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# MARK-RECAPTURE—WHAT NEXT?

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ABSTRACT.—The direction in which mark-recapture methods are likely to develop in the immediate future is discussed briefly. More sophisticated models are envisaged which will approximate more closely to real-life situations, and the biologist has an important role to play in helping the statistician to define these. A hypothetical example is used to illustrate.

A reading of Seber (1973) shows mark-recapture as having developed originally around insect populations. For example, it is commonly assumed that ages of individuals cannot be determined, that survival is independent of age, and that birth or immigration has no known distribution over time. With birds or mammals these assumptions may all be false, and the additional information on age and birth processes requires more complex models than have been available in the past. Movement patterns may also be of interest. Brownie and Robson (1976) is one of many examples of the need to create specific models for specific situations.

An excellent review of recent developments in mark-recapture with reference to avian populations is given by Nichols et al. (1981).

## A HYPOTHETICAL BANDING STUDY

### DESCRIPTION

Let us consider the imaginary goose (*Anser mysticus*) which, though rare, is plentiful on certain remote Arctic islands on one of which, called $S$, banding has taken place as convenient towards the end of the breeding season for the last three years. The population on $S$ is heterogeneous, consisting of at least two intermingling segments, $S1$ and $S2$. Both young and adult are banded in an intensive effort over a two-month period.

Segments $S1$ and $S2$ migrate to their winter residences at the same time, $S1$ to an island, $W1$, where banded birds are observed and some further banding occurs, and $S2$ to a rocky island, $W2$, where banding or close observation are considered impracticable on account of landing difficulties. Some data are also available from injured or resting birds on a small island situated on the migratory route of $S1$. Invariably the $S1$ segment return to their summer residence before $S2$ and, among these earlier arrivals, some birds have been consistently observed that have never been found on $W1$. This suggests the possibility of yet another, unknown wintering area.

The aim of the study is to assess population numbers and movements as well as to estimate survival rates. It is therefore desirable to extend the survey to include all segments of the population of *Anser mysticus* and so obtain an integrated picture of the species' behaviour. In the current year, $S1$ and $S2$ have been augmented by an influx from a neighbouring island. Virtually the complete, unknown population of this island is thought to have left in response to industrial developments. The number of these arriving to join $S1$ and $S2$ will be estimated. Since the species is strictly protected most of the data are from observations on live birds (banded or otherwise), but information on dead birds discovered will also be utilized. An attempt may also be made to initiate a small sampling scheme on $W2$.

### ASSUMPTIONS AND PROBLEMS

The following include the main initial assumptions, but these will be continually monitored as data accumulate.

*Randomness.*—At present data on $S$ are taken only from the few large concentrations of birds. A quarter to a third of the population however occur in smaller pockets. In the future sampling of these pockets will be undertaken but at a low intensity since banding there will be less cost-effective. Policy thereafter will depend on how representative is the main sample and how much information is lost if birds banded on $W1$ and spending the summer in these pockets are not recorded.

*Segments.*—Different yearly survival rates will be assumed for each segment but the same survival rate will be regarded as applicable during the summer period when the birds are together on $S$. Equal probability of capture will be assumed for all segments.

*Sex.*—Yearly survival could be different for male and female except possibly during the summer period. Probability of capture is unlikely to be associated with sex.

*Age.*—Up to four age classes can be determined approximately. Exact age will be used for birds banded in their first year. An age-survival curve will be estimated. Although young and old are likely to have the same chance of being netted while the birds are immobile, there may be circumstances when a greater proportion of immature birds are caught.

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## DISCUSSION

Over a thousand birds have been banded during the last three years at moderate cost. To avoid over-interference with the population on *S* it is thought desirable to limit the effort there while extending the study to other localities as already mentioned.

Fully efficient methods of analysis will be used, and these will be modified as necessary to take account of changes in assumptions. Whenever possible the number of parameters must be reduced to give maximum precision, as, for example, when survival and probability of capture are assumed constant over the two-month banding period (Jolly, 1981a). No general model is yet available to allow for varying probability of capture among individuals in open populations, although Burnham and Overton (1978) give a method for closed populations.

## CONCLUSIONS

The above example is intended to illustrate some of the theoretical and practical problems that can arise in a mark-recapture study. Wherever possible the aim of the investigator should be to simplify the assumptions over which he can exercise some control, in particular equal catchability over time or among classes of individuals. When this is not possible a model should be defined to take account of the facts.

At present the many recent developments have not yet had time to be sufficiently co-ordinated to enable data from the above hypothetical example to be analysed exactly as envisaged, and some further theory is still required. However, within a few years it should, in the author's opinion, be possible to have comprehensive computer programs incorporating an ever increasing range of theoretical flexibility and coming gradually closer to biological and technical reality.