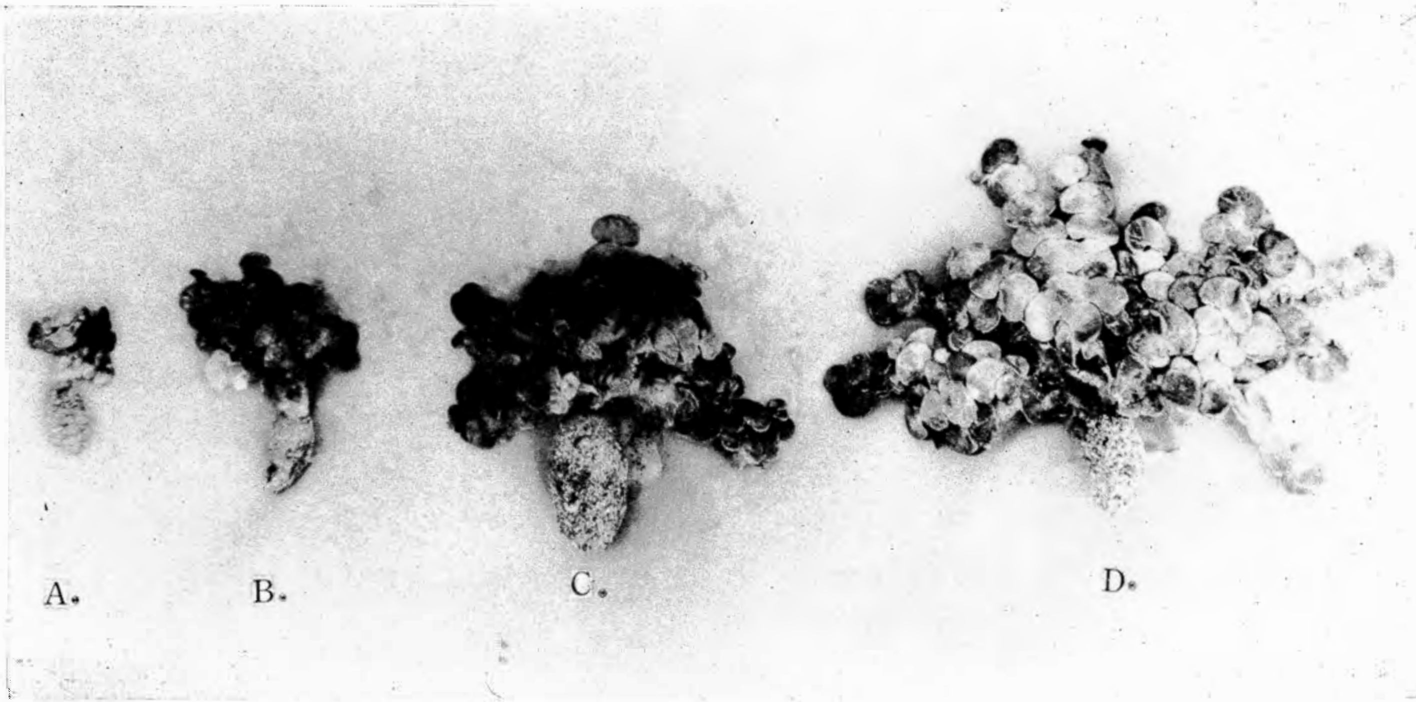

Fig. 5. Maturity stages of *H. macroloba* after initiation of first segment. (× .25)
A. 2–3 weeks. B. 1.5 months C. 2.5 months D. 3 months.

Fruiting

Fruiting specimens (Fig. 6) were observed in the field every month during the period of study. Fruiting *H. macroloba* were observed periodically by Roy T. Tsuda from June to September, 1968. It is easy to recognize fruiting *H. macroloba* because of its white segments edged with chorophyll-laden gametangia. The gametangia also appear on the surface area of the segments. During fruiting the chlorophyll in the thallus streams to the gametangia (Hillis, 1959). Fruiting is periodic but the conditions that trigger fruiting are still unknown. Several *Halimeda* specimens usually fruit simultaneously, but single fruiting *H. macroloba* have been observed. Kanda (1940) stated that fruiting occurs only during a certain period of the year, and Hillis (1959) reported *H. macroloba* producing gametangia during May and August but observations during this study have shown fruiting to occur throughout the year.

Fig. 6. Close-up photo of fruiting *H. macroloba*. Note the concentration of fruiting bodies along the edges of the segments.

Fruiting to thallus breakdown takes from three to four days in both the natural environment and in the aquarium. After fruiting the entire thallus collapses within a day or two. In the ocean, currents or wave action aid this process while in the aquaria the process was aided by nine *Cypraea moneta* Linnaeus (money cowrie). During the first three months of this study no *Cypraea moneta* were in the aquaria and the thalli did not collapse until the fourth or fifth day after fruiting was completed. A slight touch of the thallus would have aided the process. The cowries were especially attracted to the *Halimeda* during fruiting and would cling to the branches continuously. No harmful results were apparent.

Gametangial Formation

Gametes are contained in gametangia at the end of the gametophores. There are usually six globose gametangia on a gametophore and this structure is grape-like in appearance. The diameter of the gametangia ranges from 250 to 450 μ. The gametophore arises from siphons of the medullary tissue as observed by Kanda (1940). This is similar to Hillis (1959, pl. 8) Type 2 description of gametophore.

During a seven-month period, 25 fruiting specimens were observed in the laboratory aquaria. Ten out of the 25 formed a mucilaginous case around the gametangia on the thalli. There was a second way in which the *H. macroloba* fruited. Fifteen specimens did not form a mucilaginous casing around the gametangia on the segments. Instead the gametes were released along with the mucilaginous substance immediately into the water. Meiosis is assumed to have occurred previously in the gametangia. The mucilaginous substance appeared as macroscopic threads (10–20 cm in length) which seemed to sweep the gametangia contents up as with a current. On these occasions the water in the aquarium appeared extremely green. This particular type of fruiting was observed at San Vitores on March 15, 1969. On that morning at very high spring tide and heavy overcast, at least 50 to 60% of the mature *Halimeda* were fruiting. Three specimens were collected, and these released gametes in the above manner in the collecting pail.

Between September, 1968 and June, 1969 observations of fruiting specimens on the reef occurred throughout the months. However, the greatest number of fruiting specimens were observed during spring tides. Further investigation will be made to determine the relationship between fruiting, manner of fruiting and the environmental conditions that stimulate fruiting.

Fusion of Gametes

Colinvaux *et al.* (1965) refers to biflagellated swimming units but did not observe fusion of gametes. Kanda (1940) refers to egg-shaped spores with one flagellum but attributes the absence of more flagella to the extremely poor condition of the gametes due to overexposure to the sun during the trip back to his laboratory on another island. Fritsch (1961) states that these flagellated organisms are gametes. Zanardini (1876) reported sporophores on some *Halimeda* spp.

Many hours of microscopic examination of fruiting bodies confirmed that these biflagellated cells are gametes. The gametes are pear-shaped and are anisogamous varying in size with the larger gametes ranging from 3 μ wide and 6 to 10 μ in length and the smaller gametes ranging from 1.5 to 2.1 μ in length. Gametes per thallus probably run as high as a million or more, but few of these actually develop as is evident at sites studied for this research.

The gametes observed were extremely active. They moved around continuously and bumped into one another as well as into the chloroplasts which were also released. The smaller biflagellated gametes were more active. Those observed appeared to go from one larger biflagellated gamete to another, but no fusion was observed at this time. After 48 hours fusion was observed. The remaining gametes continued their active behavior for about 40 minutes. They bumped into the larger gametes continuously but no other fusion was observed. The gametes gradually slowed down and became completely inactive. No new plant appeared in the aquarium from this fruiting.

The process from contact to zygote took approximately 90 minutes. The fused gametes were in a very excited condition for the first ten minutes. At the end of one hour the zygote was motionless. The fusion in this case occurred between gametes released from the same plant and is therefore termed homothallic. Fusion was similarly observed one other time.

Calcium Carbonate Production

The most important feature of *Halimeda macroloba* is its ability to precipitate calcium carbonate and therefore contribute to the reef bulk after it dies. To obtain an estimate of *H. macroloba* as a calcium carbonate contributor to sand, seventy-two *Halimeda* specimens were collected from three different locations. The rhizoids were removed, and the remaining portion of the thalli dried and weighed. The thalli were then decalcified in a 10% hydrochloric acid solution, redried, and weighed. The difference in weight indicated the amount of calcium carbonate present (Table 3). Both juveniles and mature specimens were treated and separate records were kept. The mean height of mature specimens used for this experiment was 11.3 cm while the mean juvenile was 6.8 cm high. The mature thalli averaged 10.7 grams dry weight before decalcification and 2.5 grams after decalcification. There was a mean of 77.2% calcium carbonate present in the mature specimens from the three areas studied. The mean dry weight of the juveniles was 3.2 g before removal of calcium carbonate and 0.9 g each after the removal. The mean calcium carbonate content was 72.0% for the juvenile specimens.

The amount of calcium carbonate contributed by *H. macroloba* to sand per standing crop is possible to estimate as shown on Table 4. The number of thalli is multiplied by 8.2 g, the amount of calcium carbonate contributed to sand per mature *H. macroloba* as based on laboratory studies in which the average thalli contained 8.2 g of $CaCO_3$. Since observations at Asanite Bay showed that development from zygote formation to first segment occurred within one month and tagged specimens had a life span of three months from development of the first segment to fruiting and thallus breakdown, the amount of time from zygote to fruiting is therefore, approximately four months. This study shows therefore, that the amount of calcium carbonate contributed in four months, or per standing crop can be easily estimated.

Repopulation of *Halimeda macroloba* was studied in order to reach a yearly estimate. Repopulation at Asanite Bay showed that the November typhoons washed away 50 of the original 102 specimens of *H. macroloba* transplanted there in late September, 1968. Fifty-two specimens were counted in late November, 1968. By February there were 106 specimens in three locations and by March, 1969

Table 3. Calcium carbonate content.

Date	Location	Number of Specimens	Mean Height of thallus in cm	Mean Dry Wt. of thallus before removal of $CaCO_3$	Mean Dry Wt. of thallus after removal of $CaCO_3$	Mean Weight of CaCOt per thallus	% of $CaCO_3$ per thallus
MATURE *Halimeda macroloba*							
1/2/69	U. S. O.	22	11.5	10.7 g	2.1 g	8.6 g	80.7
1/19/69	Nimitz	12	11.2	10.5 g	2.5 g	8.0 g	76.6
1/19/69	Tumon Bay	10	11.3	10.9 g	2.8 g	8.1 g	74.3
JUVENILE *Halimeda macroloba*							
1/2/69	Nimitz	14	6.0	3.1 g	.8 g	2.3 g	73.3
1/19/69	U. S. O.	14	6.9	3.4 g	1.0 g	2.4 g	70.7

Table 4. Calcium carbonate contributed to reef areas.

Areas	No. of Mature *H. macroloba* per m^2	$\bar{X}$ $CaCO_3$ per thallus	$CaCO_3$ contributed to sand/4 mo. per m^2
Tumon Bay	22	8.2 g	180.4 g
U. S. O.—N.	10	8.2 g	82.0 g
U. S. O.—S.	30	8.2 g	246.0 g
Alutom Island	7	8.2 g	54.7 g
Nimitz	18	8.2 g	147.6 g
Cocos Island	15	8.2 g	123.0 g
Pago Bay—N.	10	8.2 g	82.0 g
Pago Bay—S.	20	8.2 g	164.0 g

the total was 118 specimens in four different locations in the bay. This study shows that within five months there was an increase of 66 plants or double the November count. From the above it seems both difficult and impractical to endeavor to estimate the amount of calcium carbonate contributed to sand per year. There are too many variable factors involved.

Summary

The role of *H. macroloba* in shallow, sandy areas is an important one since this alga contributes a considerable amount of $CaCO_3$ yearly. After fruiting the organism dies, collapses, and adds to the reef bulk which is vitally important to life on a coral reef. Observations made during this study indicate three stands of *H. macroloba* yearly.

H. macroloba is abundant on Guam's sandy reef. Sifting and analyzing sand sizes from various areas indicate *H. macroloba*'s preference for fine, compact sand. This alga tolerates extremes in temperature, salinity, and currents; however this alga has a definite preference for areas washed by mild currents. In areas washed regularly by stronger currents and constantly shifting sand *H. macroloba* is usually found near *Enhalus acoroides* beds which apparently provide some protection.

Halimeda macroloba provides shelter for various invertebrates, i.e., opistobranchs, serpulids, amphipods, and foraminiferans. *Cypraea moneta* have been observed frequently on this alga. They cling to the segments and at times are not readily observed. This occurs in both the laboratory and on the reef. The large rhizoids also provide hiding places for amphipods and small molluscs. With the presence of other sand inhabiting plants an entirely new faunal community can develop.

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