Stock-recruitment relationships

- How to interpret a SR curve
- Density independence
- Density dependence
- Ricker, Beverton-Holt, and Shepherd models
- Conclusions/alternatives
- Chapter 4 in textbook

Stock-recruitment relationships

Number of offspring vs. Number of parents

Stock (S)

Recruits (R)

Stock-recruitment relationships

Stock
- part of population under consideration for actual or potential utilization; or
- sample of individuals with similar production characteristics

Recruitment
- # of individuals still alive at some specified point in time (stage) after the egg stage
Stock-recruitment relationships

Principles:
- curve must pass through origin
  (if your parents didn’t have children, you won’t have children)
- no other Stock level results in 0 recruits
- Recruits must exceed Stock size over some part of the range of Stock size

Interpreting the shape of stock-recruitment relationships

• Straight S-R curve implies density-independence
• Non-linear curve implies density-dependence
  – Decreasing slope = compensatory
  – Increasing slope = depensatory
Interpreting the shape of stock-recruitment relationships

Compensatory curves
- rate of recruitment decreases continually (i.e. slope is maximum at origin)
- When curve meets replacement line = K
- Angle of intersection determines dynamics
- Maximum recruitment = max distance
Another way to look at it...

What about depensation?

Compensatory
Depensatory

rate of recruitment

$dR/dS$
Stock-recruitment relationships: depensation

Potential Mechanisms:
- Constant predation
- Allee effect

Queen conch in the Caribbean

Some Allee effect humor.....
Families of Stock-recruitment curves:

- Beverton-Holt
- Ricker
- Shepherd

Stock-recruitment curves:

Beverton-Holt

\[ R = \frac{aS}{1 + bS} \]

\( a/b = \text{max } R \text{ at high } S \)

\( a = \text{max } R/S \text{ at low } S \text{ i.e. initial slope} \)
Stock-recruitment curves:

Beverton-Holt
- Recruitment asymptotic
- Intra-year feedback
- Recruits limited by food/habitat
- many Marine species

Stock-recruitment curves:
Ricker

\[ R = aSe^{-bS} \]

- \( b \) = rate of decline in \( R \) as \( S \) increases
- \( a \) = max \( R/S \) at low \( S \)
  i.e. initial slope
Stock-recruitment curves:

Ricker
- Recruitment declines at high stock sizes
- Inter-year feedback
- Recruits limited by cannibalism, egg superimposition
- Anadromous species

Stock-recruitment curves: Ricker vs B-H

Summary
- Both models contain dens-dep and -indep terms
- Compensatory mortality reduces recruitment at high stock levels
- Mechanism of compensation differs: intra vs. inter year class effects

Stock-recruitment curves: Shepherd curve

\[ R = \frac{aS}{1 + (bS)^c} \]

- 1 additional parameter (c)
- Can take Ricker or B-H form, depending on c
Stock-recruitment relationships: Shepherd curve

\[ R = \frac{aS}{1 + (bS)^c} \]

- C determines shape of the curve:
  - \( c < 1 \) curve rises indefinitely (dens indep)
  - \( c = 1 \) B-H form
  - \( c > 1 \) Ricker form (more dens dep)
Stock-recruitment curves: Examples
Stock-recruitment relationships: Conclusions

- Generally do not fit data well, but fit is only as good as data used
- Measurement Error in R and S can obscure fits
Stock-recruitment relationships: Conclusions

• Generally do not fit data well, but fit is only as good as data used.
• Measurement Error in R and S can obscure fits
• Despite variation, some generalizations can be made
Stock-recruitment relationships: Conclusions

• Environmental variability can mask true relationship
• Simple models do not incorporate environmental factors

Incorporating environmental variability

Incorporating environmental and harvest variability
A simple 2-stage life history

Number of recruits produced by given stock size

Number of adults produced by given number of recruits

Survival to recruitment
Stock-recruitment relationships: Conclusions

- **S-R relationships** easiest to detect at very low or very high stock sizes, when compensatory and depensatory mechanisms are most evident

- Lack of **contrast** is most serious problem
Stock-recruitment relationships: alternatives

• Spawner-recruit probability transition matrix (see Table 4.1)
  – Partition S & R into intervals, and assess probability of a given S producing a given R
    • advantages: incorporates variation, is not constrained by a specific SR relationship
    • disadvantages: long data series over a range of stock sizes needed

Stock-recruitment relationships: alternatives

• Paulik diagrams
  – Multistage models with a series of SR curves over various life history stages
Irish Sea plaice, *Pleuronectes platessa*:
real data: 1963-1994

Irish Sea plaice, *Pleuronectes platessa*:
temperature variation

Fig. 12. Three-year running average of annual sea surface temperature for Port Erin Bay, Isle of Man, Irish Sea for the years 1990 to 1994.
Irish Sea plaice, *Pleuronectes platessa*: fitting Ricker curves

Irish Sea plaice, *Pleuronectes platessa*: Paulik diagram

Irish Sea plaice, *Pleuronectes platessa*: conceptual Paulik diagram
Hilborn and Walters (1992) conclude:

“Analysis of stock-recruitment data provides an enormous number of traps for the unwary – good luck”