Mark-recapture lab

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Question 1

The Lincoln-Peterson estimate of abundance is N=200.

```
n1<-100
n2<-50
m2<-25

N<-n1*n2/m2
N
```

```
## [1] 200
```

Models

```
require(mra)
```

```
## Loading required package: mra
```

```
## mra (version 2.16.11)
```

```
#M0 model
M0 <- F.huggins.estim(capture=~1, recapture=NULL, histories=ch.mat)
M0
```

```
## Call:
## F.huggins.estim(capture = ~1, recapture = NULL, histories = ch.mat)
##
##  Capture and Recapture model:
##  Variable     Est       SE
##  (Intercept)  -2.37255  0.49911
##
## Population Size Estimate (se): 41.0364 (16.6626)
## 95% confidence interval for population size: 24.04 to 99.05
## Individuals observed: 17
## Effective sample size: 102
##
## Message =  SUCCESS: Convergence criterion met
## Number of estimable coefficients (estimated) =  1
## Log likelihood =  -43.9354578026216
## Deviance =  87.8709156052432
## AIC =  89.8709156052432
## AICc =  89.9109156052432
```

```
round(M0$p.hat, digits=3)
```

```
##        [,1]  [,2]  [,3]  [,4]  [,5]  [,6]
##  [1,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [2,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [3,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [4,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [5,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [6,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [7,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [8,] 0.085 0.085 0.085 0.085 0.085 0.085
##  [9,] 0.085 0.085 0.085 0.085 0.085 0.085
## [10,] 0.085 0.085 0.085 0.085 0.085 0.085
## [11,] 0.085 0.085 0.085 0.085 0.085 0.085
## [12,] 0.085 0.085 0.085 0.085 0.085 0.085
## [13,] 0.085 0.085 0.085 0.085 0.085 0.085
## [14,] 0.085 0.085 0.085 0.085 0.085 0.085
## [15,] 0.085 0.085 0.085 0.085 0.085 0.085
## [16,] 0.085 0.085 0.085 0.085 0.085 0.085
## [17,] 0.085 0.085 0.085 0.085 0.085 0.085
```

```
#Mb model
Mb <- F.huggins.estim(capture=~1, recapture=~1, histories=ch.mat)
Mb
```

```
## Call:
## F.huggins.estim(capture = ~1, recapture = ~1, histories = ch.mat)
##
##  Capture Model   Est       SE           Recapture Model   Est       SE
##  (Intercept)     -0.67847  0.48712      C:(Intercept)     -0.67847  0.48712(fixed)
##                                         B:(Intercept)     -1.97829  0.71051
##
## Population Size Estimate (se): 18.5841 (2.1527)
## 95% confidence interval for population size: 17.21 to 28.76
## Individuals observed: 17
## Effective sample size: 102
##
## Message =  SUCCESS: Convergence criterion met
## Number of estimable coefficients (estimated) =  2
## Log likelihood =  -41.6092532319818
## Deviance =  83.2185064639637
## AIC =  87.2185064639637
## AICc =  87.3397185851758
```

```
round(Mb$p.hat, digits=3)
```

```
##        [,1]  [,2]  [,3]  [,4]  [,5]  [,6]
##  [1,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [2,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [3,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [4,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [5,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [6,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [7,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [8,] 0.337 0.337 0.337 0.337 0.337 0.337
##  [9,] 0.337 0.337 0.337 0.337 0.337 0.337
## [10,] 0.337 0.337 0.337 0.337 0.337 0.337
## [11,] 0.337 0.337 0.337 0.337 0.337 0.337
## [12,] 0.337 0.337 0.337 0.337 0.337 0.337
## [13,] 0.337 0.337 0.337 0.337 0.337 0.337
## [14,] 0.337 0.337 0.337 0.337 0.337 0.337
## [15,] 0.337 0.337 0.337 0.337 0.337 0.337
## [16,] 0.337 0.337 0.337 0.337 0.337 0.337
## [17,] 0.337 0.337 0.337 0.337 0.337 0.337
```

```
round(Mb$c.hat, digits=3)
```

```
##       [,1]  [,2]  [,3]  [,4]  [,5]  [,6]
##  [1,]   NA 0.066 0.066 0.066 0.066 0.066
##  [2,]   NA 0.066 0.066 0.066 0.066 0.066
##  [3,]   NA 0.066 0.066 0.066 0.066 0.066
##  [4,]   NA 0.066 0.066 0.066 0.066 0.066
##  [5,]   NA 0.066 0.066 0.066 0.066 0.066
##  [6,]   NA 0.066 0.066 0.066 0.066 0.066
##  [7,]   NA 0.066 0.066 0.066 0.066 0.066
##  [8,]   NA 0.066 0.066 0.066 0.066 0.066
##  [9,]   NA 0.066 0.066 0.066 0.066 0.066
## [10,]   NA 0.066 0.066 0.066 0.066 0.066
## [11,]   NA 0.066 0.066 0.066 0.066 0.066
## [12,]   NA 0.066 0.066 0.066 0.066 0.066
## [13,]   NA 0.066 0.066 0.066 0.066 0.066
## [14,]   NA 0.066 0.066 0.066 0.066 0.066
## [15,]   NA 0.066 0.066 0.066 0.066 0.066
## [16,]   NA 0.066 0.066 0.066 0.066 0.066
## [17,]   NA 0.066 0.066 0.066 0.066 0.066
```

```
#Mt model
time <- tvar(factor(1:6), nan=nrow(ch.mat)) ## 6 time periods. 14 animals.
Mt <- F.huggins.estim(capture=~time, recapture=NULL, histories=ch.mat)
Mt
```

```
## Call:
## F.huggins.estim(capture = ~time, recapture = NULL, histories = ch.mat)
##
##  Capture and Recapture model:
##  Variable     Est        SE
##  (Intercept)  -1.66753   0.64342
##  time:2       -0.78331   0.74956
##  time:3       0.18611    0.6113
##  time:4       -1.21711   0.85368
##  time:5       -0.78331   0.74956
##  time:6       -31.02057  268608.00057
##
## Population Size Estimate (se): 37.7944 (14.7706)
## 95% confidence interval for population size: 22.94 to 89.78
## Individuals observed: 17
## Effective sample size: 102
##
## Message =  SUCCESS: Convergence criterion met
## Number of estimable coefficients (estimated) =  5
## Log likelihood =  -37.42450409473
## Deviance =  74.8490081894601
## AIC =  84.8490081894601
## AICc =  85.4740081894601
```

```
round(Mt$p.hat, digits=3)
```

```
##        [,1]  [,2]  [,3]  [,4]  [,5] [,6]
##  [1,] 0.159 0.079 0.185 0.053 0.079    0
##  [2,] 0.159 0.079 0.185 0.053 0.079    0
##  [3,] 0.159 0.079 0.185 0.053 0.079    0
##  [4,] 0.159 0.079 0.185 0.053 0.079    0
##  [5,] 0.159 0.079 0.185 0.053 0.079    0
##  [6,] 0.159 0.079 0.185 0.053 0.079    0
##  [7,] 0.159 0.079 0.185 0.053 0.079    0
##  [8,] 0.159 0.079 0.185 0.053 0.079    0
##  [9,] 0.159 0.079 0.185 0.053 0.079    0
## [10,] 0.159 0.079 0.185 0.053 0.079    0
## [11,] 0.159 0.079 0.185 0.053 0.079    0
## [12,] 0.159 0.079 0.185 0.053 0.079    0
## [13,] 0.159 0.079 0.185 0.053 0.079    0
## [14,] 0.159 0.079 0.185 0.053 0.079    0
## [15,] 0.159 0.079 0.185 0.053 0.079    0
## [16,] 0.159 0.079 0.185 0.053 0.079    0
## [17,] 0.159 0.079 0.185 0.053 0.079    0
```

```
round(Mt$c.hat, digits=3)
```

```
##       [,1]  [,2]  [,3]  [,4]  [,5] [,6]
##  [1,]   NA 0.079 0.185 0.053 0.079    0
##  [2,]   NA 0.079 0.185 0.053 0.079    0
##  [3,]   NA 0.079 0.185 0.053 0.079    0
##  [4,]   NA 0.079 0.185 0.053 0.079    0
##  [5,]   NA 0.079 0.185 0.053 0.079    0
##  [6,]   NA 0.079 0.185 0.053 0.079    0
##  [7,]   NA 0.079 0.185 0.053 0.079    0
##  [8,]   NA 0.079 0.185 0.053 0.079    0
##  [9,]   NA 0.079 0.185 0.053 0.079    0
## [10,]   NA 0.079 0.185 0.053 0.079    0
## [11,]   NA 0.079 0.185 0.053 0.079    0
## [12,]   NA 0.079 0.185 0.053 0.079    0
## [13,]   NA 0.079 0.185 0.053 0.079    0
## [14,]   NA 0.079 0.185 0.053 0.079    0
## [15,]   NA 0.079 0.185 0.053 0.079    0
## [16,]   NA 0.079 0.185 0.053 0.079    0
## [17,]   NA 0.079 0.185 0.053 0.079    0
```

```
#Mtb model
Mtb <- F.huggins.estim(capture=~time, recapture=~1, histories=ch.mat)
Mtb
```

```
## Call:
## F.huggins.estim(capture = ~time, recapture = ~1, histories = ch.mat)
##
##  Capture Model   Est        SE               Recapture Model   Est        SE
##  (Intercept)     -0.96169   0.96236          C:(Intercept)     -0.96169   0.96236     (fixed)
##  time:2          -0.62584   0.84758          C:time:2          -0.62584   0.84758     (fixed)
##  time:3          0.66289    1.23518          C:time:3          0.66289    1.23518     (fixed)
##  time:4          -0.67604   1.49986          C:time:4          -0.67604   1.49986     (fixed)
##  time:5          -0.13542   1.69741          C:time:5          -0.13542   1.69741     (fixed)
##  time:6          -31.22411  122955.34396     C:time:6          -31.22411  122955.34396(fixed)
##                                              B:(Intercept)     -1.23793   2.07832
##
## Population Size Estimate (se): 21.6967 (13.1183)
## 95% confidence interval for population size: 17.26 to 101.55
## Individuals observed: 17
## Effective sample size: 102
##
## Message =  SUCCESS: Convergence criterion met
## Number of estimable coefficients (estimated) =  6
## Log likelihood =  -37.3456782098957
## Deviance =  74.6913564197915
## AIC =  86.6913564197915
## AICc =  87.5755669461072
```

```
round(Mtb$p.hat, digits=3)
```

```
##        [,1] [,2]  [,3]  [,4] [,5] [,6]
##  [1,] 0.277 0.17 0.426 0.163 0.25    0
##  [2,] 0.277 0.17 0.426 0.163 0.25    0
##  [3,] 0.277 0.17 0.426 0.163 0.25    0
##  [4,] 0.277 0.17 0.426 0.163 0.25    0
##  [5,] 0.277 0.17 0.426 0.163 0.25    0
##  [6,] 0.277 0.17 0.426 0.163 0.25    0
##  [7,] 0.277 0.17 0.426 0.163 0.25    0
##  [8,] 0.277 0.17 0.426 0.163 0.25    0
##  [9,] 0.277 0.17 0.426 0.163 0.25    0
## [10,] 0.277 0.17 0.426 0.163 0.25    0
## [11,] 0.277 0.17 0.426 0.163 0.25    0
## [12,] 0.277 0.17 0.426 0.163 0.25    0
## [13,] 0.277 0.17 0.426 0.163 0.25    0
## [14,] 0.277 0.17 0.426 0.163 0.25    0
## [15,] 0.277 0.17 0.426 0.163 0.25    0
## [16,] 0.277 0.17 0.426 0.163 0.25    0
## [17,] 0.277 0.17 0.426 0.163 0.25    0
```

```
round(Mtb$c.hat, digits=3)
```

```
##       [,1]  [,2]  [,3]  [,4]  [,5] [,6]
##  [1,]   NA 0.056 0.177 0.053 0.088    0
##  [2,]   NA 0.056 0.177 0.053 0.088    0
##  [3,]   NA 0.056 0.177 0.053 0.088    0
##  [4,]   NA 0.056 0.177 0.053 0.088    0
##  [5,]   NA 0.056 0.177 0.053 0.088    0
##  [6,]   NA 0.056 0.177 0.053 0.088    0
##  [7,]   NA 0.056 0.177 0.053 0.088    0
##  [8,]   NA 0.056 0.177 0.053 0.088    0
##  [9,]   NA 0.056 0.177 0.053 0.088    0
## [10,]   NA 0.056 0.177 0.053 0.088    0
## [11,]   NA 0.056 0.177 0.053 0.088    0
## [12,]   NA 0.056 0.177 0.053 0.088    0
## [13,]   NA 0.056 0.177 0.053 0.088    0
## [14,]   NA 0.056 0.177 0.053 0.088    0
## [15,]   NA 0.056 0.177 0.053 0.088    0
## [16,]   NA 0.056 0.177 0.053 0.088    0
## [17,]   NA 0.056 0.177 0.053 0.088    0
```

```
# create HTML table using kableExtra
library(kableExtra)
# create HTML table using kableExtra
library(kableExtra)
require(knitr)

Model<-(c("M0", "Mt", "Mb", "Mtb"))
Model_Description<-(c("The most basic model in which p and c are constant", "p differs among sampling occ
asions and pt = ct", "Behavioral response model in which p and c differ.", "Combination of models Mt and
 Mb"))
N<-(c(41.03, 37.79,18.58, 21.70))
SE<-(c(16.66, 14.77, 2.15, 13.12))
AICc<-(c(89.91, 85.47, 87.34, 87.58))
tab<-data.frame(Model,Model_Description,N,SE,AICc)


#table
options(knitr.kable.NA = "") # leave NA cells empty
knitr::kable(tab, digits = 3,booktabs=T, align="c",
      caption = "<center><strong>Table 1. Results for mark-recapture analysis for stink pots.</strong></
center>")%>%
  kable_styling(bootstrap_options = c("striped", "hover", "condensed", "bordered"))
```

Table 1. Results for mark-recapture analysis for stink pots.

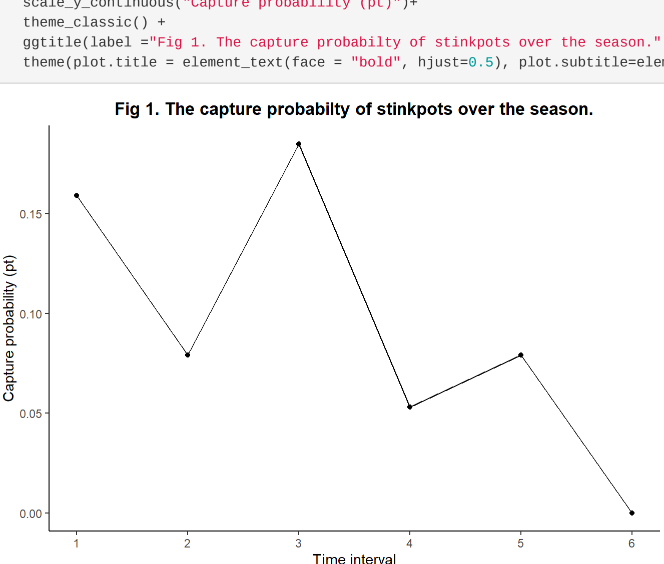
Model	Model_Description	N	SE	AICc
M0	The most basic model in which p and c are constant	41.03	16.66	89.91
Mt	p differs among sampling occasions and pt = ct	37.79	14.77	85.47
Mb	Behavioral response model in which p and c differ.	18.58	2.15	87.34
Mtb	Combination of models Mt and Mb	21.70	13.12	87.58

```
Time<-(c(1, 2, 3, 4, 5, 6))

pt<-(c(0.159, 0.079, 0.185, 0.053 ,0.079,0))

pdata<-data.frame(Time,pt)

require(ggplot2)
```

```
## Loading required package: ggplot2
```

```
ggplot(pdata, aes(x=Time, y=pt)) + geom_point() + geom_line()+
  scale_x_continuous("Time interval", breaks =c(1,2,3,4,5,6)) +
  scale_y_continuous("Capture probability (pt)")+
  theme_classic() +
  ggtitle(label ="Fig 1. The capture probabilty of stinkpots over the season.")+
  theme(plot.title = element_text(face = "bold", hjust=0.5), plot.subtitle=element_text(hjust=0.5))
```

Fig 1. The capture probabilty of stinkpots over the season.



Question 4

Model M_t has the lowest AICc value. Model M_t does not measure behavioural responses but model M_b and M_{tb} both do. Model M_b suggests that recapture is relatively low (0.06) suggesting a trap shy strategy, and model M_{tb} shows that recapture varies depending on the the trapping inteval. For interval 2 there is a low recaptue (0.05), interval 3 there is a higher recapture rate (0.17), and interval 4 has a lower recapture (0.08). This suggests for this model that there is a trap shy behavior after the first time an individual is caught and marked,a trap happy-ish response for interval 3, and then for interval 4 and 5 trap shyness.

Question 5

Model M_0 was the worst model because captures and recaptures varied overtime and this model was unable to account for this variation since it assumed both were constant over time.