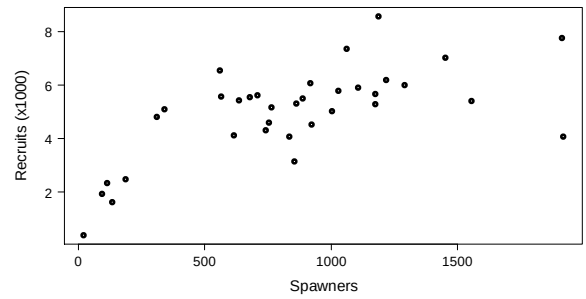
WF4113-Fisheries Science

Lecture 10: Population and harvest dynamics

Housekeeping

- No lab… Will post and you can do as a take home.
- Exam I is Wednesday February 15th.
- Multiple choice
- True false
- Intepretation
- Will post some examples on web

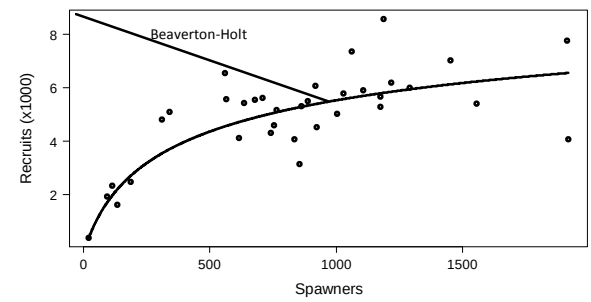
Which model would you fit?



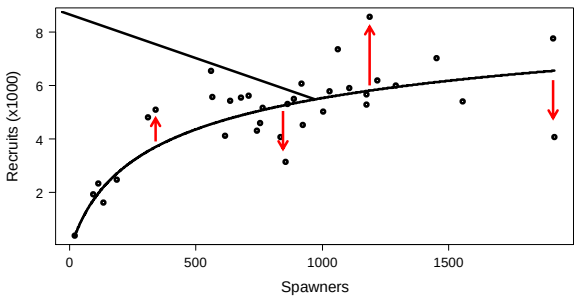
Responses

Model	Count
Ricker	3
Beverton Holt	11
Sheperd	0

And the winner was



Recruitment variability



Recruitment variability

- Match-mismatch: food resources don't match emergence timing
- Micropredation: smaller fish eating eggs
- Allee effect: spawners have a tough time finding each other
- Depensation?
- Depensation-offspring reduced at low spawning levels

Recruitment variability

- Temperature-incubation time
- Water quality-turbidity,
- Spawning Habitat-gravel, aerated substrates
- Macrophytes-needed to spawn for some fish
  Water levels-access to spawning areas

Fisheries icon: Emmaline Moore

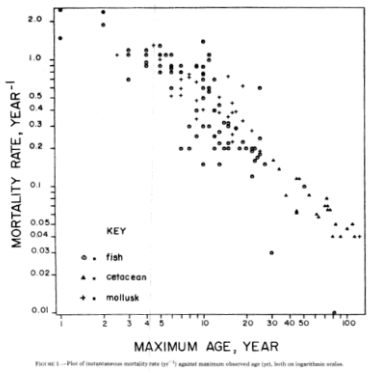
- Summer investigator for the U.S. Bureau of Fisheries
- Ph.D. in 1916 in biology from Cornell

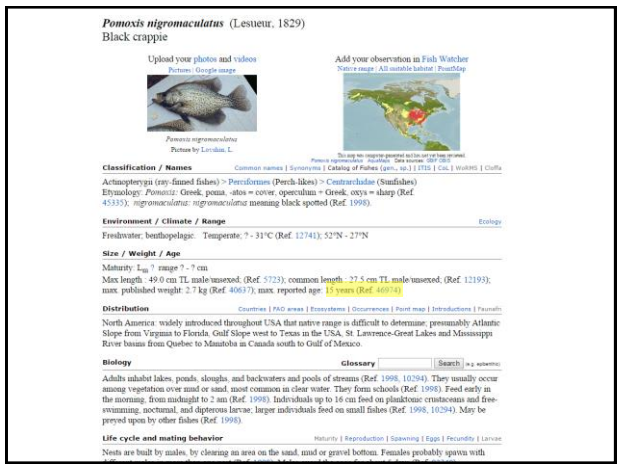
Penn Yan, July 21, 1915 - Miss Emmeline Moore of Churchville, N.Y., Ph.D. (student) Cornell University and an instructor in botany at Vassar College, passed through this village yesterday afternoon in an automobile en route to Lakes Waneta and Lamoka to spend some time in the investigation of water plant and weed life for which these lakes offer unusual opportunity. Miss Moore fishes with a long handled rake or grappling device from a flat bottomed boat, and usually locates her prey at a depth of fifteen feet or less. (Comment: the reporter appeared to be slightly confused over fish or plants.)

Claims to fame

- 1920 she became the first woman biologist for the New York State Department of Conservation.
- She undertook a fish productivity study delineating the biological, chemical, and physical characteristics of Lake George.

Hoenig, J. M. 1983. Empirical Use of Longevity Data to Estimate Mortality Rates. Fishery Bulletin 82:898-903.





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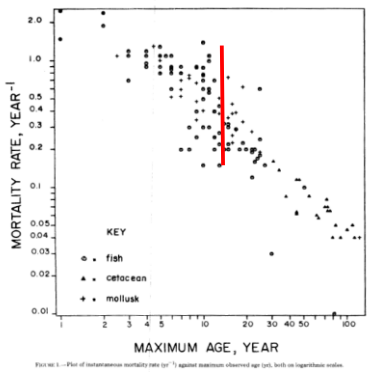


Total mortality (*Z*)

$Z = F + M$

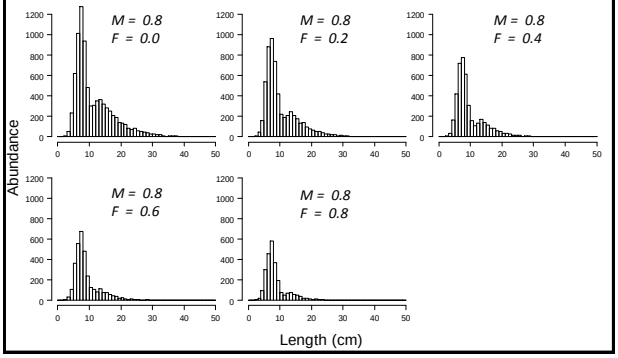
Where,

F = Fishing mortality

M = Natural mortality

Difficult to estimate *F* and *M*

Effect of fishing on size structure

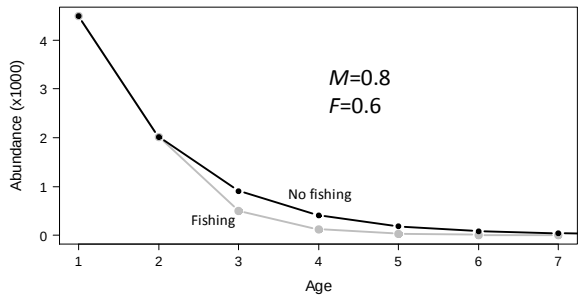


The effects of fishing may be obfuscated

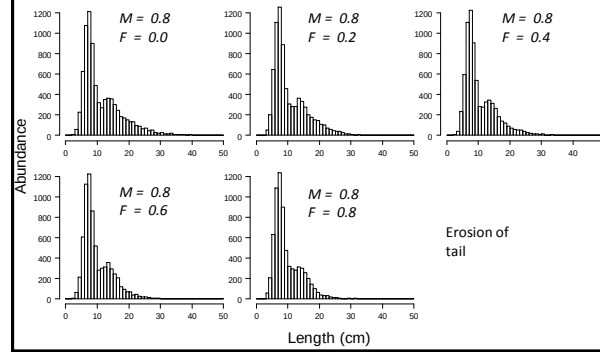
Lake	County	Length Limit	Creel Limit
Enid Lake	Yalobusha, Lafayette, Panola	12" MLL	20
Grenada Lake	Grenada, Calhoun, Yalobusha	12" MLL	20
Horn Lake	Desoto Co.	10" MLL	30
Lake Okhissa	Franklin	10"MLL	10
Lake Washington	Washington	10" MLL	30 (5 under 10")
Moon Lake (includes part east of Hwy 1)	Coahoma	10" MLL	30 (5 under 10")
Pickwick & Tenn-Tom Waterway	Hwy 25 in Divide Section to Aliceville Lock & Dam	9" MLL	30
Sardis Lake	Lafayette, Marshall, Panola	11" MLL	15
Spillways of Arkabutla Enid Grenada Sardis & Barrow Lake	To Prichard Road Bridge To I-55 To Hwy 51 To Spaulding Creek		20 20 20 20

http://www.mdwfp.com/media/218652/creel_limits_pt._3_chaper_1.pdf

Effect of fishing



Fish > age 2 recruited to fishery



Types 1 fishing mortality

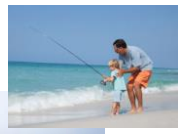
- F and M occur concurrently
- Generally assume F and M are distributed proportionally throughout year
- Most fisheries models assume this

Types 2 fishing mortality

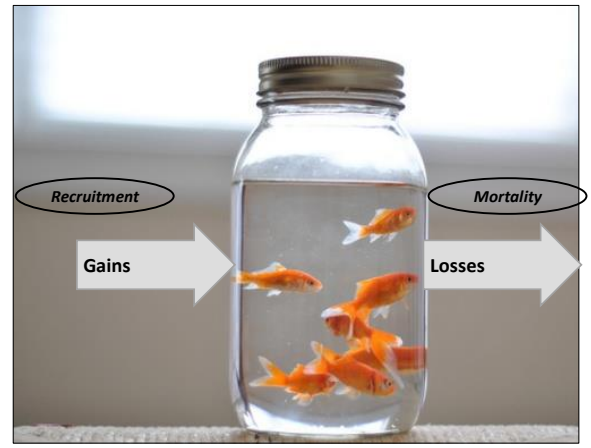
- F and M separated in time
- F during intense, short season (days - few months)
- M during rest of year
- Less common; sometimes less efficient

Types of fisheries

1. Recreational
2. Commercial
3. Subsistence
4. Culture



GAINS AND LOSSES DEPENDENT ON POPULATION ABUNDANCE



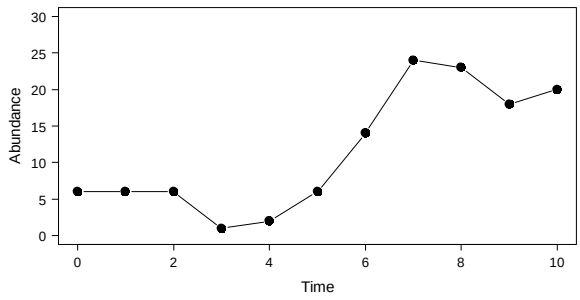
What if rates vary over time?

Time (years)	Gains (fish year^{-1})	Losses (fish year^{-1})	Net (fish year^{-1})
1	2	2	0
2	3	3	0
3	4	9	-5
4	6	5	1
5	8	4	4
6	9	1	8
7	12	2	10
8	4	5	-1
9	1	6	-5
10	6	4	2

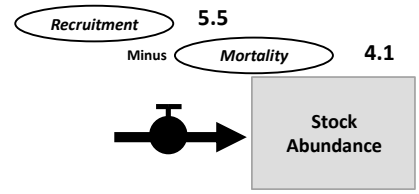
How do the dynamics play out?

dA/dt		0	0	-5	1	4	8	10	-1	-5	2
Abund.	6										

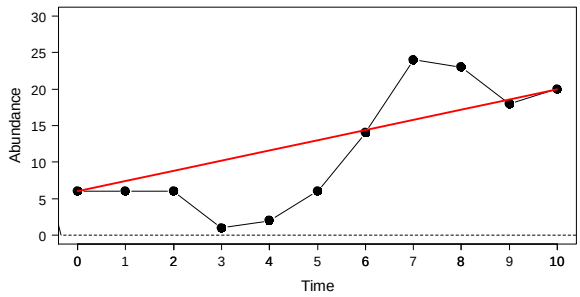
True population dynamics



Fish dynamics

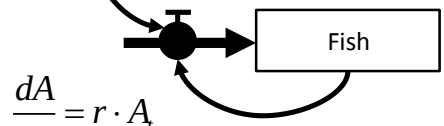


Average population dynamics



Exponential population model

Intrinsic growth rate (r) $r = 2$



$$\frac{dA}{dt} = r \cdot A_t$$

Year	Fish
1	2
2	
3	
4	
5	

$$\frac{dA}{dt} = r \cdot A_t$$

$$\frac{A_{t+dt} - A_t}{dt} = r \cdot A_t$$

$$A_{t+dt} - A_t = dt \cdot r \cdot A_t$$

$$A_{t+dt} = A_t + dt \cdot r \cdot A_t$$

Notation

Change in Abundance

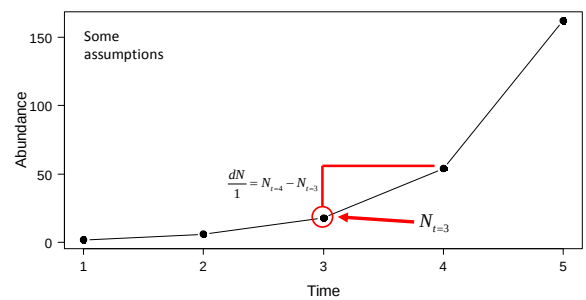
Intrinsic growth rate

$$\frac{dA}{dt} = r \cdot A_t$$

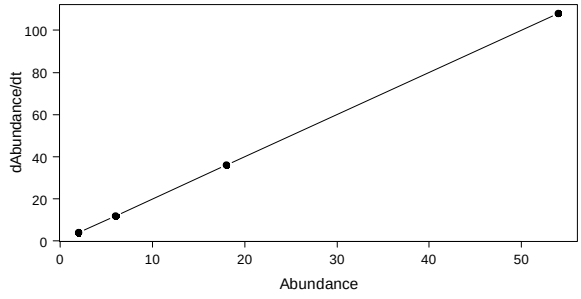
Change in time

Abundance

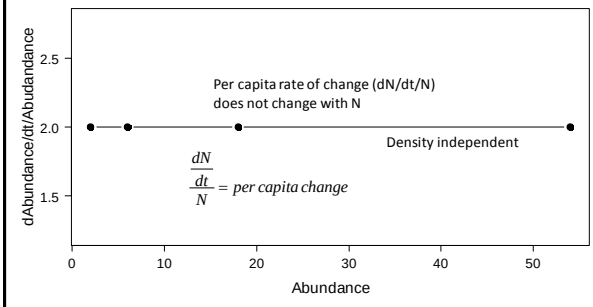
Exponential population model



dAbundance/dt versus Abundance



dAbundance/dt/Abundance versus Abundance

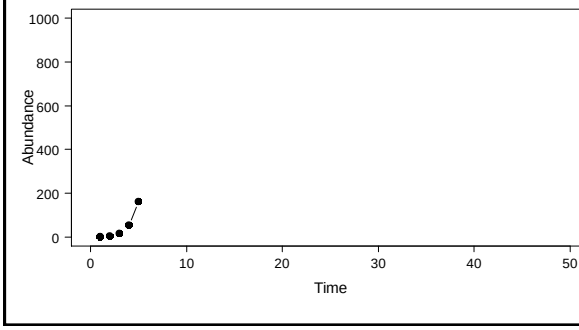


Assumptions

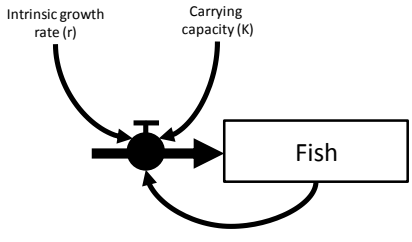
- Growth dependent on population size
- No density dependence

$$\frac{dA_t}{dt} = r \cdot A_t$$

Is this biologically reasonable?

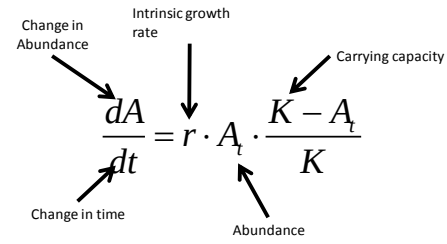


Graham-Schaefer model



$$\frac{dA}{dt} = r \cdot A_t \cdot \frac{K - A_t}{K}$$

Notation



Dynamics

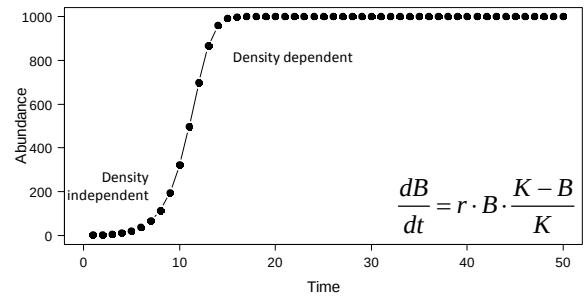
$$\frac{dA}{dt} = r \cdot A_t \cdot \frac{K - A}{K}$$

$$\frac{A_{t+dt} - A_t}{dt} = r \cdot A_t \cdot \frac{K - A_t}{K}$$

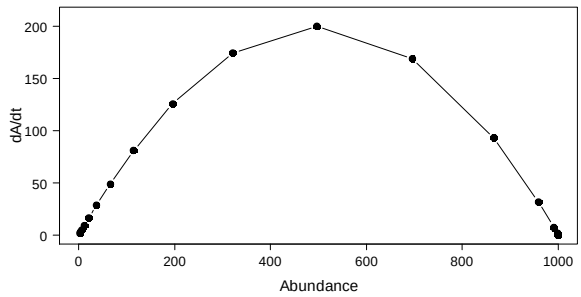
$$A_{t+dt} - A_t = dt \cdot \left(r \cdot A \cdot \frac{K - A_t}{K} \right)$$

$$A_{t+dt} = A_t + dt \cdot \left(r \cdot A_t \cdot \frac{K - A_t}{K} \right)$$

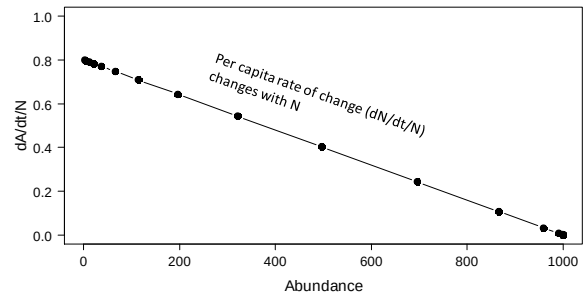
Graham-Schaefer model

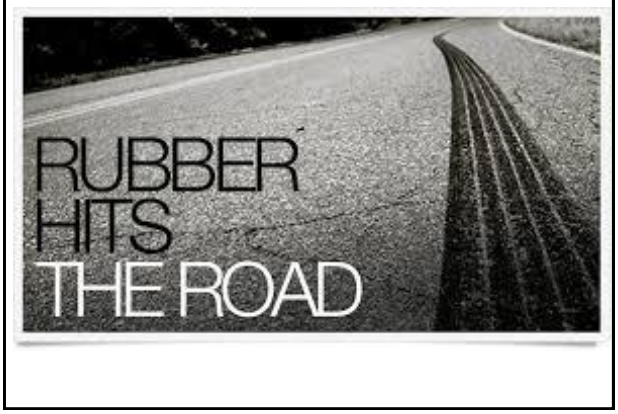


dA/dt versus Abundance



dN/dt/N versus N

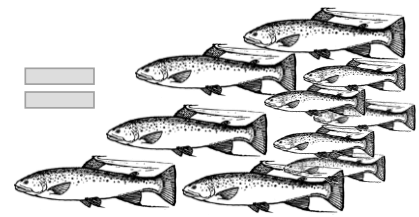




Thinking *inside* the box

Fish	Value	Habitat

10 Fish or 28 Kilograms



Thinking *inside* the box

Fish | Value | Habitat

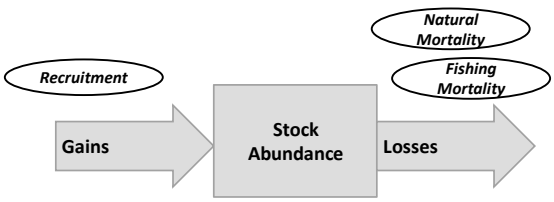
1. Population characteristics
2. Population dynamics

Thinking *inside* the box

Fish | Value | Habitat



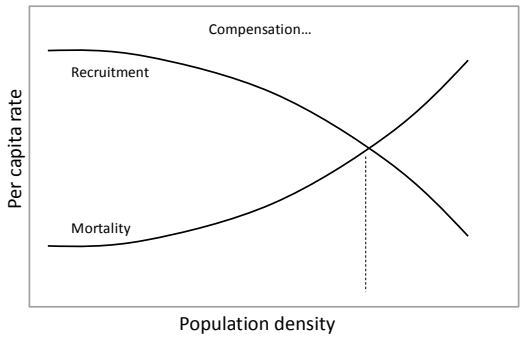
Fish population dynamics



Surplus production

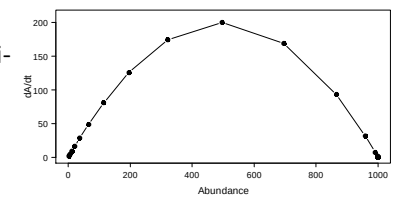
- Compensatory effect of harvest
- Fish populations produce more offspring than necessary to replace themselves
- Harvest the 'doomed surplus', those fish that were going to die anyways
- Harvest has no effect on stock…

Surplus production



Surplus production

- Should be able to estimate the amount of surplus production
- Fish the population at that level
- Basis for maximum – yiedl



Sustainability

1. Ability to persist in the long-term. Often used as “short hand” for sustainable development;

2. Characteristic of resources that are managed so that the natural capital stock is non-declining through time, while production opportunities are maintained for the future.

https://www.st.nmfs.noaa.gov/st4/documents/FishGlossary.pdf