Yield per recruit analysis

fish5105yieldrec Yield per recruit analysis

Gunnar Stefánsson

December 19, 2016

Introduction

- Initial assessment gives total mortality (Z)
- Assume a value for natural mortality (M)
- Assume we have an idea of the fishing mortality by age group
- Can, for example, use back-calculation to get F or selection pattern
- Want to use these to compute expected yield for fixed year-class size

Yield per recruit input data

Use F and s_a to get $F_a = F \cdot s_a$.

Note: Assume equilibrium or track a cohort...

Example: Data on cod in Icelandic waters:

	s	M	w
3	0.064	0.2	1310
4	0.326	0.2	1897
5	0.626	0.2	2473
6	0.903	0.2	3155
7	1.099	0.2	3784
8	1.124	0.2	5671
9	1.124	0.2	7230
10	1.124	0.2	9780
11	1.124	0.2	9723

Simulating a stock

Simulations are useful for testing the effects of assumptions.

Can use vonB with length-weight relationship to get weight at age.

Can use curves for selection and maturity at age.

First year yield and stock size

$$C_1 = \frac{F_1}{Z_1}\left(1 - e^{-Z_1}\right) N_1$$

$$Y_1 = w_1 C_1$$

$$N_2 = N_1 e^{-Z_1}$$

Second year

$$C_2 = \frac{F_2}{Z_2}\left(1 - e^{-Z_2}\right) N_2$$

$$Y_2 = w_1 C_2$$

$$N_3 = N_2 e^{-Z_2}$$

Example: Continuing the earlier example, typical second-year computations in R could be:

```
Fmort<-Fmult*sa[2]
Z<-Fmort+M[2]
C2<-(Fmort/Z)*(1-exp(-Z))*N2
w2<-w[2]
Y2<-w2*C2
N3<-N2*exp(-Z)
```

The entire sequence

Catch of age, a, fish: $C_a = \frac{F_a}{Z_a}(1 - e^{-Z_a})e^{-\sum_{a'<a} Z_{a'}} R$

Year-class yield: $Y = \sum_a Y_a = \sum_a \frac{F_a}{Z_a}(1 - e^{-Z_a}) w_a e^{-\sum_{a'<a} Z_{a'}} R.$

Yield per recruit: $Y/R = \sum_a \frac{F_a}{Z_a}(1 - e^{-Z_a}) w_a e^{-\sum_{a'<a} Z_{a'}}$

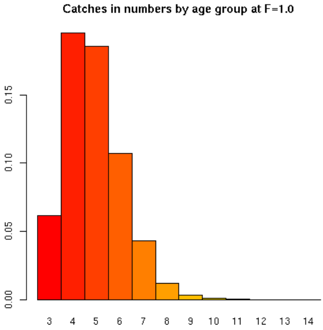
The R function for accumulation is cumsum:

```
cumsum(3:1)
3 5 6
```

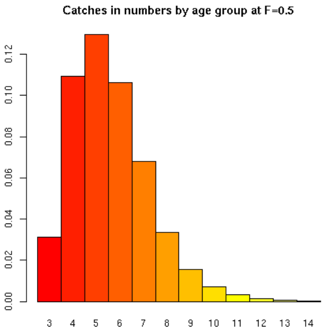
Can set up a vector of cumulative Z-values:

```
Fmort<-Fmult*sa
Z<-Fmort+M
prop<-(Fmort/Z)*(1-exp(-Z))
Ztemp<-c(0,Z[1:(length(Z)-1)])
cumZ<-cumsum(Ztemp)
C<-prop*exp(-cumZ)
Y<-sum(w*C)
```

Results 1


Catches in numbers by age group at F=1.0
0.00
0.05
0.10
0.15
3
4
5
6
7
8
9
10
11
12
13
14

Results 2: Reduced effort



F multiplier = 0.5.

```
Fmult<-0.5
Fmort<-Fmult*sa
Z<-Fmort+M
prop<-(Fmort/Z)*(1-exp(-Z))
Ztemp<-c(0,Z[1:(length(Z)-1)])
cumZ<-cumsum(Ztemp)
```

The yield per recruit curve

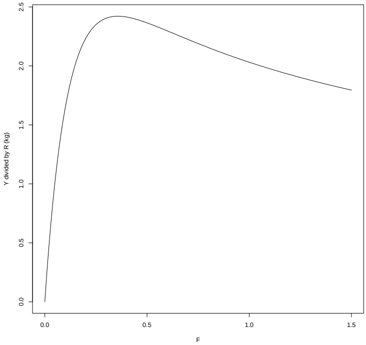


Figure : A typical yield per recruit curve gives the yield in weight per recruit for each level of fishing mortality.

F multiplier = 0.5.

```
Fmult<-0.5
Fmort<-Fmult*sa
Z<-Fmort+M
```

Yield per recruit and age composition

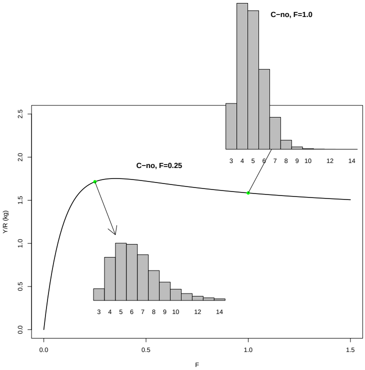
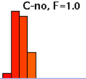


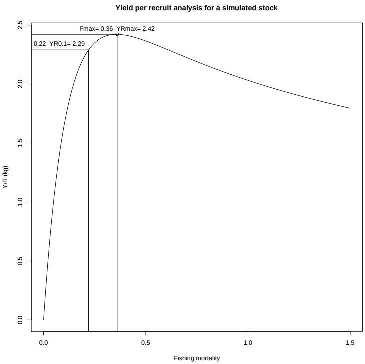
Figure : The effect of variable fishing mortality on yield-per-recruit (solid line) and the age composition of catches at low and high fishing mortality (histograms).

Example: Suppose we define an R function with

```
yrfun<-function(Fmult,M=natmort,sa=selpat,wa=wt.a
  Fmort<-Fmult*sa
  Z<-Fmort+M
```



F0.1


Yield per recruit analysis for a simulated stock
Fmax= 0.36 YRmax= 2.42
0.22 YR0.1= 2.29
Y/R (kg)
0.0
0.5
1.0
1.5
2.0
2.5
0.0
0.5
1.0
1.5
Fishing mortality