AN EVALUATION OF CORAL REEF SURVEY METHODS BY COMPUTER SIMULATION

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INTRODUCTION

A computer program package has been developed to generate simulated coral distributions on a "reef." These "reefs" can be designed to incorporate variations in species number, size of coral heads of each species, and the position of each species in an "hierarchy of aggression" (Lang, 1973). The output from the reef-generating program gives the location and size of each head as well as information for each species. The species information includes cover, average head size, and variability of head size. These "reefs" with known parameters are then "sampled" using simulations of a number of techniques presently used by reef workers. The methods simulated are the chain link method (Porter, 1972, 1974; Loya, 1972); a line-point method with two sampling intensities: 40 points per 10 m and 20 points per 10 m (Roy and Smith, 1971); a point-quadrat method using 25 uniformly placed points in a $1m^2$ quadrat that is placed at three positions along the 10 m transect line; and a count method that simply counts the heads of each species that fall within the three quadrats.

All of these methods except the quadrat-count technique give cover estimates for each species. From field studies, we ranked the cover estimating methods according to effort. The concept of effort includes the time spent under water counting and the work involved in placing the gear on the reef. From most difficult to easiest they are: chain link, point-quadrat, 40 points, and 20 points. The first question we asked was whether there was enough improvement in accuracy in the use of the more difficult methods to justify the added effort (and hence reduced number of transects that could be run in a given amount of time).

The second question we asked was whether there was a significant quadrat-size effect and, if so, whether differences in the densities of corals in quadrats of differing sizes can be used in determining the dispersion patterns of the corals (Morisita, 1959; Grieg-Smith, 1964). Another measure of dispersion patterns was simulated using a number of nearest-neighbor techniques (Clark and Evans, 1954; Pielou, 1960).

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METHODS

We generated three series of "reefs" in order to study the estimates of coral cover and coral abundance. The reef parameters we varied were cover, head size, and abundance. Keeping any one of these constant and letting the other two vary, we developed three series: (A) cover of each species constant; (B) head size of each species constant (each of the four species had a mean radius two times that of the next smaller species); and (C) relative head size and abundance were constant while the cover was reduced by a factor of two in each of the "reefs" in the series. The reason for these series was to see if the methods were differentially sensitive to species which might have equal cover but which differed in head size and abundance.

In order to evaluate the dispersion estimates, we generated another series of "reefs" that ranged from uniform through random to clumped. This was accomplished by varying head size, order of placement on the reef, and the degree of "aggressiveness" and hence the spacing of the heads.

Three sets of ten transects using each of the transect methods were run on each of the "reefs." The measure of correctness was how many times out of ten the cover estimate was within $\pm$ 20% of the correct cover. A mean and standard deviation of correctness were obtained. The variable sized quadrat method used the entire "reef," so it was actually not a "sampling" method. The sample size of the nearest-neighbor technique had to be variable because of the different numbers of coral heads of each species.

RESULTS

The accuracy of all the methods was quite poor. In no case was the accuracy of a cover estimate greater than seven out of ten and usually it was less than five out of ten; that is, estimates of cover were within $\pm$ 20% of the true value less than five out of ten times. There is a tendency for the smaller, more abundant corals to have their cover estimated more correctly than larger, rarer corals even though both species have equal cover (A "reefs").

At moderate levels of cover all the methods are about equally bad; hence there is little to recommend those methods consuming more time. In addition, utilization of more rapid techniques will allow more transects to be run. While the accuracy of any one of these will be low, the fact that a larger area of the reef under study will be sampled will at least give a more inclusive picture of the reef. If corals are relatively rare (10 to 15% cover), the more time consuming methods do show more sensitivity than the faster techniques. If cover is less than 5%, none of the methods are at all accurate.

The results of the studies on dispersion estimates are less clear. We had no absolute ranking of the dispersion patterns of the corals (see Pielou, 1960), so the differences detected by the methods were not directly testable. However, both methods simulated did rank the species more or less in the way that we predicted, with effects of "aggression" increasing uniformity, and small size combined with last choice of position on the reef causing aggregations. In addition, we had no field information comparable to our studies on cover estimates on the difficulties of the use of the dispersion estimates under water. We are, however, satisfied, that our simulations are reasonable approaches to the actual field techniques.

CONCLUSIONS

When coral species are relatively abundant or have high cover there is little to recommend the more laborious and time consuming sampling methods. In fact, the faster methods are to be preferred, because more transects can be run in the same amount of time--covering a wider area of the reef, thus improving reliability if not accuracy. When species are moderately rare, the more time consuming methods may be justified, and when species are uncommon only very extensive work would be expected to give reasonably accurate results anyway. We are preparing documentation for this program package and will make it available to interested parties. A more detailed discussion of the programs and an extended analysis of the results is presented elsewhere (Kinzie and Snider, in press).

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