

STANDING STOCK MEASUREMENTS OF CRUSTOSE CORALLINE ALGAE (RHODOPHYTA) AND OTHER SAXICOLOUS ORGANISMS

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Abstract: A photographimetric technique is described for 'sampling' the standing stocks of encrusting organisms, and has been used to estimate cover, relative density, and frequency of reef-building organisms on a Hawaiian fringing reef. The photographimetric data are compared with those obtained by a line-transect method. As applied during this study, the photographimetric technique required less time and produced more reliable results than the line-transect method.

INTRODUCTION

Many investigators have observed and recorded the apparent importance of the Melobesioideae – crustose coralline red algae – for their contributions to the formation of reefs, yet little is known concerning their ecology, biology, and productivity. There are essentially no quantitative assessments of their communities because techniques for measuring their standing stocks have been lacking. On the other hand, reef-building corals have been extensively investigated, usually by rather subjective qualitative means. Most quantitative studies have followed the methods of Manton (1935) and Abe (1937) in which sketches depicting distributional patterns, as seen in a horizontal plane, are made in the field and used to calculate cover or to count 'colonies'. Stoddard (1969) has pointed out the problems arising from the general lack of standard criteria in recording methods and in describing the complex three-dimensional patterns of many reef organisms.

A grid and glass-bottom view box were used by Pollock (1928) to estimate percentage cover by calcareous organisms along transects on shallow portions of reefs on Oahu Island, Hawaii. Pollock found that crustose corallines formed the dominant cover with corals ranking second. The relative abundance of crustose corallines in samples of the substrata was utilized by Adey (1964, 1966, 1968) to compare the relative melobesioid cover along the northwestern North Atlantic coast and the coasts of Iceland. As a first step toward understanding the relationships of these algae to their environment, the methods described below have been devised.

METHODS

Unpublished work on Hawaiian crustose corallines by Dr. M. S. Doty, disclosed that photosynthetic activity is more nearly a function of surface area than of mass

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and it therefore seems reasonable to consider that area measurements of standing stock would be more informative than some form of mass measurement.

Underwater note-taking, as described by Breslau, Zeigler & Owen (1962) and perfected further by Neushul (1964), was found to be very useful in water up to 10 m deep. This method employs an underwater, transistorized tape-recorder and SCUBA for recording data along transects. Three such line-transects (Fig. 1), each 280 m in

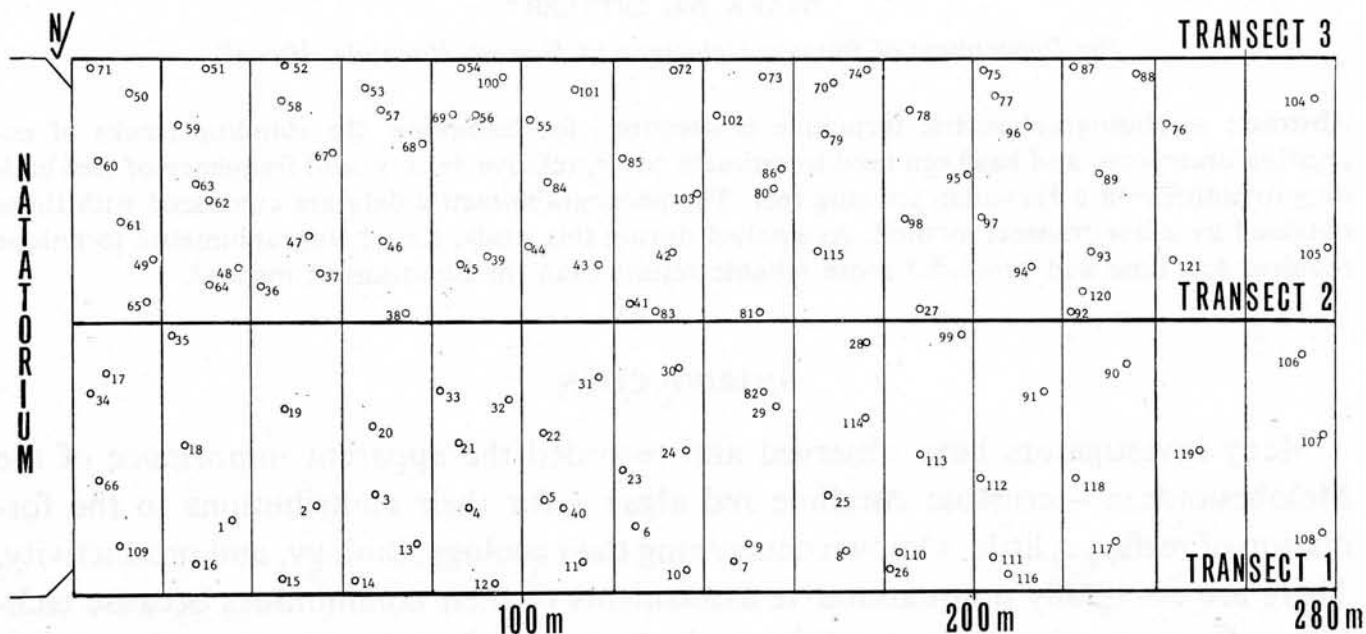


Fig. 1. The positions of the 'photo-samples' and line-transects in relation to the 14 study zones on the Waikiki fringing reef, Oahu Island, Hawaii.

length, were examined during the present study. Each was defined by a nylon line which was marked at 1.0 m intervals by numbered lead weights. The line was stretched, tight and secured at right angles to the shore-line and the frondose algae, sand, silt and dead rubble were cleared from beneath the line. The diver swam just above the line and recorded the distance from shore, the substrata and the depth, along with the measured cover (in cm) of the encrusting organisms intercepted by the line. Recording measurements by this technique, however, is physically exhausting and requires much field time under water. There is also some uncertainty as to how the intercepts obtained are to be related to either area or mass.

To overcome objections to these techniques and others, an area selection, positioning, and quantification method has been developed as follows. A ring, 30 cm in diameter and labeled with a numbered tag, was tossed into zones selected for investigation (Fig. 1) to obtain sample areas without bias as to substrata or cover. The ring was always tossed approximately 10 m into an area out of the investigator's vision. This provided an 0.07 m^2 stratified-random plot which was sufficient for sampling the dominant Hawaiian reef-builders, as shown by the relatively high frequency of the species (Fig. 2) occurring in the samples. Optimum plot area, shape, position, and number for sampling other organisms in different habitats similarly would have to be determined by preliminary reconnaissance and test sampling. (For more detailed

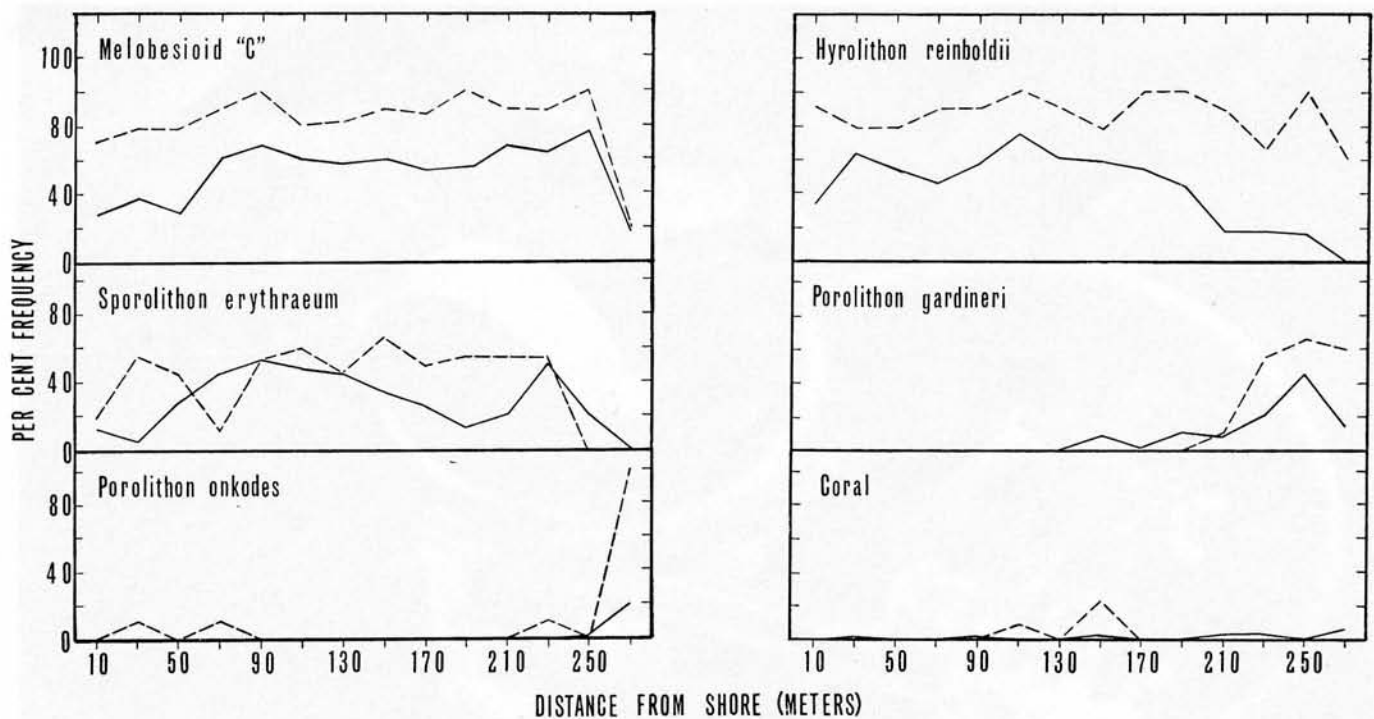


Fig. 2. The frequency distributions of the major saxicolous reef-builders on the Waikiki fringing reef: transect data are plotted as solid lines and photogrammetric data as broken lines.

information see the paper by Johnston (1957) in which variance analysis is used to determine the most efficient sample area and number of samples for measuring basal area of grasses by line intercept, vertical point, and loop methods.)

The sample position was located by recording three angles from magnetic north to reference markers located on shore and on a chart or aerial photograph of the area. The non-crustose seaweeds enclosed within the numbered ring were photographed in a plane at right angles to the plane of the ring. A waterproof case was developed (Fig. 3) to adapt an electronic flash to the underwater camera used, thereby, permitting the use of a narrow lens aperture to assure adequate resolution and depth of focus. Furthermore, the quality of the photographs is enhanced when the flash is near, or on, the camera because shadows are eliminated. The seaweed cover was then removed, sand and silt were scrubbed away, and the crustose corallines and other saxicolous organisms (then clearly visible in the ring) were photographed. The photographs were developed as 9×13 cm color prints on which the area of each algal species was measured with a planimeter. The first photograph of each sample was used to determine the projected or horizontal area covered by each member of the non-crustose community and the second to determine the area of the melobesioids and other crustose organisms. The ring diameter in the photograph provided the scale.

A water-tight case of 6 mm thick plastic (Fig. 4) was specially designed to enclose the compact Suunto "Fast Accuracy" (registered or patented trade name) sighting compass used for measuring the horizontal angles. The accuracy and precision of this compass under rugged field use is reported by Lyons (1967) to be superior to hand

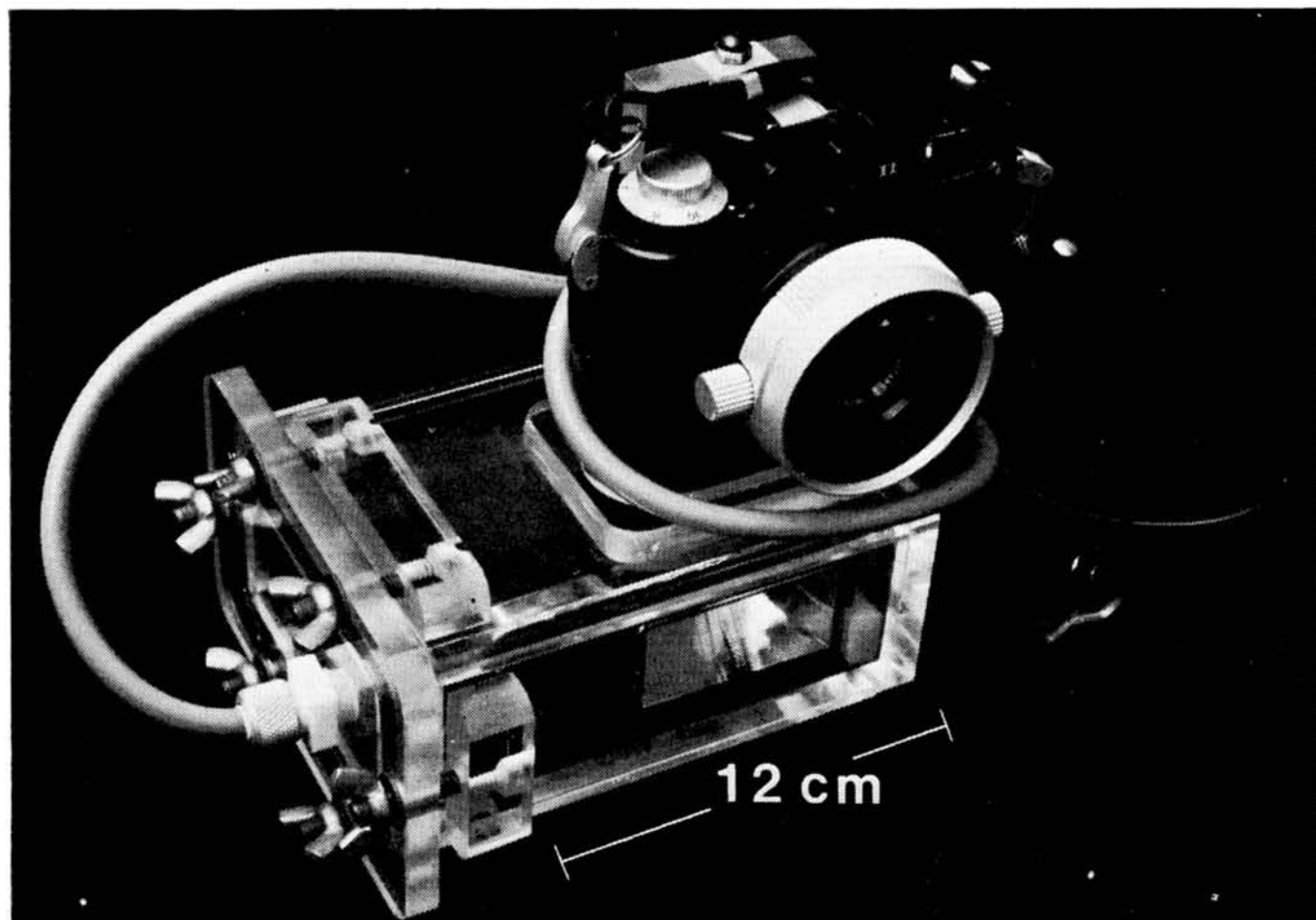


Fig. 3. The underwater housing, strobe and Nikonos camera used in 'photo-sampling'.

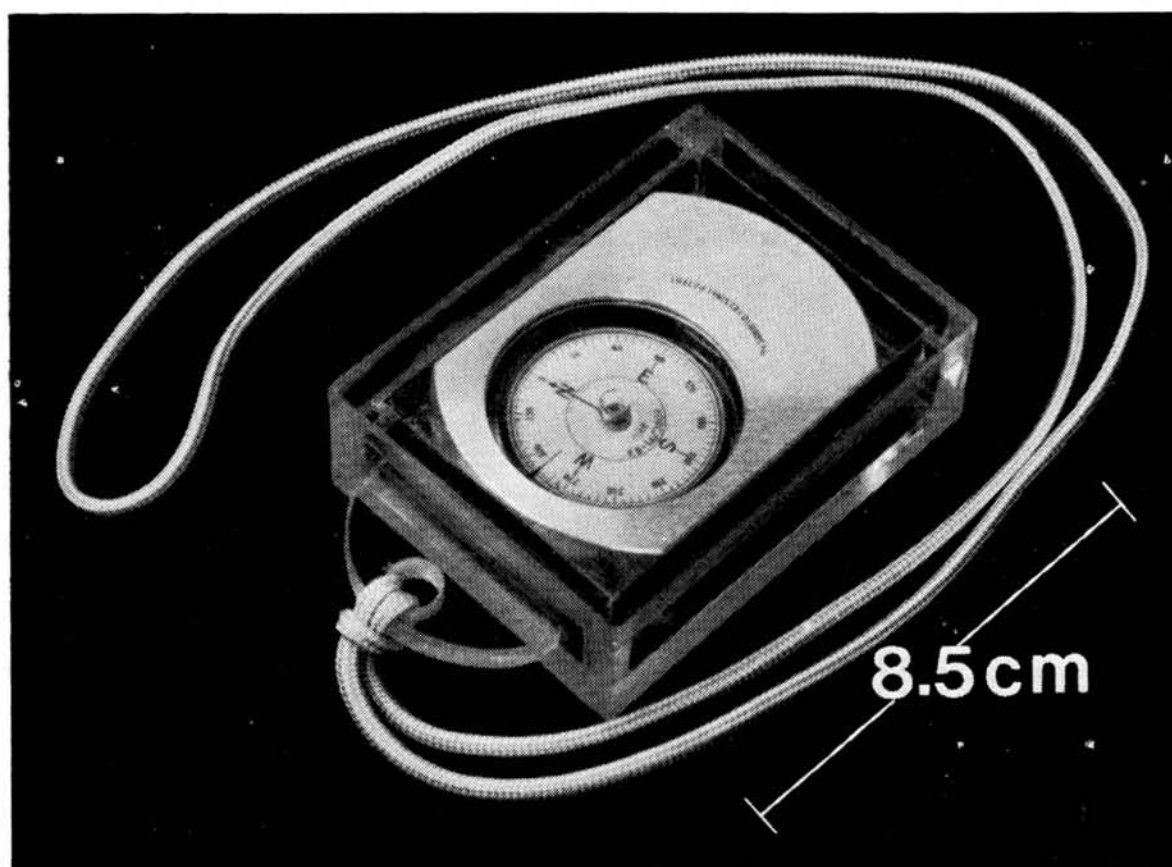


Fig. 4. The Suunto compass and watertight case used for locating the positions of random samples and for laying out the line-transects.

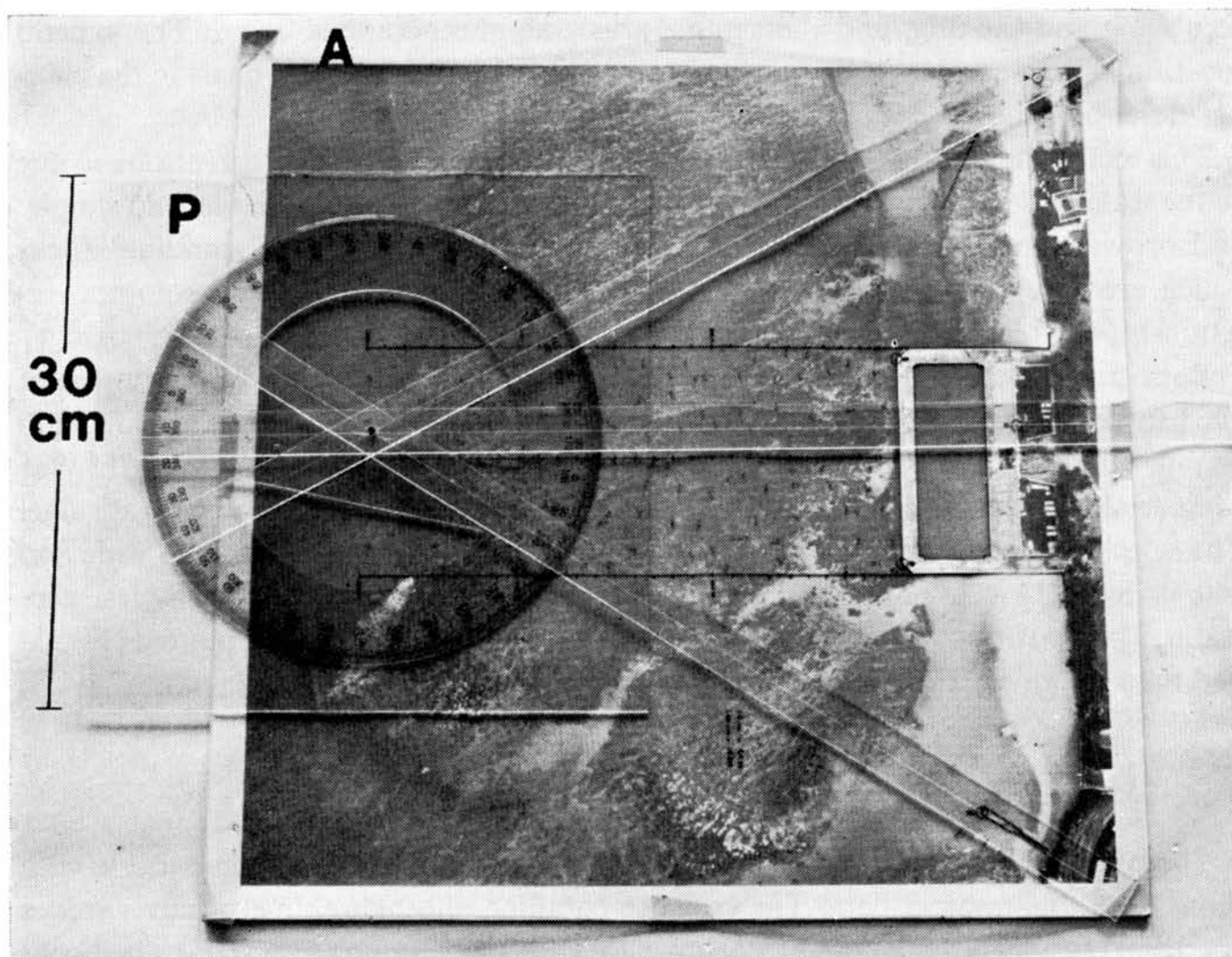


Fig. 5. The three-armed protractor (P) and the aerial photograph (A) used in relocating and plotting sample positions.

transits and costlier instruments. Hand-held, the compass can be read to one fourth of a degree.

Fig. 5 shows the plastic three-armed protractor constructed for locating and plotting the samples taken. In the laboratory, the three angles recorded for each sample were set on the protractor which was then fitted to the corresponding shore reference points on an overlay of the chart or aerial photograph. The sample location at the vertex of the protractor angles was then marked and numbered to correspond with the ring number. Plotting time was approximately 2 min per sample and is nearly as accurate as the much more time-consuming plotting of sample position from a surveyor's transit readings.

At depths greater than 10 m, artificial lighting is indispensable for obtaining photographs suitable for identifying the organisms, and the photogrammetric technique has proved greatly superior to the transect method in such situations because of the limited time one can spend on the bottom, and the difficulty in detecting and making field identifications of crustose species because of altered light quality. The diver, walking or swimming without looking at the substratum, tossed the ring to assure sample randomness. After the initial photograph, the sand and silt were removed by

scrubbing and fanning, and the sample area was photographed again. The general location of deep samples is best plotted from a boat and located on a chart in the manner described above.

This method tends to underestimate cover, since very small thalli are overlooked due to the scale of the photographs. It is, however, relatively accurate, reliable, and simple, and provides an empirical basis for the quantitative estimation of standing stocks which are necessary first steps toward elucidation of the aut- and synecological relationships of reef-building Melobesioideae and other associated organisms.

Both transect and photogrammetric techniques were used during the summer of 1968 to determine melobesioid standing stocks on the fringing reef at Waikiki, Oahu Island, Hawaii. The area selected for detailed analysis extends from the Waikiki War Memorial Natatorium for 280 m across the shallow reef flat through the algal ridge. The selected area was marked off into 14 zones parallel to shore, each 20 m wide and 140 m long. One hundred and twenty-one stratified-random photo-samples were taken. Their positions along with the 84 000 cm of intercepts have been plotted (Fig. 1) and data obtained from these samples are compared in the following section.

RESULTS AND DISCUSSION

The photogrammetric method yielded % cover values (Fig. 6) comparable with those from line-transect data. The crustose coralline photogrammetric cover values (PC) and transect cover values (TC) showed a good correlation ($P = 0.06$); the linear regression of PC on TC is

$$PC = 49.9 \% TC + 1.9 \%$$

As may be seen, the former method gave lower estimates of cover than the latter. Mean coralline cover from the photogrammetric data was 31.9 % and 45.6 % from the transect data. The causes of the discrepancy between the two methods, other than experimental error, are probably two-fold. First, parallax appears to be a major source of error in intercept measurements; the observer encountered extreme difficulty in maintaining a fixed position relative to the transect line while recording in waters affected by waves, surf, and currents. Secondly, as stated above, the photogrammetric method tends to overlook very small thalli that would be included by the line-transect method.

Apart from the 14 % absolute difference (35 % relative difference) the two methods yielded very similar results. The order of abundance in cover of the six major saxicolous organisms was the same when determined by both techniques. In addition, both methods resulted in similar patterns of cover (Fig. 6) for the dominant crustose corallines, with the exception of melobesioid 'C'. As well as estimates of cover, density and frequency are useful criteria for characterizing distributional patterns and community structure and such information is readily extractable from the photogrammetric samples as outlined below.

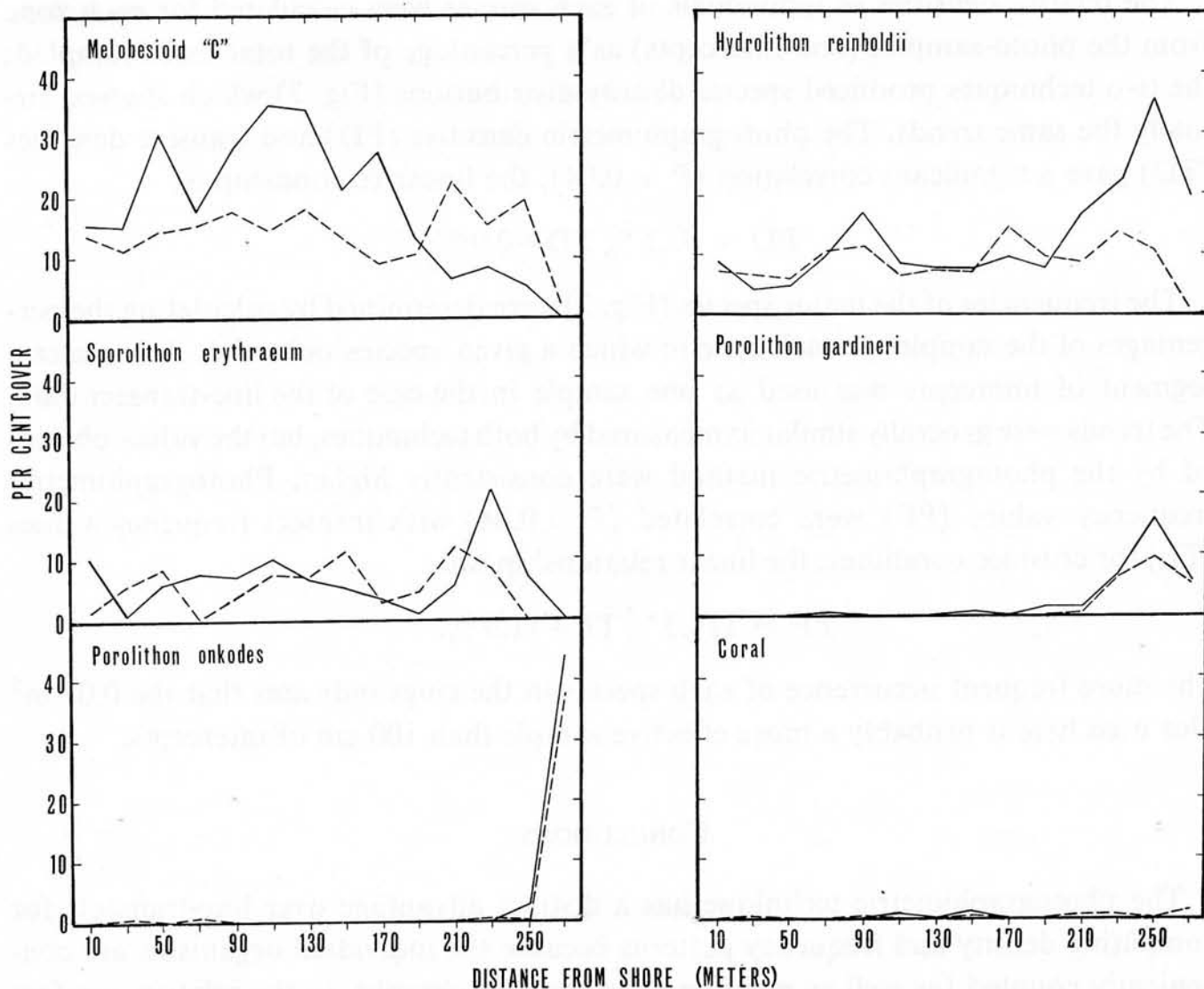


Fig. 6. The quantitative cover of the major saxicolous reef-builders on the Waikiki fringing reef: transect data are plotted as solid lines and photogrammetric data as broken lines.

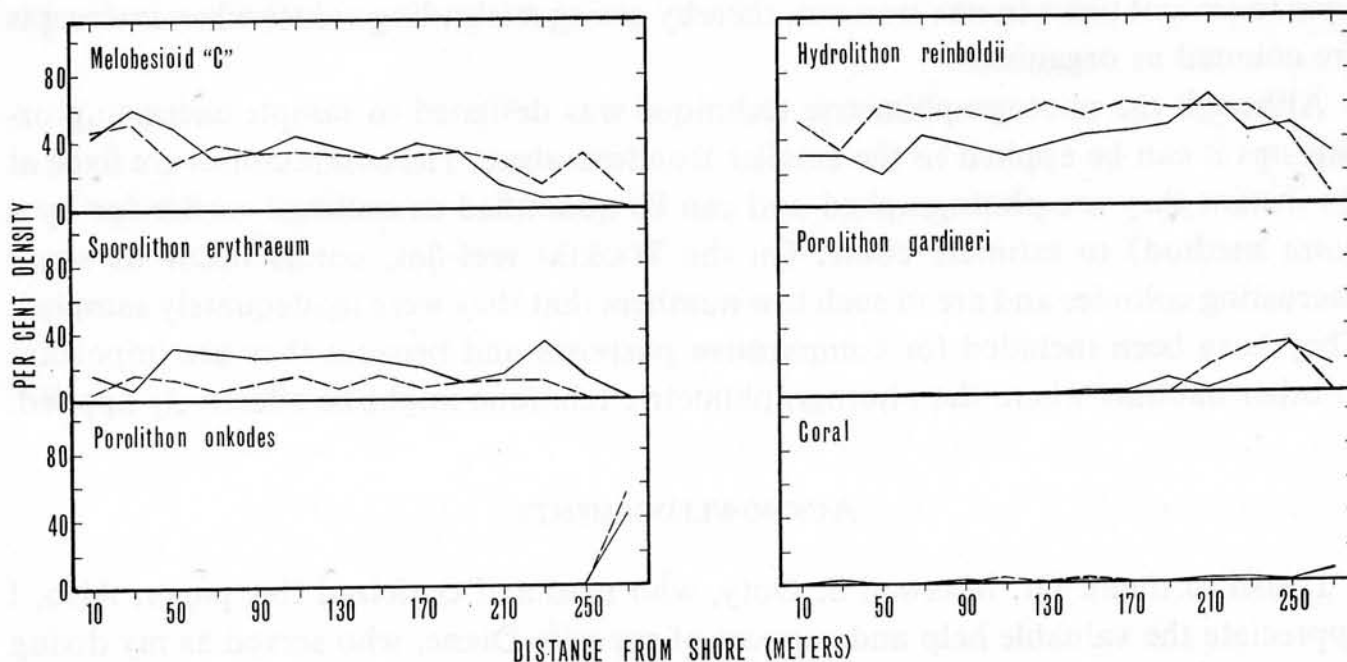


Fig. 7. The relative-density distributions of the major saxicolous reef-builders on the Waikiki fringing reef: transect data are plotted as solid lines and photogrammetric data as broken lines.

The relative densities of individuals of each species were calculated for each zone from the photo-samples (and intercepts) as a percentage of the total thalli sampled; the two techniques produced species density distributions (Fig. 7) which showed virtually the same trends. The photographimetric densities (PD) and transect densities (TD) gave a significant correlation ($P = 0.04$); the linear relationship is,

$$PD = 97.5 \% TD + 0.9 \%$$

The frequencies of the major species (Fig. 2) were determined by calculating the percentages of the samples in each zone in which a given species occurred. A one-metre segment of intercepts was used as one sample in the case of the line-transect data. The trends were generally similar as measured by both techniques, but the values obtained by the photographimetric method were consistently higher. Photographimetric frequency values (PF) were correlated ($P = 0.04$) with transect frequency values (TF) for crustose corallines: the linear relationship was,

$$PF = 116.3 \% TF + 11.9 \%$$

The more frequent occurrence of each species in the rings indicates that the 0.07 m^2 plot used here is probably a more effective sample than 100 cm of intercepts.

CONCLUSIONS

The photographimetric technique has a distinct advantage over line-transects for computing density and frequency patterns because the individual organisms are conveniently counted (as well as measured) on the photographs, in the relative comfort of the laboratory. Numbers of individuals are difficult to include when recording intercepts under field conditions. Also, one organism of irregular shape may be recrossed once to several times in one transect, thereby giving misleading values when intercepts are counted as organisms.

Although the photographimetric technique was designed to sample encrusting organisms it can be applied to the smaller frondose algae. The communities are fixed at the instant they are photographed and can be quantified as outlined earlier (or by a point method) to estimate cover. On the Waikiki reef-flat, corals occur as small encrusting colonies and are in such low numbers that they were inadequately sampled. They have been included for comparative purposes and because they are important in other habitats where the photographimetric technique might be effectively applied.

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