1回放流の標識再捕試験におけるモデル選択

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Short Paper

Model Selection of Single Release Tagging Studies: The Effect of Natural Mortality

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Kitada and Shiota[1] studied the mortality of swimming crab *Portunus trituberculatus* MEIRS from tag recoveries. They obtained maximum likelihood estimates and standard errors of the fishing mortality coefficient F and the total mortality coefficient Z. The estimates of F and Z (denoted by $\hat{F}$ and $\hat{Z}$) were 0.0055/day and 0.0071/day, respectively, and standard errors of $\hat{F}$ and $\hat{Z}$ were 0.0011 and 0.0061, respectively. Accordingly, the estimate of natural mortality coefficient M ($\hat{M}=\hat{Z}-\hat{F}$) is smaller than $\hat{F}$ and the variance of $\hat{M}$,

$$V[\hat{M}]=V[\hat{Z}]+V[\hat{F}]-2\,Cov[\hat{Z},\hat{F}]\,, \qquad (1)$$

may be very large. It suggests that the natural mortality did not affect the swimming crab population.

In order to study the effect of the natural mortality on the data analysis, we consider the following two multinomial models:

model 1: the model with F and M (the standard model),

model 2: the model without M.

The likelihood function of the models is given by

$$L=\frac{N!}{(N-n)!\cdot\prod_{t=1}^{u} n_t!}\prod_{t=1}^{u} P_t^{n_t}\cdot\left(1-\sum_{t=1}^{u} P_t\right)^{N-n}\,, \qquad (2)$$

where

N: total number of released animals

n: total number of recoveries until time u

n_t: the number of recoveries at time t $(t=1, 2, \cdots, u)$

u: the censoring time of observation,

and

$$P_i=\frac{F}{F+M}(1-\exp(-F-M))\times\exp(-(F+M)\cdot(i-1))\,, \qquad (3)$$

for model 1, and

$$P_i=(1-\exp(-F))\exp(-F\cdot(i-1))\,, \qquad (4)$$

for model 2.

AIC (Akaike Information Criterion) is used to judge the model performance and parsimony.[2] The model with minimum AIC is the most likely model. Maximum likelihood estimates of F and M are numerically obtained. Standard errors of the estimates are also numerically obtained from the information matrix. The estimates and AIC values indicate that the natural mortality of adult swimming crab for this period is negligible compared with the fishing mortality and hence it is desirable to use model 2 for this data (Table 1). Other information is necessary for the precise estimation of the natural mortality.

It should be pointed out that the standard error of $\hat{F}$ is reduced using model 2. The choice of model may make a substantial difference in estimates of standard errors. Although Kitada and Shiota[1] described that the large variance estimate of $\hat{Z}$ was due to the varying daily recoveries, it should be considered that the unnecessary parameter M leads to this large variance.

References

1) S. Kitada and K. Shiota: *Nippon Suisan Gakkaishi*, **56**, 1449–1453 (1990).

2) Y. Sakamoto, M. Ishiguro, and G. Kitagawa: Akaike Information Criterion Statistics, KTK Scientific Publishers, Tokyo, 1986, p. 290.

Table 1. Parameter estimates, standard errors, and AIC values for models 1 and 2

Model	$\hat{F}$ (/day)	SE[$\hat{F}$] (/day)	$\hat{Z}$ (/day)	SE[$\hat{Z}$] (/day)	$\hat{M}$ (/day)	SE[$\hat{M}$] (/day)	AIC
1	0.0055	0.0011	0.0071	0.0061	0.0016	0.0052	201.03
2	0.0053	0.0006	—	—	—	—	199.12

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