The densities also of solid and liquid gallium were determined,—data which have especial interest because the expansion of gallium on freezing has been attributed by some investigators to impurity. In the first place careful determinations were made by means of a pycnometer for solids[3] of the density of the impure material containing some indium in the solid and liquid condition, the values found being respectively 5.975 and 6.166. Subsequently when the purest material had been obtained, the determinations were repeated with equal care, giving values 5.885 and 6.081 respectively. Evidently indium had produced no essential effect upon the expansion on freezing and even if the more carefully prepared gallium was not absolutely pure, it is evident from the outcome, by extrapolation, that the purest gallium must still possess this unusual property.

[1] This method also has since been published by Dennis and Bridgman in their interesting article on Gallium.

[2] Richards and Speyers, *J. Amer. Chem. Soc., Easton, Pa.*, 36, 1914, (491).

[3] Richards and Wadsworth, *Ibid.*, 38, 1916, (222).

THE GROWTH-RATE OF SAMOAN CORAL REEFS

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Communicated October 30, 1918

In April, 1917, reef corals from Pago Pago Harbor, American Samoa, were measured, photographed, weighed, marked by numbered brass tags and replaced in favorable situations upon the reef-flats either by tying them with wire to iron stakes or imbedding their bases in concrete.

In July, 1918, these corals were again studied in order to ascertain their growth-rate, and as the specimens selected were of average size it was hoped that an approximate determination of the average growth-rate for each species might be determined. It was our object to calculate the weight of stony matter which coral heads of average size add to the reef per annum. In order to do this, the weight of the living coral was ascertained both in 1917 and in 1918. Then, in 1918, the coral was killed and its animal substance dissolved in KOH, after which the fresh water was largely abstracted by washing the skeleton in 90% ethyl alcohol; and finally the coral was dried in the sun, and then weighed.

This showed that the weight of the dried stony substance in various species of reef corals is on an average about 0.8 that of the same coral heads when alive. Various *Acropora* ranged from 0.7 to 0.9, while branched *Porites* were about 0.8, and large massive *Porites* slightly above 0.9.

Applying this correction, we find that on these Samoan reefs the gain in weight of stony substance per year in various coral heads of average size appears to be as follows:

Acropora......................	19 ounces avoirdupois, or 539 grams per annum
Porites........................	8 ounces avoirdupois, or 227 grams per annum
Pocillopora....................	10 ounces avoirdupois, or 283 grams per annum
Pavona........................	12 ounces avoirdupois, or 340 grams per annum
Psammocora....................	3 ounces avoirdupois, or 85 grams per annum

Knowing the number of coral heads of these genera upon a reef-flat, we have a means for ascertaining the weight of limestone added to the reef each year by the growth of coral upon its upper surface.

By counting the numbers of coral heads and species of corals on squares of 24 feet on the side (576 square feet), the squares being staked out from 50 to 100 feet apart from the shore to the seaward edge of the reef-flat, we are led to the following conclusions:

On the upper surface of the Aua reef-flat between Breaker Point, Pago Pago Harbor, and the southern end of Aua Village, the area of the reef being 2,550,000 square feet, the number of corals are approximately as follows:

There are about 502,200 heads of *Porites* growing over 72% of the area of the upper surface of the reef-flat, and contributing (due to their growth) per annum 251,000 pounds of limestone.

347,500 *Acroporas* distributed over 56% of the reef-flat contribute annually 500,400 pounds of limestone.

57,600 heads of *Pocillopora* scattered over the entire reef-flat contribute 31,700 pounds of limestone.

55,900 Psammocora distributed over 30% of the reef-flat contribute each year 11,000 pounds of limestone.

15,500 Pavona found over 35% of the reef-flat area contribute each year about 11,600 pounds of limestone.

Thus the growth of these corals appears to add about 805,000 pounds of limestone each year to the upper surface of the reef-flat and as these genera contribute 95% of the entire coral heads of the reef-flat, it is probable that about 840,000 pounds or 380,500 kilograms of limestone is added to the coral reef each year by the growth of the corals over its surface.

There are, however, certain obvious losses which may be approximately determined. Among these the wash of the breakers due to the prevailing trade wind drives a current of about 40 feet per minute over the surface of the reef-flat from Breaker Point, northward to the jagged northern edge of the reef-flat over which the drifted limestone sand spills into deep water.

In order to determine the annual loss of loose limestone sand lost to the reef-flat by being drifted off its northern edge, 6 barrels each 2 feet in diameter were weighted with volcanic rocks and sunk off the reef-flat close to the northern edge so that the water was about 1 foot deep over their open tops at lowest tide.

It was found that on an average each barrel caught 0.7 of a pound of limestone sand per day; the sand being dehydrated in alcohol and dried in the sun before being weighed.

Further tests showed that the barrels caught on an average only 12% of the sand which was carried in the current over their open tops from the edge of the reef-flat.

The northern edge of the reef-flat is about 1200 feet wide, but sand spills over its edge along only about 800 feet of this length, the 400 outermost feet of reef edge being subjected to the constant inward wash of the waves.

Using these data, it appears that about 100,000 pounds of sand are washed off from the reef-flat by currents each year.

There are 290,000 holothurians on the Aua reef-flat between Breaker Point and the edge of the reef off Aus Village; and as the acidity of their gastric cavities appears to be the same as that of the holothurians of Florida, each one, according to experiments made at Tortugas in 1917, might be expected to dissolve 10 pounds of sand per annum; or 2,900,000 pounds of sand may be destroyed annually over this reef-flat by solution due to holothurians.

Thus the corals appear to add annually about 840,000 pounds of limestone to the reef, but 3,000,000 pounds, or nearly $3\frac{1}{2}$ times this weight of limestone appears to be removed annually by holothurians and by currents, and other factors such as boring algae, mollusca and fishes; the efficacy of which we have not been able to calculate, add still more to the destruction of limestone although their influence is in some measure offset by the growth of nullipore algae, and lithothamnion. Alcyonaria although a decided factor in some reefs are so rare as to be negligible over the Aua reef-flat.

In most respects this Aua reef is a typical average Pacific fringing reef and our data appear to explain the disappearance of the lithothamnion ridge over the shoreward parts of the reef-flat as the reef grows outward. Moreover, the reef-flat appears to be deepening at present although the average depth of water over it at low spring tide is less than one foot.

This does not mean that such a fringing reef must necessarily change into a barrier reef through waste and solution of limestone from its floor, for as the reef-flat deepens the currents must lessen, and a sandy or muddy bottom, while unsuited to the growth of coral, is also not so favorable for holothurians as are the small patches of limestone sand surrounded by dead and living coral such as characterizes the Aua reef-flat today.

Thus as the reef-flat deepens, the factors which degrade it probably diminish and a balance may be attained between the accession of limestone due to growth of corals and other organisms and its loss due to mechanical and organic causes.

It is interesting to see that although *Porites* heads are more numerous than *Acropora*, yet *Acropora*, due to its remarkable growth-rate, is the most important coral genus in building up the Pacific reefs.

These results account for the disappearance of the lithothamnion ridge as the reef grows outward. This ridge is formed only on the breaker-washed seaward edge of the reef and it projects somewhat above low tide level, but as the reef extends seaward the ridge disappears over the shoreward parts of the reef-flat.

The growth-rate of these Samoan corals is nearly twice as rapid as is that of similar genera in Florida and the Bahamas, the growth rate of Atlantic corals being well determined due to the exhaustive studies of Vaughan.

This is probably due to the fact that in the Atlantic the corals live chiefly on the outer edges of shallow limestone flats the muddy bottoms of which become churned up by the waves, and pelagic life is largely killed in the water over the flats. Thus in the Atlantic, the corals are well fed only on the incoming tide, very little reaching them from the water passing outward from the flats.

In the Pacific, on the other hand, the lagoons are generally deeper than in the Atlantic and there is but little limestone mud so that the corals receive food both from the rising and from the ebbing tide; and, as is well known, the growth-rate of coelenterates is a factor of their food supply.

The following table shows the average increase in dimensions of corals from Samoa, and from the Florida-Bahama region; the growth-rate of the Atlantic genera being taken from the report by T. W. Vaughan, 1915, *Year Book of the Carnegie Institution of Washington*, No. 14, pp. 227–228.

GENUS OF CORAL, AND LOCALITY	AVERAGE INCREASE IN DIAMETER	NUMBER OF RECORDS	AVERAGE INCREASE IN HEIGHT	NUMBER OF RECORDS
	mm.		*mm.*	
Acropora from Samoa	98	21	48	21
From the Atlantic according to Vaughan*	54	71	35	42
Branched Porites from Samoa	47	6	25	6
From the Atlantic according to Vaughan	26	207	19	106
Massive Porites from Samoa	35	9		
From the Atlantic according to Vaughan	13	120		

* Vaughan's estimate is based upon branching species such as *Acropora cervicornis; A. prolifera* and *A. palmata*. My records of somewhat similar species in Samoa show an average increase in width of 178 mm. and 79 mm. in height. Many of the Samoan *Acroporas* are low, encrusting or dome-shaped forms such as are not found in the Atlantic.

It will be observed that on the average the 21 Samoan *Acroporas* each gained 539 grams in weight per annum. This appears to be about 3 times as great as the annual increase in weight of *Acropora palmata*, of the Bahamas, for Vaughan 1915 *loc. cit.* p. 230 gives this as 173 grams per annum.

The final paper of which this is a preliminary abstract will be published by the Carnegie Institution of Washington.