

Contributed Papers

Chairman : Mr. P. C. Bull.

The Sampling Problem, with particular reference to Marine Organisms

R. Morrison Cassie

INTRODUCTION

This paper is headed "*The Sampling Problem . . .*" because it deals with the type of phenomena which are observed when we try to estimate the number of organisms in a population or community. Often the pattern in space is so complex that difficulties are met in making such an estimate. The appropriate statistical methods are dealt with in text-books, but the fundamental reasons behind these problems are not so well understood as yet.

A marine ecologist has a more mobile population to deal with than, say, a plant ecologist and perhaps for this reason there has been a tendency to be preoccupied with field technique without many fundamental changes in outlook. However, recent technical advances such as underwater television, the aqualung, and the sonic detector may put the marine biologist in a position to contribute some new ideas of his own to ecology in general.

THE PATTERN OF SPATIAL DISTRIBUTION

One of the simplest assumptions which can be made as to the pattern formed by organisms in space is that they are randomly distributed. In practice randomness is fairly uncommon, the usual pattern being an "aggregated" one in which organisms tend to cluster in certain regions. This creates a problem in sampling because so many of the samples may fall by chance in the blank or nearly blank spaces between the clusters. Such a case was found on the toheroa beds at Muriwai. It was calculated that if 20

sample plots were dug at random on the beach there was an even chance that no toheroa would be found in any of them (Cassie, 2). If they had been randomly distributed nearly every sample would have had at least one toheroa.

REASONS FOR AGGREGATION

Sometimes the reason for aggregation is obvious. Shade loving plants cluster in shady niches. Young animals like to stay near their parents. On the other hand there is no obvious reason why fully grown plankton should not to be randomly distributed, since there seem to be no specially favourable niches in the ocean. Winsor and Clarke (5) conducted some experiments which suggested that plankton were aggregated, but concluded that this was a spurious effect due to variations in the volume of water filtered by their nets. Barnes and Marshall (1) repeated these experiments using a water pump and controlling the volume filtered. Even so aggregation was still apparent. This suggests that some of the anomalous variations which have been blamed on plankton nets are real after all, and that the expensive water meters on many modern nets may be unnecessary.

MATHEMATICAL MODELS

The random distribution can be described by a simple mathematical expression or "model" known as the Poisson series. There have been various attempts to find a model for aggregated distributions. For instance, Taylor (4) has fitted a negative binomial series to the numbers of fish taken in

standardized trawl catches. Often, however, the biologist after finding a model which "works" is at a loss to say *why* it works. In the following remarks a tentative explanation is given for one such model.

NON-HOMOGENEITY OF WATER MASSES

There has been a tendency to assume that sea water is a homogeneous environment. However, Liebermann (3) has shown in quite extensive oceanic observations from a submarine that small-scale fluctuations in temperature over distances as small as two feet are almost invariably found. Figure 1 is a temperature record taken near the floating dock in Wellington Harbour, showing similar though somewhat exaggerated fluctuations in inshore water.

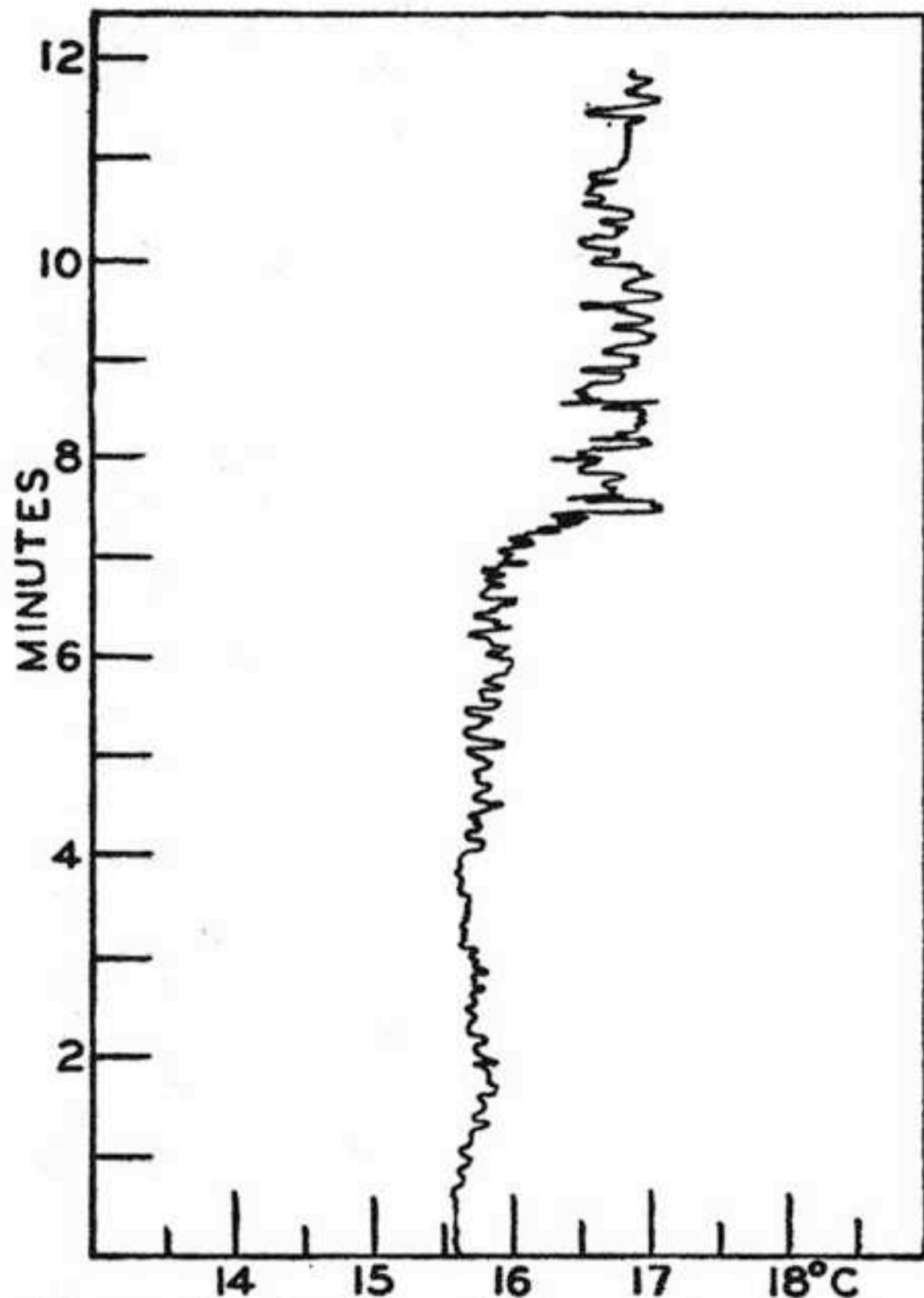


Figure 1. Rapid variation of temperature with time.

Although much work has been done on a geographic scale to correlate plankton with temperature and other physical variables, I know of only one where this has been done

on a relatively small spatial scale. Barnes and Marshall (1) give some data in which the pattern of plankton distribution is very similar to the salinity pattern. I have calculated the actual correlations and found they are nearly all significant (some highly significant), but that an even higher correlation is obtained if the logarithm rather than the actual number of organisms is used.

THE LOG-NORMAL MODEL

It has been known for some time that many aggregated distributions would fit the bell-shaped normal (or Gaussian) curve if they were first transformed to logarithms. Fig. 2 shows two sets of plankton counts from Wellington Harbour. The raw data on the left are skew, but the logarithmic data on the right resemble closely the normal distribution. The counts are thus said to be log-normally distributed.

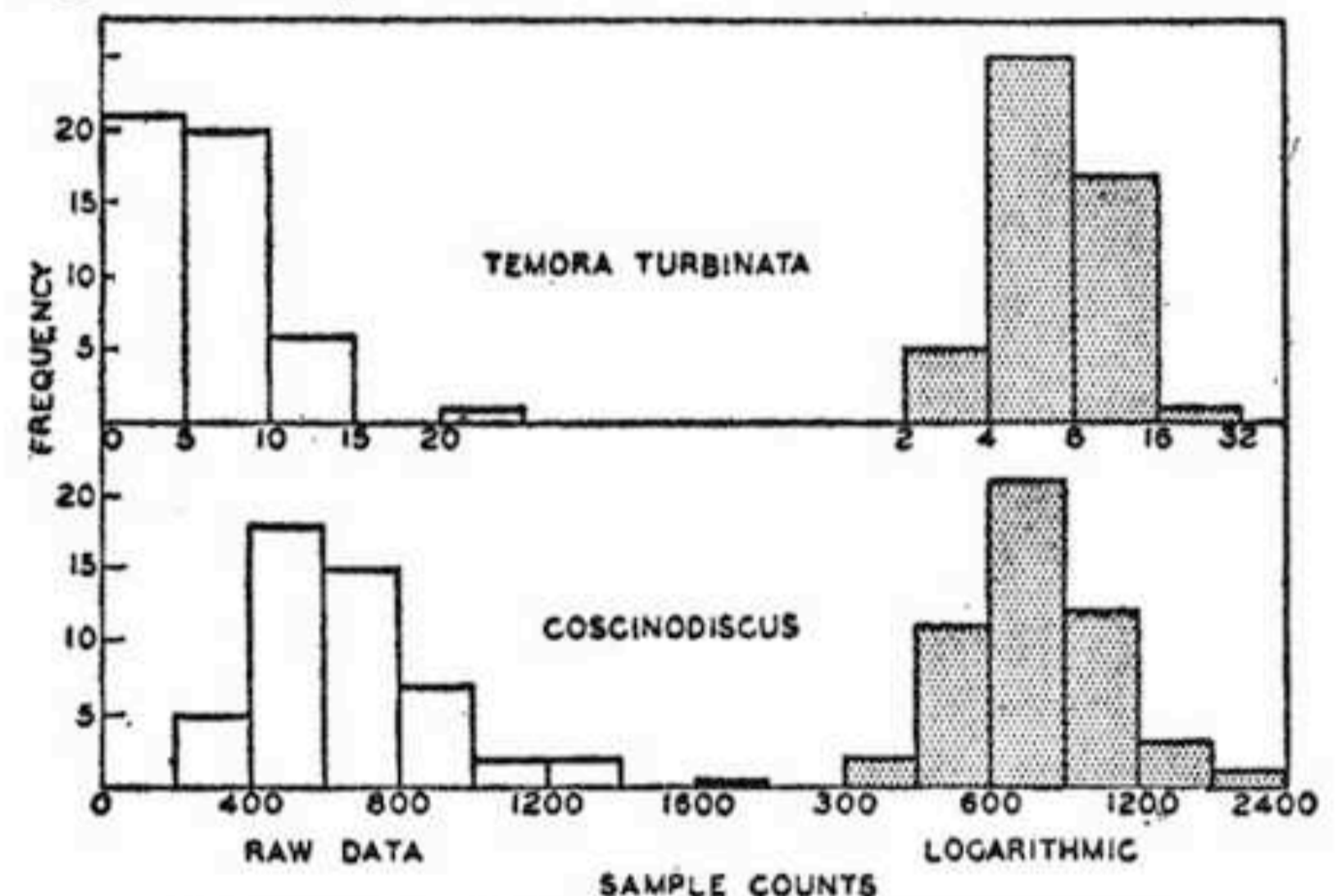


Figure 2. Examples of log-normal distributions.

The fact that logarithms were used, both in this case and with Barnes' data suggests some connection between the two examples. If we assume that individual plankton tend to migrate to regions of favourable salinity and that the salinity itself is normally distributed, the result will be a log-normal distribution of organisms. In fact, salinity and other physical variables are not necessarily normally distributed, but they are often sufficiently nearly so to give a close, if not exact, resemblance to the log-normal model.

This is one line of investigation where I believe plankton research may contribute some fundamental concepts to ecology. It is admittedly a tedious task to make repeated determinations of the many variable physical

properties of sea-water, but nearly all of them *can* be determined, a task which is well-nigh impossible in most other environments.

PROPOSED EXPERIMENTAL WORK

An apparatus is being developed which will pump and filter the plankton from measured volumes of sea water, and at the same time make a continuous record of temperature and salinity. Undoubtedly other physical variables will be involved, but already a number of interesting correlations are being found which it is hoped will eventually lead to further understanding of the spatial distribution problem.

REFERENCES

- (1) BARNES, H. and S. M. MARSHALL, 1951: *J. Mar. Biol. Ass. U.K.* 30: 233-263.
- (2) CASSIE, R. M., 1955: *Aust. J. Mar. Freshw. Res.* 6: 348-391.
- (3) LIEBERMANN, L., 1951: *J. Acoust. Soc. Amer.* 23: 563-570.
- (4) TAYLOR, C. C., 1953: *Fish. Bull., U.S.* 83: 145-166.
- (5) WINSOR, C. P. and G. L. CLARKE, 1940: *J. Mar. Res.* 3: 1-34.

DISCUSSION

DR. R. M. WILLIAMS said that various distributions that are not normally negative binomial have a mathematical background, e.g., the number of insects jumping onto a leaf will be in proportion to the number already there. Ecologists should be aware

that there are a number of reasonable mathematical models such as the model worked out for aphids. There could be all kinds of non-normal distributions which could be transformed to normal distributions by the use of mathematical models.

K. R. ALLEN said there were two basic types of explanation of non-normal distribution, one purely in the behaviour of the organisms themselves, e.g. the number of insects jumping on a leaf is affected by the numbers already there, the other, where distribution is affected by a non-uniform environment. The second type may approximate to the negative binomial distribution if organisms are randomly distributed in an environment in which the particular determining characteristic is also randomly distributed.

MR. CASSIE said there were causal reasons which could generate negative binomials. Biologists could not see any reason behind legitimate mathematical models because their ideas could not be fitted in with those of mathematicians. Another model worth exploring is provided by the known laws of diffusion from some focal point.

DR. WILLIAMS said the exact mechanism which could explain distribution should be considered and mentioned the case of rabbit droppings (e.g. in damp grass, which caused quicker decay).

Autecology and the New Zealand Flora

Barbara Croker

In the investigation and description of our native and introduced plant communities we are reaching the stage when there is need for more detailed knowledge of the actual species—that is their autecology. In his presidential address to the British Ecological Society Clapham (1956) pointed out that "it is the primary concern of a plant ecologist to explain why a plant of this species and not of that is growing in a given spot."

The New Zealand flora affords plenty of scope for autecological studies among the endemic species, monotypic genera, species

of diverse life forms such as cushion plants, lianes and epiphytes and those with distinct juvenile and adult forms; but very few such studies have been published. Various aspects of the growth and ecology of the *Nothofagus* species have been admirably dealt with by Pool and Holloway, but there is very little of this type of information on the podocarps or other species of the subtropical rainforest and the symposium at the last meeting of this society emphasised the gaps in our knowledge of the life-cycle and growth of the species of the tussock grassland.