Cohort analysis

fish5104vpa Assessment methods based on back-calculations

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Other approximations - Cohort analysis

N assumed known in the last year

M assumed known and inflicted mid-year

Catch known

Revised equation easily solved w.r.t. N

Data on North Sea plaice (available at http://notendur.hi.is/ gunnar/tutor-web.data/biol/nsplaice.canum)

	2	3	4	5	6
1970	17294	51174	56153	40686	35074
1971	29591	48282	33475	26059	22903
1972	36528	62199	52906	23043	16998

```
cnum<-read.table("http://notendur.hi.is/~gunnar/tutor-web.data/biol/nsplaice.canum
cnum<-as.matrix(cnum)
cnum["1971","5"]
26059
```

Cohort analysis - mid-year formula

First project cohort to mid-year without catches
Then subtract mid-year catches so cohort size after catches becomes:

$$N_{ay}e^{-M/2} - C_{ay}$$

End of year cohort size becomes:

$$N_{a+1,y+1} = (N_{ay}e^{-M/2} - C_{ay})e^{-M/2}$$

```
print(cnum[22,1])      # 2 year olds in 1991
C2<-cnum["1991","2"]   # Same thing
print(C2)
M<-0.15
N0<-150000             # Set start of year
N0*exp(-M/2)           # Half natural mortality
N0*exp(-M/2)-C2        # Then catches
N1<-(N0*exp(-M/2)-C2)*exp(-M/2) # Full-year cohort-analysis prediction
```

Cohort analysis, back-calculations

$$N_{ay} = (N_{a+1,y+1} e^{M/2} + C_{ay}) e^{M/2}$$

```
# Example:  Suppose we assume there is a single fish left as 11-year old
# at the end of 1995 (i.e. 12-year old at the beginning of 1996).
M<-0.15
N12<-1
C11<-cnum["1995","11"]
# Then we can back-calculate the numbers
N11<-(N12*exp(M/2)+C11)*exp(M/2)
```

Back-calculating a full year

Fix year, y and back-calculate

$$N_{ay} = (N_{a+1,y+1}e^{M/2} + C_{ay})e^{M/2}$$

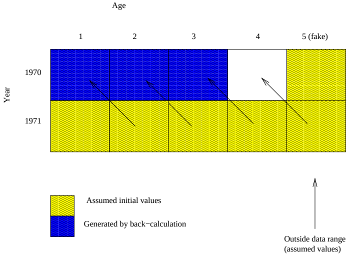
for each age. Get all but oldest.

```
C95<-cnum["1995",]   # Entire year  ages 2-11
N96<-c(60000,60000,60000,40000,40000,40000,10000,10000,10000,1)
names(N96)<-as.character(3:12)  # Note these are beg. yr ages 3 through 12
N95<-(N96*exp(M/2)+C95)*exp(M/2)# Backwards, up diagonally
names(N95)<-as.character(2:11)  # Note the shift
```

We are now missing age 12 in the stock for 1995 - need to add that before we set up the full table.

Making ends meet

Need to adjust endpoints
Insert recruits in later and oldest in former for pairs of years




```
cnum<-read.table("http://notendur.hi.is/~gunnar/tutor-web.data/biol/nsplaice.canum
cnum<-as.matrix(cnum);  M<-0.15;  C95<-cnum["1995",]
N96<-c(0,60000,60000,60000,40000,40000,40000,10000,10000,10000,1)
names(N96)<-as.character(2:12)  # Note these are beg. yr ages 2 through 12
N1<-N96[as.character(3:12)]     # Drop the youngest
N0<-(N1*exp(M/2)+C95)*exp(M/2)
names(N0)<-as.character(2:11)   # Note the shift
N95<-c(N0,1)                    # Add the extra one
C94<-cnum["1994",]
N1<-N95[as.character(3:12)]     # Drop the youngest
N0<-(N1*exp(M/2)+C94)*exp(M/2)
names(N0)<-as.character(2:11)   # Note the shift
N94<-c(N0,1)                    # Add the extra one
```

Cohort analysis - F-computations

Compute F within table afterwards:

$$F = ln(N_0/N_1) - M$$

or

$$F_{ay} = ln(N_{ay}/N_{a+1,y+1}) - M_{ay}$$

Easy in principle - careful with indices!

```
log(Nmat[2,3]/Nmat[3,4])  # Simple example

log(Nmat[1:10,1:2]/Nmat[2:11,2:3])  # The whole matrix
A<-ncol(Nmat); Y<-nrow(Nmat)
Fmat<-log(Nmat[1:(Y-1),1:(A-1)]/Nmat[2:Y,2:A])-M  # The general case
```

The trend in fishing mortality

Want an overall measure of fishing mortality per year.
Use average, $\bar{F}_y$ over selected age group.
Common choices: Oldest ages or well-sampled ages.

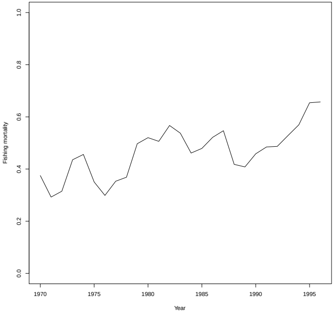
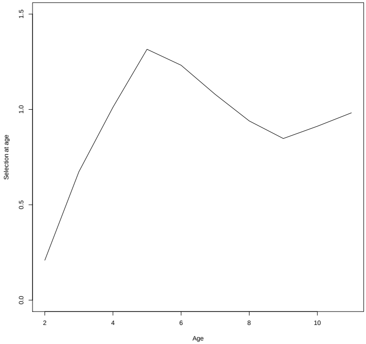


Figure : Fishing mortality trend for initial assessment of North Sea plaice

The selection pattern



Cohort analysis using F as a starting point

Assume a value for F:

$$N_{ay} = \frac{C_{ay}}{\frac{F_{ay}}{Z_{ay}}(1 - e^{-Z_{ay}})}$$

NB: Now use the same number of ages and years as in the data.

```
#
# cohortF - cohort analysis based on fishing mortalities
#
cohortF<-function(cnum,Fterm,selpat,Foldest){
  A<-ncol(cnum)
  Y<-nrow(cnum)
  Flast<-Fterm*selpat
  Ages<-as.numeric(dimnames(cnum)[[2]]) # Age range in catches
  Years<-as.numeric(dimnames(cnum)[[1]])# Year range in catches

  Cline<-cnum[Y,]
  N1<-Cline/((Flast/(Flast+M))*(1-exp(-(Flast+M))))
  Nmat<-N1
  for(y in (Y-1):1){
    Cline<-cnum[y,]
    psi<-((Foldest[y]/(Foldest[y]+M))*(1-exp(-(Foldest[y]+M))))
```

The oldest fish

Need assumptions for oldest fish: Use mean across some ages within year
Need to check the fishing pattern first

The last year

Need assumptions for the last year:

- Use average F over time
- Check (average) fishing pattern
- Repeat VPA with mean F*pattern

Cohort analysis

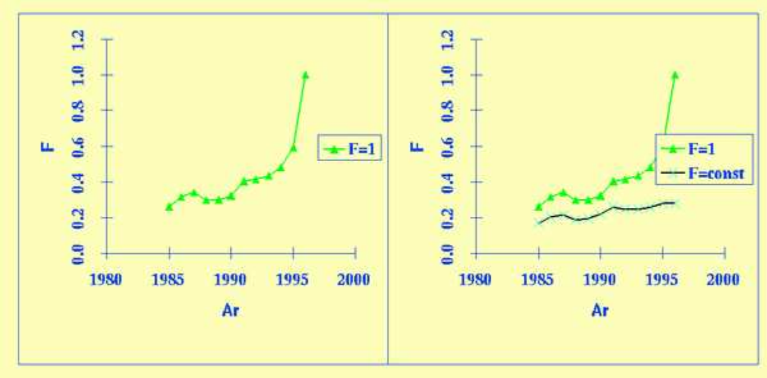


Figure : Using cohort analysis iteratively for North Sea plaice.

- Backcalculate N
- Compute F later : $F = ln(N_{ay}/N_{a+1,y+1}) - M$
- Estimate oldest fish through mean-F
- Need improved method for F in last year