# WF4113-Fisheries Science

Lecture7: Recruitment continued

## Housekeeping

- Lab responses due by 5 pm next Monday.


## Job of the week

- Kent Toler, hatchery – Delta(?)
- Looking for some help to primarily work the hatchery season (May to the middle of July) producing hybrids

## Fisheries icon: Dr. Ken Carlander

- B.S., M.S., and Ph.D. degrees at the University of Minnesota in 1936, 1938, and 1943
- In 1946, Dr. Carlander began a long career as a member of the faculty of Iowa State University.
- Served as leader of the Iowa Cooperative Fishery Research Unit from 1946 to 1965

## Claims to fame

- Carlander, Kenneth D. 1953. Handbook of freshwater fishery biology, with the first supplement. Wm. C. Brown Company, Dubuque, Iowa, USA.
- Carlander, Kenneth D. 1969. Handbook of freshwater fishery biology, Volume 1. Iowa State University Press, Ames, Iowa, USA.
- Carlander, Kenneth D. 1977. Handbook of freshwater fishery biology, Volume 2. Iowa State University Press, Ames, Iowa, USA.

## RECAP

## Recruitment failure can occur due to:

- Overfishing
- Habitat alteration
- Abiotic events
- Biotic events

## Recruitment failure can lead to

- reduced adult abundance
- reduce angler catch rates

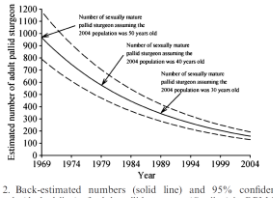
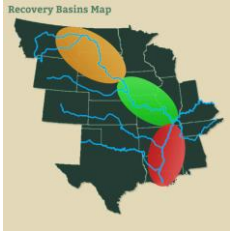



Fig. 2. Back-estimated numbers (solid line) and 95% confidence intervals (dashed line) of adult pallid sturgeon (*S. albus*) in RPMA 2 by year

## In severe cases

Populations can collapse



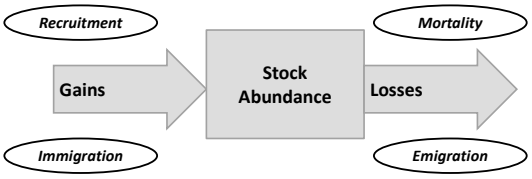

## Example…

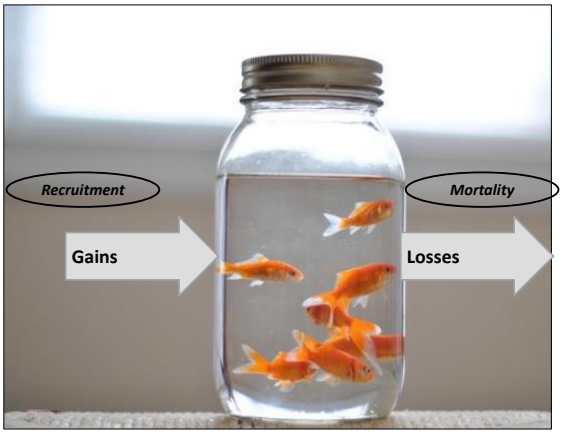
- Defenders of Wildlife are suing USACE, USFWS, and BOR


## Recruitment booms

- Strong recruitment can lead to abundant adults and high catch rates-assuming density-dependent factors are not excessive
- Recruitment can be a major determinate of population dynamics

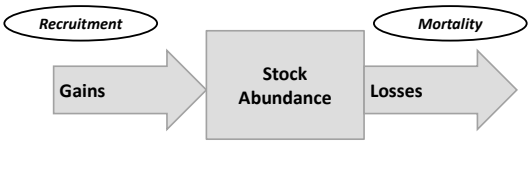
## Fish dynamics



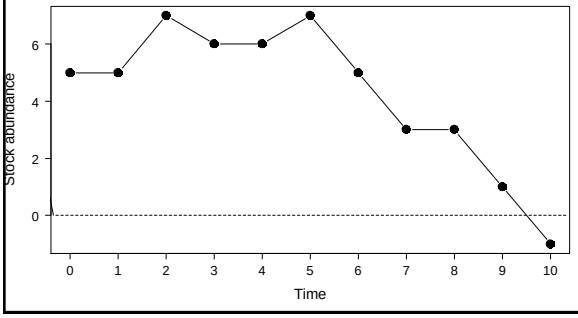

## Fish dynamics

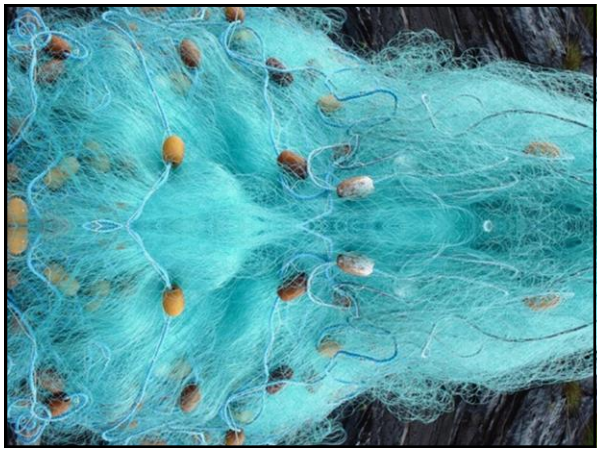
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Recruitment | 3 | 5 | 2 | 3 | 4 | 1 | 1 | 3 | 1 | 1 |
| Mortality | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |




**Assuming no immigration or emigration**

## What's wrong with these dynamics?





## Stock recruit relationship

Recruits

*What do you expect this relationship to look like?*

Spawner abundance

## Recruits/spawner relationship

Recruits per spawner

*What do you expect this relationship to look like?*

Spawner abundance

## Some principles for stock recruit models

1. Must pass through origin
2. Recruits must exceed spawners over some part of the ranges of stock size

## Stock recruit relationship

Recruits

$Recruits = a + b \cdot Spawners$

**Recruitment increases linearly with stock abundance**

**Is this biologically reasonable?**

Spawner abundance

## Recruits/spawner relationship

Recruits per spawner

$\frac{Recruits}{Spawner} = a$

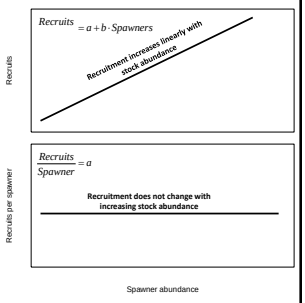
**Recruitment does not change with increasing stock abundance**

**Is this biologically reasonable?**

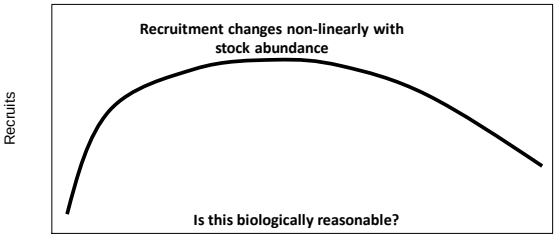
Spawner abundance

## Density independent if

- Number of recruits increases at a constant **rate** (i.e., *b*)
- Recruits-per-spawner is **constant** (i.e., *a*) for all numbers of spawners.

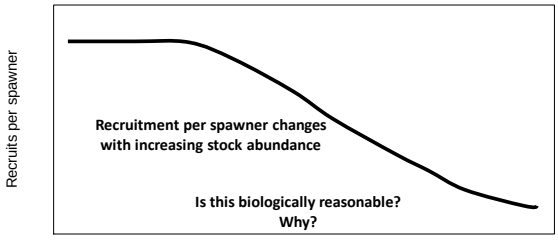



## Stock recruit relationship




Spawner abundance

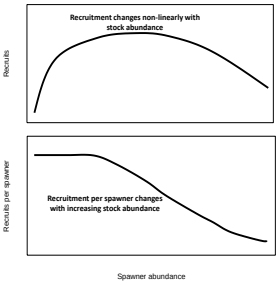
## Recruits/spawner relationship



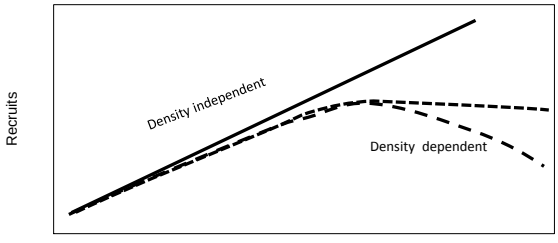

Spawner abundance

## Density Dependence if…

- Number of recruits does **not** increase at a constant **rate**
- Recruits-per-spawner ***decreases*** with increasing number of spawners




## Putting them all together

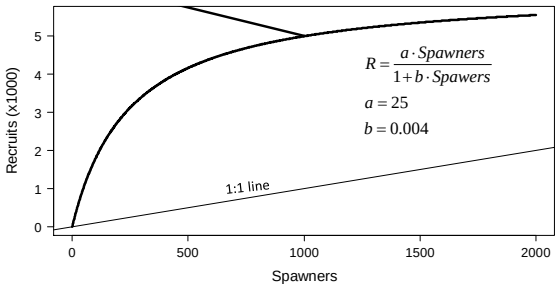



Spawner abundance

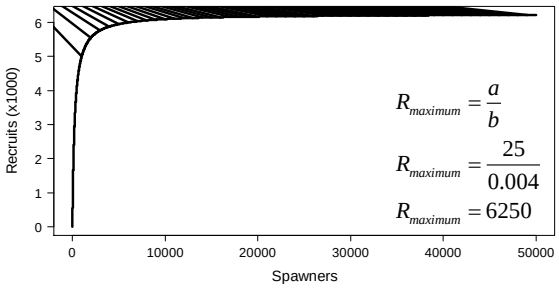
## Stock recruit relationships

1. Beverton-Holt
2. Ricker
3. Sheperd
4. Others exist…

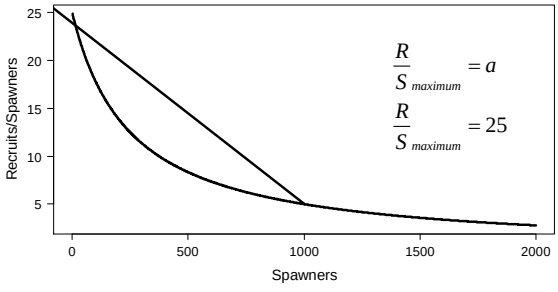
## Beverton-Holt




## Beverton-Holt: Recruits/spawner




## Maximum recruits/spawner

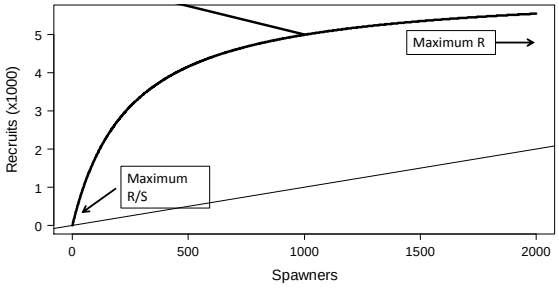



## Beverton-Holt

$R = \frac{a \cdot Spawners}{1 + b \cdot Spawers}$

$a = 25$

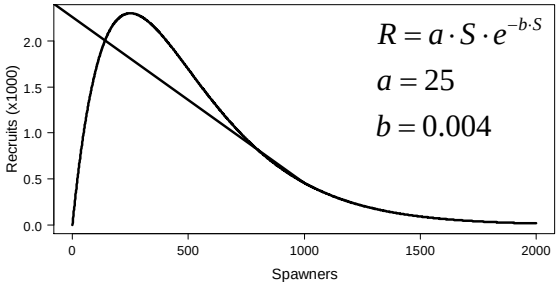
$b = 0.004$



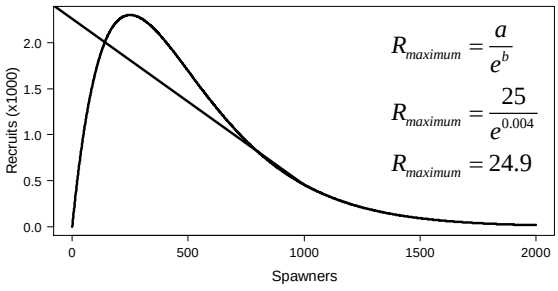

## Beverton-Holt

- Asymptotic recruitment
- Recruits limited by:
  - Food
  - Space
  - Habitat
- Many marine species

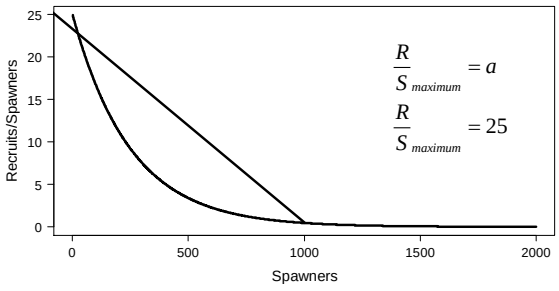
## Ricker



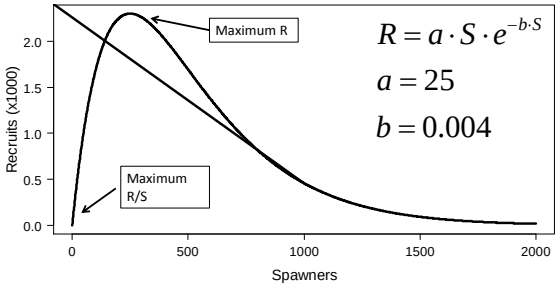
## Maximum recruits




## Ricker: Recruits/spawner




## Ricker



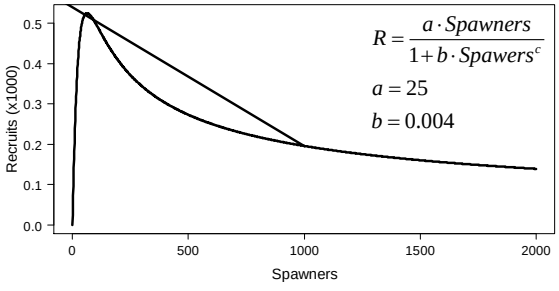

## Ricker model

- Recruitment declines at high stock sizes
- Recruits limited by cannibalism, redd superimposition
- Typical for anadromous species

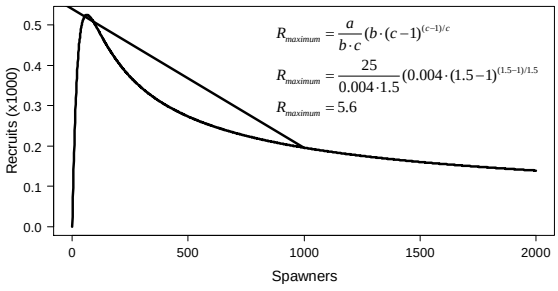
## Beverton-Holt and Ricker

- Both models contain density dependent and density independent terms
- Compensatory mortality reduces recruitment at high stock levels

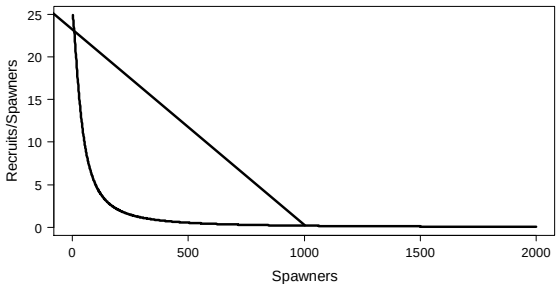
## Sheperd curve



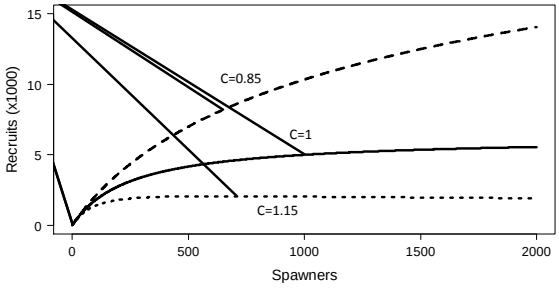
## Maximum recruits




## Maximum R/S



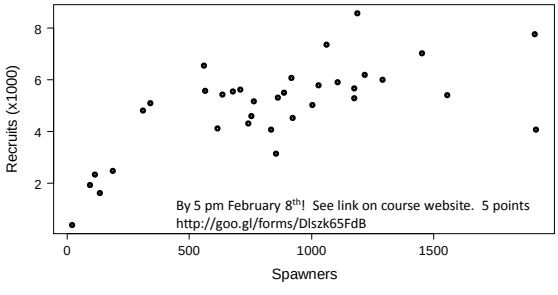

## Flexible




## Sheperd model

- c<1 density independent
- c=1 Beverton-Holt model
- c>1 Ricker model

## Which model would you fit?




## Stock recruit or environment?

- Current debate
- Which one drives the show
- Variability & environment?
- Spawning stock?
- Life history & environment?
- Rich research area

## r versus K selection

- Stable environments tend to make few, "expensive" offspring
  - Nest guarders, mouth brooders…parental care
- Unstable environments tend to make many, "cheap" offspring.
  - Broadcast spawners

## Parental care

## Broadcast spawning