Stock recruitment relationships

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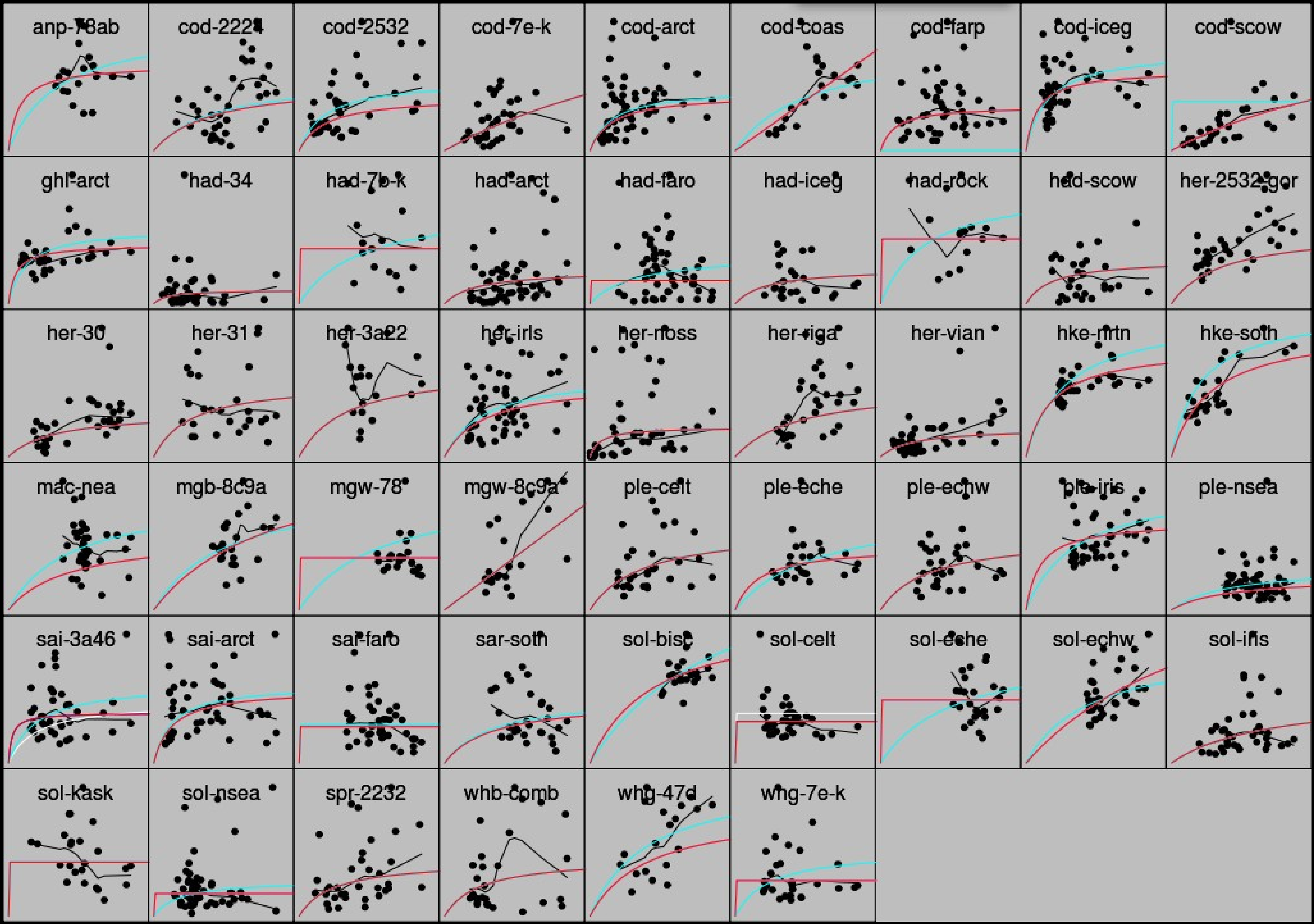
Stock-recruitment

- “The most important and generally most difficult problem in biological assessment of fisheries” - Hilborn & Walters, 1991.
- How much can the stock drop before recruitment is affected.
- Simplifies life history up to recruits: management

What are stock and recruits?

- Stock (SSB) = reproductive potential
- Recruits: individuals reaching a certain stage
  - Larvae settlement
  - Fishery
- Recruits (N at age 1) = realized reproduction
- SSB_y & rec_y+1



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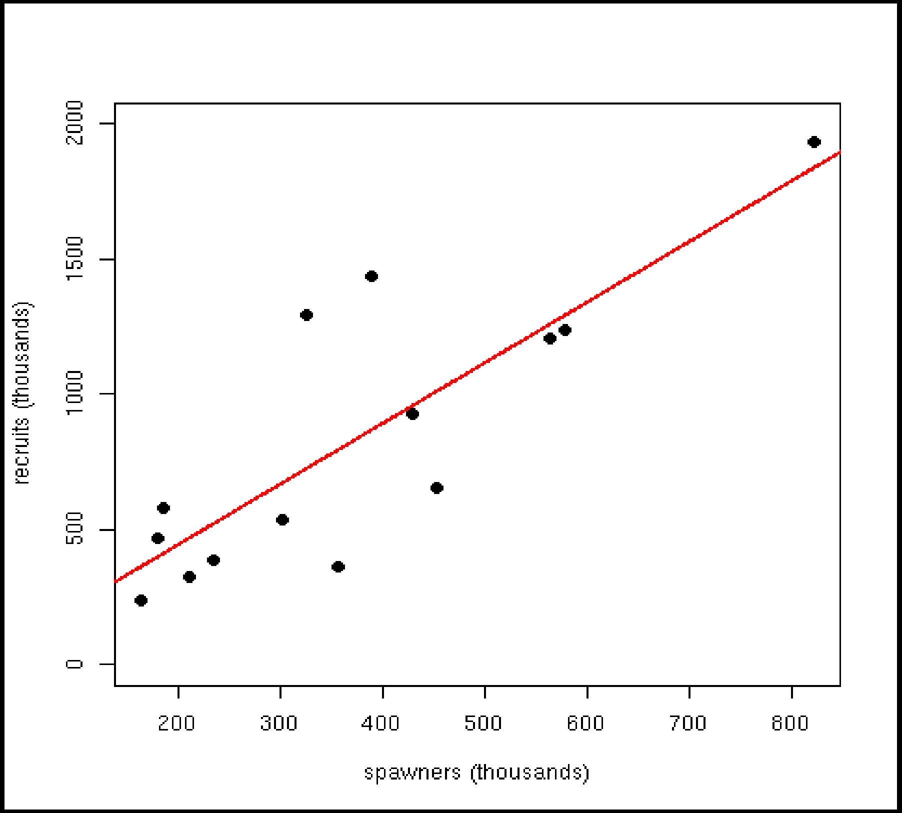
Biological processes

- Density independence: predation, starvation and environmental impacts
- Must have limits



Biological processes

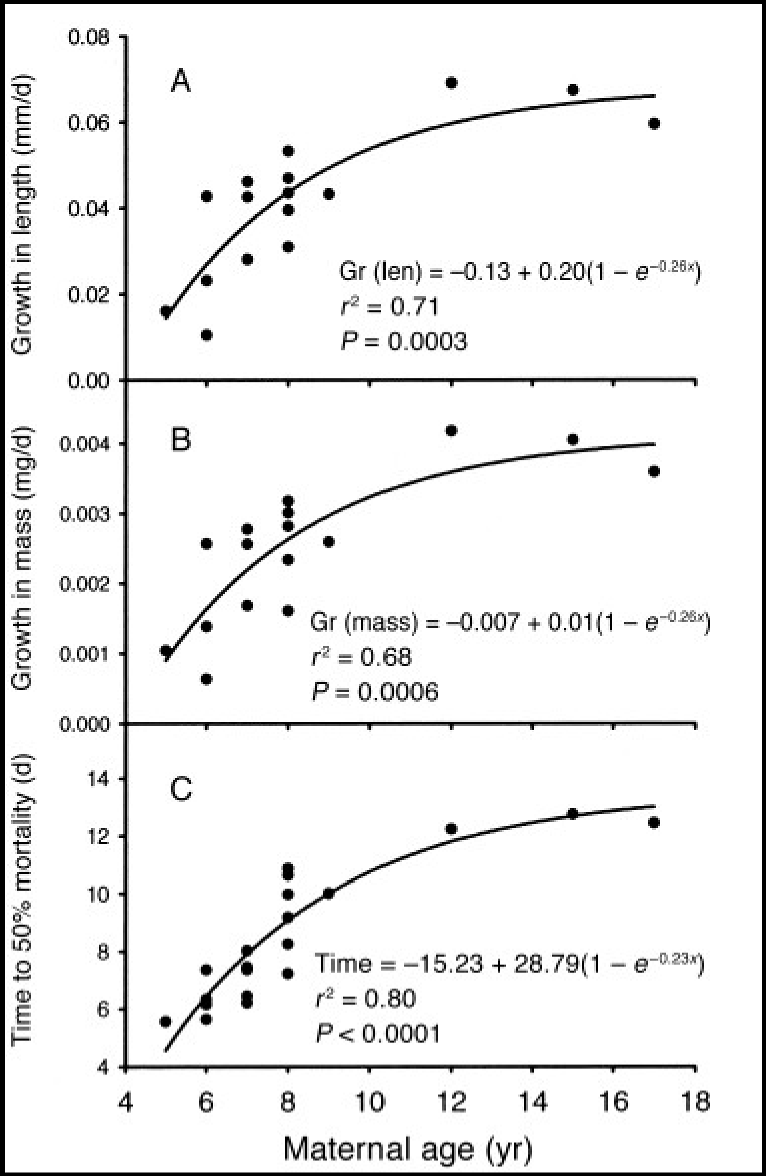
- Compensation: recruitment becomes independent of spawners
- Recruits-per-spawner decreases
- Competition for food or space, cannibalism

Biological processes

- Depensation: recruits-per-spawner increases
- (1) Predation constant, smaller % as SSB increases
- (2) Reduced fertilization success (Allee effect)

Reproductive potential and SSB

- SSB is a proxy of reproductive potential
- But egg production not linearly related to SSB
  - eggs/g body weight
  - Maternal effects
  - Egg size vs. age
  - BOFFFF hypothesis



Beverton & Holt

- Mortality rate linearly dependent upon fish in cohort due to juvenile competition

$$R=\frac{a*S}{1+b*S}$$

- a changes the height of the asymptote
- b increases the rate of approach to it

$$R=\frac{\alpha*S}{\beta*S}$$

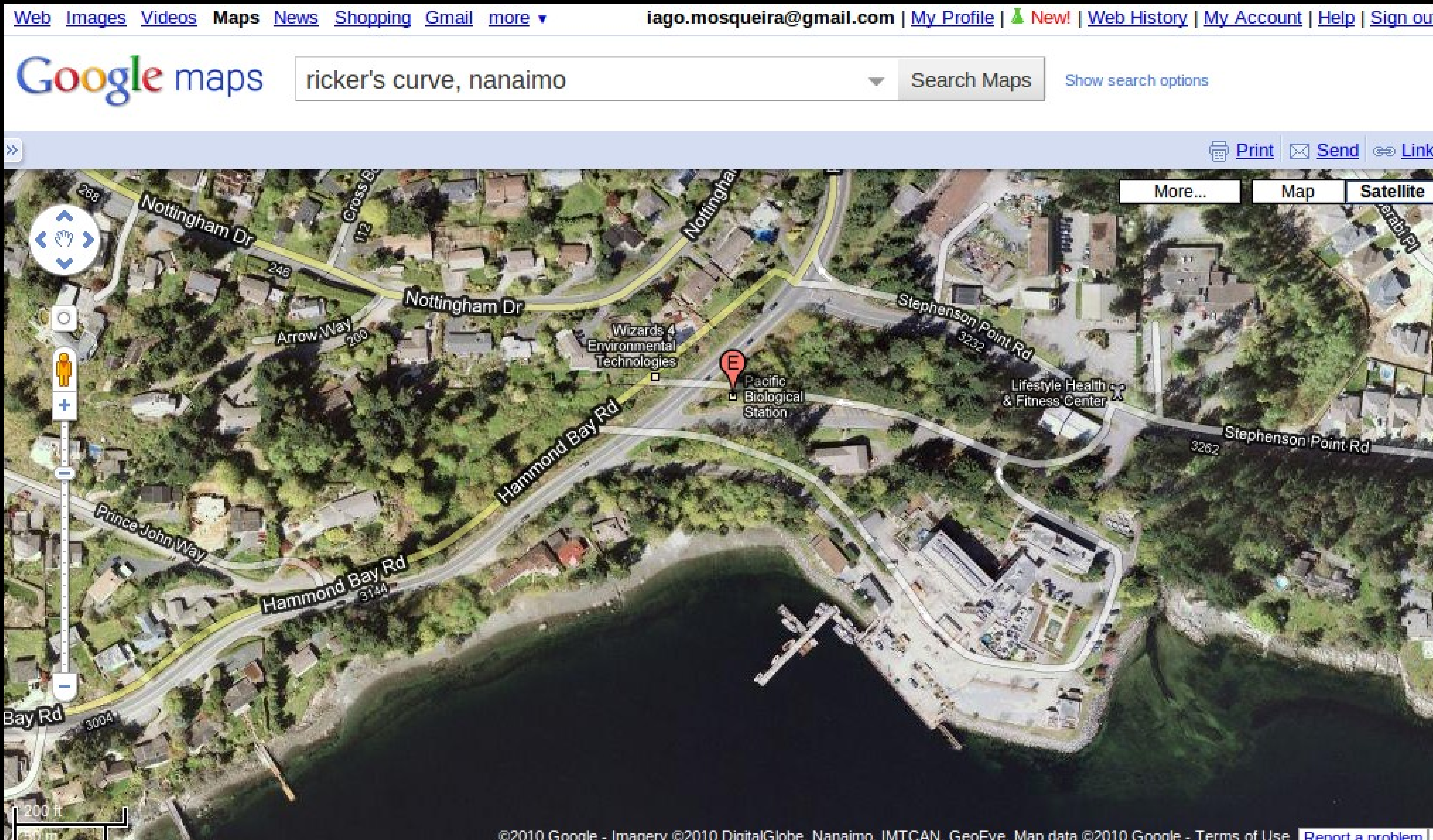
- α max number of recruits
- β SSB that gives mean rec of α/2

Ricker

- Mortality rate linearly dependent to initial cohort size

$$R = a * S e^{-b*S}$$

- a is the density-independent parameter
- b is the density-dependent parameter
- Maximum mean rec at S = 1/b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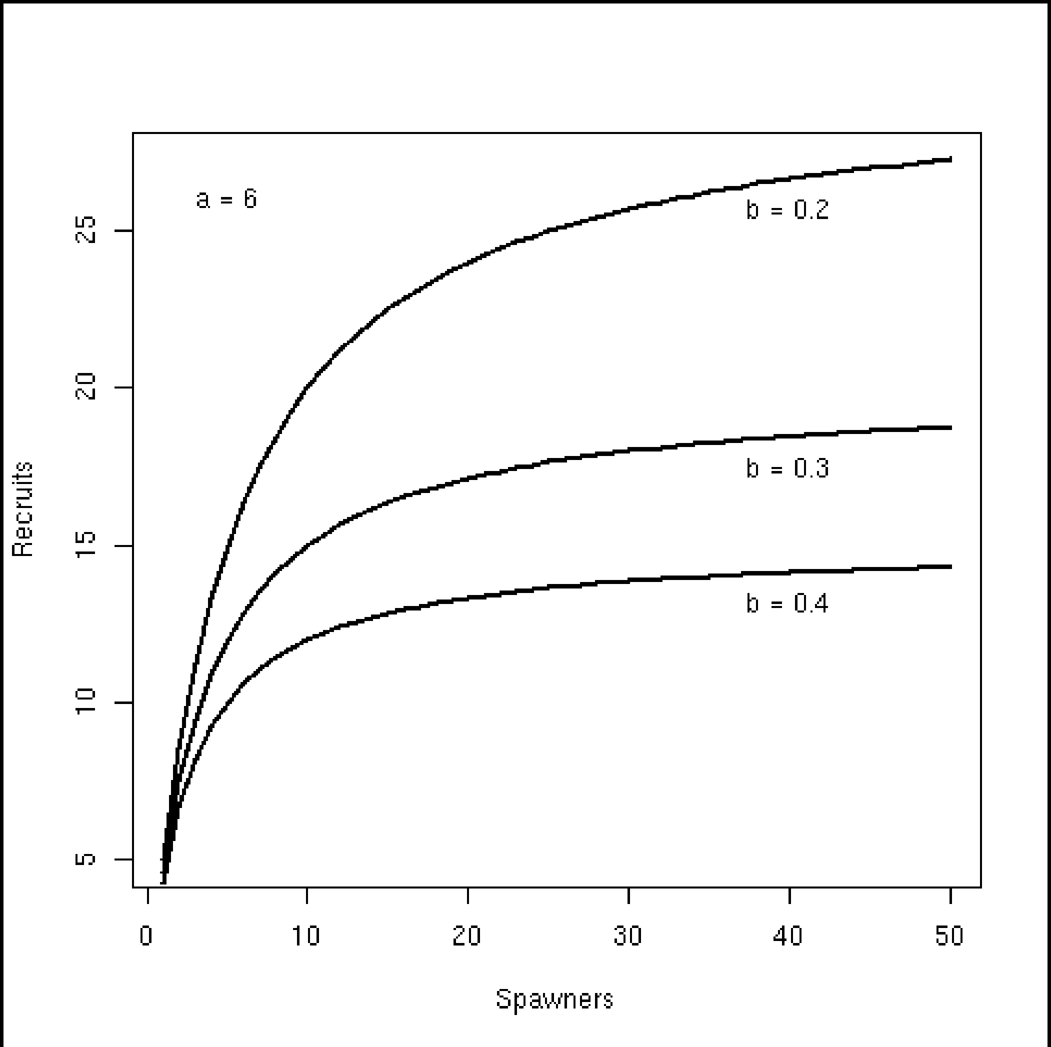
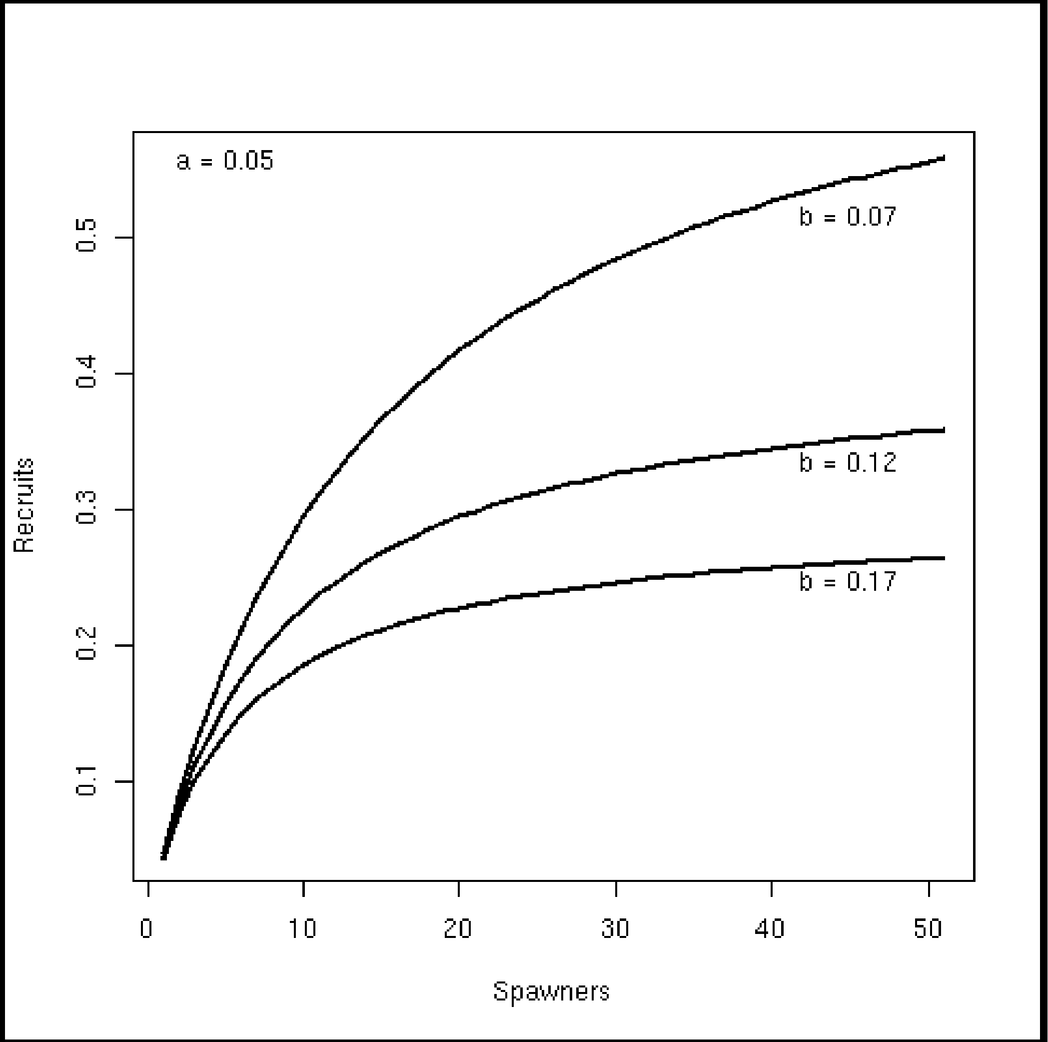
Ricker's Curve
MAXIMUM
Main

Exercise: Beverton & Holt

- Plot B&H model changes with α, β
- `spawn <- seq(1,50)`
- `a=6, b=seq(0.2, 0.4, by=0.1)`
- `b=0.2, a=c(2,4,6)`
- EXTRA: Do the same for Ricker $R = a * S e^{-b*S}$
- `a=0.05, b=c(0.05, 0.10, 0.15)`
- `B=0.07, b=seq(1,5)`

Exercise: Beverton & Holt





Shepherd

$$R = \frac{a * S}{1 + (b * S)^c}$$

- a slope at low stock sizes
- b is the density-dependent parameter
- c shape parameter
  - c<1 curve rises
  - c=1 B&H
  - c>1 Ricker
- Usually no information to estimate c, but worth trying!

Depensatory models

- Potential recruits are then subject to predation
- Models are added a depensatory parameter

$$R = a * S^m e^{-b*S}$$

- M is greater than 1
- Estimated from data, should be much greater than 1

Model fitting: good, bad and ugly

- Some models can be linearized in log scale (Ricker)
- Error structure given by lm, and inputs assumed without error
- Non-linear regression, error structure chosen
- Non-linear models, solved by numerical methods.
- State-space for observation & model error
- Bayesian models

Model fitting: maximum likelihood

- Alternative to SS
- Minimize the -log(likelihood) of the model given the data
- Explicit formulation of error structure