Supplementary Appendix 3

RMark Analysis

The below analysis was performed in R Version 4.2.1 (R Core Team 2022) with RStudio 2022.07.01 (RStudio Team 2022) using RMark package (Laake 2013).

```
# 1 Process Data
dresight.process=process.data(dresight,model="CJS",begin.time=1993,groups="SEX")
# 2 Make Design Data
dresight.ddl=make.design.data(dresight.process)
```

Make Models

The default in mark() for CJS model is

```
Phi.const=list(formula=~1)
p.const=list(formula=~1)
```

Phi = Survival
p = Recapture probability
The formula ~1 is equivalent in MARK to the constant or "." model, ~time is equivalent to the "t" model and create some more parameter specifications

```
Phi.time=list(formula=~time)
Phi.sex=list(formula=~SEX)
Phi.age=list(formula=~age)
Phi.sex.p.age=list(formula=~SEX+age)
Phi.sex.x.age=list(formula=~SEX*age)
Phi.time.p.sex=list(formula=~time+SEX)
Phi.time.x.sex=list(formula=~time*SEX)
#triple interaction
Phi.time.x.sex.x.age=list(formula=~time*SEX*age)


p.time=list(formula=~time)
p.sex=list(formula=~SEX)
p.time.p.sex=list(formula=~time+SEX)
p.time.x.sex=list(formula=~time*SEX)
```

Time for this code chunk to run: 0.0252559185028076

p Models

Use global model (Phi=Phi.time.x.sex.x.age) while altering detection probabilities

```
CJS01pI=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.x.sex.x.age,p=p.const))
```

Time for this code chunk to run: 9.0445450146993

```
CJS02pI=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.x.sex.x.age,p=p.time))
```

Time for this code chunk to run: 6.90193729797999

```
CJS03pI=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.x.sex.x.age,p=p.sex))
```

Time for this code chunk to run: 6.74177396694819

```
CJS04pII=mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.x.sex.x.age,p=p.time.p.sex))
```

Time for this code chunk to run: 8.50767348210017

```
CJS05pIII=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.x.sex.x.age,p=p.time.x.sex))
```

Time for this code chunk to run: 7.51088203589121

p AICcs

```
collect.models(lx = NULL, type = NULL, table = TRUE, adjust = FALSE,
  external = FALSE)
##                                 model npar     AICc DeltaAICc weight Deviance
## 5 Phi(~time * SEX * age)p(~time * SEX)  592 116040.4    0.0000      1 19859.78
## 4 Phi(~time * SEX * age)p(~time + SEX)  571 116163.5  123.0242      0 20025.92
## 2       Phi(~time * SEX * age)p(~time)  570 116348.7  308.2621      0 20213.21
## 3        Phi(~time * SEX * age)p(~SEX)  550 118789.3 2748.8794      0 22694.85
## 1          Phi(~time * SEX * age)p(~1)  549 119040.0 2999.5793      0 22947.60
collect.models(lx = NULL, type = NULL, table = TRUE, adjust = TRUE,
  external = FALSE)
##                                 model npar     AICc DeltaAICc weight Deviance
## 5 Phi(~time * SEX * age)p(~time * SEX)  592 116040.4    0.0000      1 19859.78
## 4 Phi(~time * SEX * age)p(~time + SEX)  571 116163.5  123.0242      0 20025.92
## 2       Phi(~time * SEX * age)p(~time)  570 116348.7  308.2621      0 20213.21
## 3        Phi(~time * SEX * age)p(~SEX)  550 118789.3 2748.8794      0 22694.85
## 1          Phi(~time * SEX * age)p(~1)  549 119040.0 2999.5793      0 22947.60
CJS10=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time,p=p.time.x.sex))
```

Time for this code chunk to run: 9.34825396537781

Phi Models

```
CJS11=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.sex,p=p.time.x.sex))
```

Time for this code chunk to run: 5.81859016418457

```
CJS12=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.age,p=p.time.x.sex))
```

Time for this code chunk to run: 10.205178976059

```
CJS13=mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.p.sex,p=p.time.x.sex))
```

Time for this code chunk to run: 10.1844189167023

```
CJS14=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.time.x.sex,p=p.time.x.sex))
```

Time for this code chunk to run: 15.186625957489

```
CJS15= mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.sex.p.age,p=p.time.x.sex))
```

Time for this code chunk to run: 9.73357200622559

```
CJS16=
  mark(dresight.process,dresight.ddl,model.parameters=list(Phi=Phi.sex.x.age,p=p.time.x.sex))
```

Time for this code chunk to run: 15.0124771595001

AICc table

```
models1 = collect.models(lx = NULL, type = NULL, table = TRUE, adjust = TRUE,
  external = FALSE)
models1
##                                  model npar     AICc  DeltaAICc       weight
## 12        Phi(~SEX * age)p(~time * SEX)   88 115531.0    0.00000 1.000000e+00
## 11        Phi(~SEX + age)p(~time * SEX)   67 115581.6   50.55299 1.053315e-11
## 10       Phi(~time * SEX)p(~time * SEX)   88 115826.9  295.90000 0.000000e+00
## 9        Phi(~time + SEX)p(~time * SEX)   67 115850.1  319.04299 0.000000e+00
## 7              Phi(~SEX)p(~time * SEX)   46 116011.9  480.90563 0.000000e+00
## 5  Phi(~time * SEX * age)p(~time * SEX)  592 116040.4  509.40220 0.000000e+00
## 4  Phi(~time * SEX * age)p(~time + SEX)  571 116163.5  632.42640 0.000000e+00
## 8              Phi(~age)p(~time * SEX)   66 116201.6  670.59698 0.000000e+00
## 2        Phi(~time * SEX * age)p(~time)  570 116348.7  817.66429 0.000000e+00
## 6             Phi(~time)p(~time * SEX)   66 116422.6  891.57698 0.000000e+00
## 3         Phi(~time * SEX * age)p(~SEX)  550 118789.3 3258.28163 0.000000e+00
## 1           Phi(~time * SEX * age)p(~1)  549 119040.0 3508.98147 0.000000e+00
##    Deviance
## 12 20373.95
## 11 20466.65
## 10 20669.85
## 9  20735.14
## 7  20939.11
## 5  19859.78
## 4  20025.92
## 8  21088.70
## 2  20213.21
## 6  21309.68
## 3  22694.85
## 1  22947.60
```

c-hat qAICc table

```
adjust.chat(chat=1.7,models1)
##                                  model npar    QAICc DeltaQAICc      weight
## 12        Phi(~SEX * age)p(~time * SEX)   88 68032.05     0.0000 0.997956815
## 11        Phi(~SEX + age)p(~time * SEX)   67 68044.43    12.3824 0.002043185
## 9        Phi(~time + SEX)p(~time * SEX)   67 68202.36   170.3177 0.000000000
## 10       Phi(~time * SEX)p(~time * SEX)   88 68206.10   174.0588 0.000000000
## 7              Phi(~SEX)p(~time * SEX)   46 68280.24   248.1927 0.000000000
## 8              Phi(~age)p(~time * SEX)   66 68408.33   376.2882 0.000000000
## 6             Phi(~time)p(~time * SEX)   66 68538.32   506.2764 0.000000000
## 5  Phi(~time * SEX * age)p(~time * SEX)  592 68753.16   721.1193 0.000000000
## 4  Phi(~time * SEX * age)p(~time + SEX)  571 68807.78   775.7329 0.000000000
## 2        Phi(~time * SEX * age)p(~time)  570 68915.90   883.8513 0.000000000
## 3         Phi(~time * SEX * age)p(~SEX)  550 70334.66  2302.6169 0.000000000
## 1           Phi(~time * SEX * age)p(~1)  549 70481.29  2449.2432 0.000000000
##    QDeviance chat
## 12  11984.68  1.7
## 11  12039.20  1.7
## 9   12197.14  1.7
## 10  12158.74  1.7
## 7   12317.12  1.7
## 8   12405.12  1.7
## 6   12535.10  1.7
## 5   11682.23  1.7
## 4   11779.95  1.7
## 2   11890.12  1.7
## 3   13349.91  1.7
## 1   13498.59  1.7
```

AIC table

```
AIC.table = models1
AIC.table$model.table = model.table(models1, use.AIC = TRUE)
AIC.table
##                                  model npar      AIC DeltaAIC       weight
## 12        Phi(~SEX * age)p(~time * SEX)   88 115530.7     0.00 1.000000e+00
## 11        Phi(~SEX + age)p(~time * SEX)   67 115581.4    50.70 9.786669e-12
## 10       Phi(~time * SEX)p(~time * SEX)   88 115826.6   295.90 0.000000e+00
## 9        Phi(~time + SEX)p(~time * SEX)   67 115849.9   319.19 0.000000e+00
## 7              Phi(~SEX)p(~time * SEX)   46 116011.8   481.16 0.000000e+00
## 5  Phi(~time * SEX * age)p(~time * SEX)  592 116024.5   493.83 0.000000e+00
## 4  Phi(~time * SEX * age)p(~time + SEX)  571 116148.6   617.97 0.000000e+00
## 8              Phi(~age)p(~time * SEX)   66 116201.4   670.75 0.000000e+00
## 2        Phi(~time * SEX * age)p(~time)  570 116333.9   803.26 0.000000e+00
## 6             Phi(~time)p(~time * SEX)   66 116422.4   891.73 0.000000e+00
## 3         Phi(~time * SEX * age)p(~SEX)  550 118775.6  3244.90 0.000000e+00
## 1           Phi(~time * SEX * age)p(~1)  549 119026.3  3495.65 0.000000e+00
##    Deviance
## 12 20373.95
## 11 20466.65
## 10 20669.85
## 9  20735.14
## 7  20939.11
## 5  19859.78
## 4  20025.92
## 8  21088.70
## 2  20213.21
## 6  21309.68
## 3  22694.85
## 1  22947.60
```

References

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