WF4313/6413-Fisheries Management

Class 4

Announcements

MsState AFS Meeting

Date: *Wednesday, Sept. 12, 2018*

Place: Thompson Hall, Room 118

5:00 PM

Pizza and Drinks provided at all meetings

Questions?

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Dedicated to Strengthening the Fisheries Profession, Advancing Fisheries Science, & Conserving Fisheries Resources

AMERICAN FISHERIES SOCIETY
MISSISSIPPI STATE UNIVERSITY STUDENT SUB-UNIT

Announcements

- Reminder to see website for content, links, and so on. https://mcolvin.github.io/WFA4313-Fisheries-Management/
- Lab groups same as last week

1. Understand the importance of abundance and biomass in fisheries
2. Approaches to model biomass dynamics
3. How populations are structured

CLASS OBJECTIVES

Fish dynamics

Fish dynamics: state variables

Abundance

State Variable: Something **measureable & can stored or lost over time**:

- Abundance
- Biomass

Fish dynamics: processes

Fish dynamics: Mechanisms

Fish dynamics: Mechanisms

Gains:

1. Recruitment
2. Immigration
3. Stocking
4. Other(s)?

Losses:

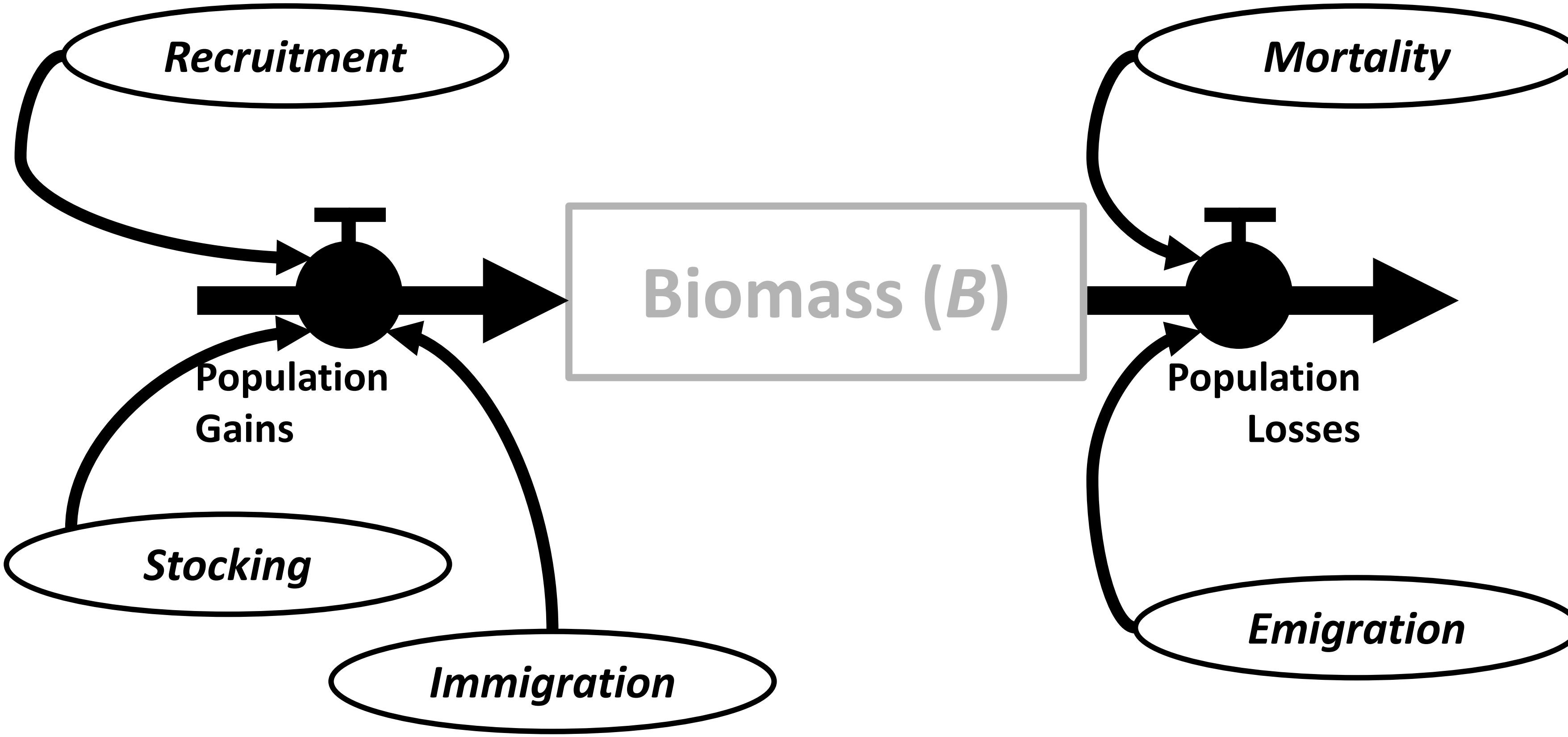
1. Mortality
   a) Fishing
      a) Commercial
      b) Recreational
   b) Natural
      a) Predation
      b) Pathogen
2. Emigration
3. Other(s)?

Processes & Mechanisms

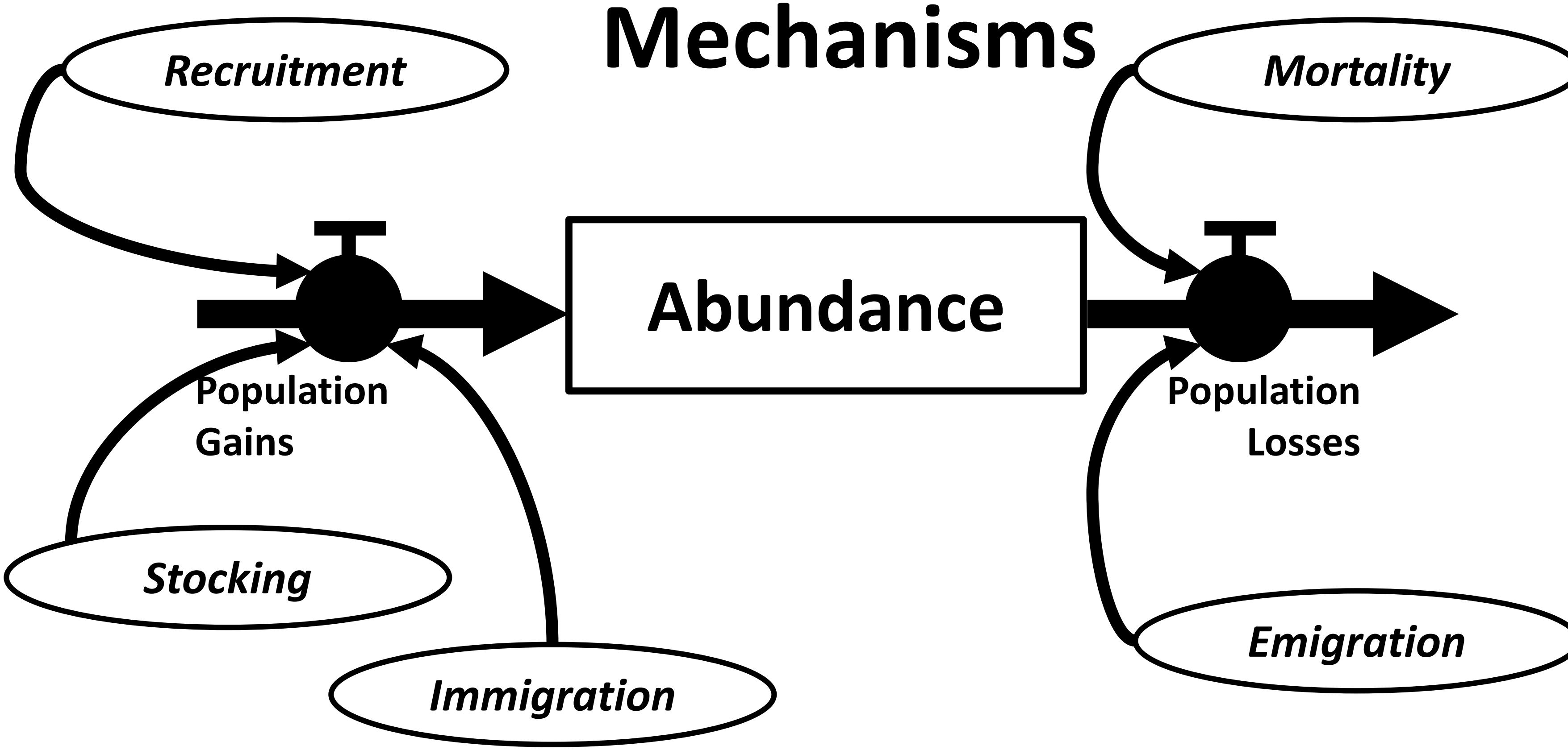
$$Gains = \quad recruitment + stocking + immigration$$

$$Losses = \quad mortality + emigration$$

Fish dynamics: States, Processes, & Mechanisms



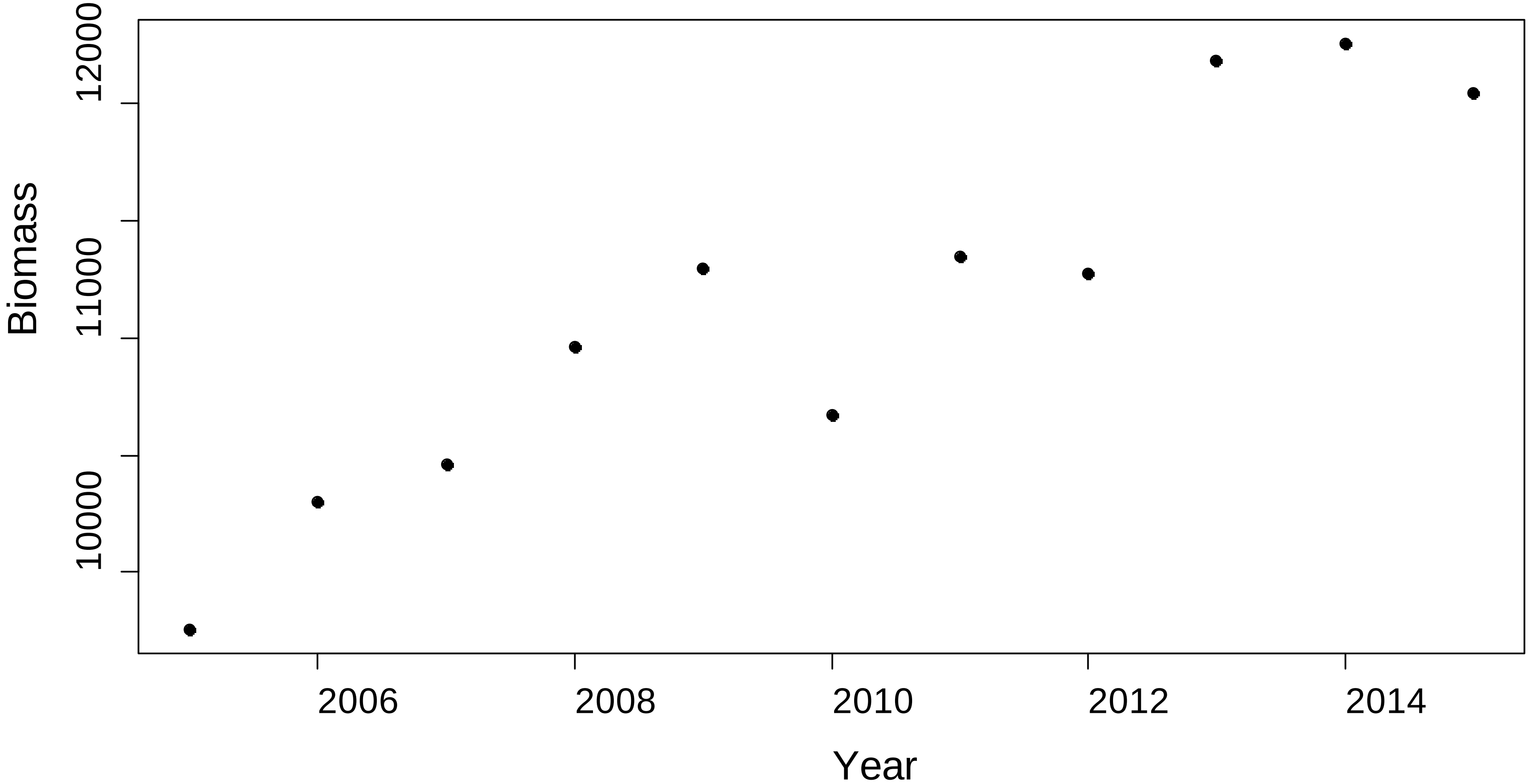
Fish dynamics: States, Processes, & Mechanisms



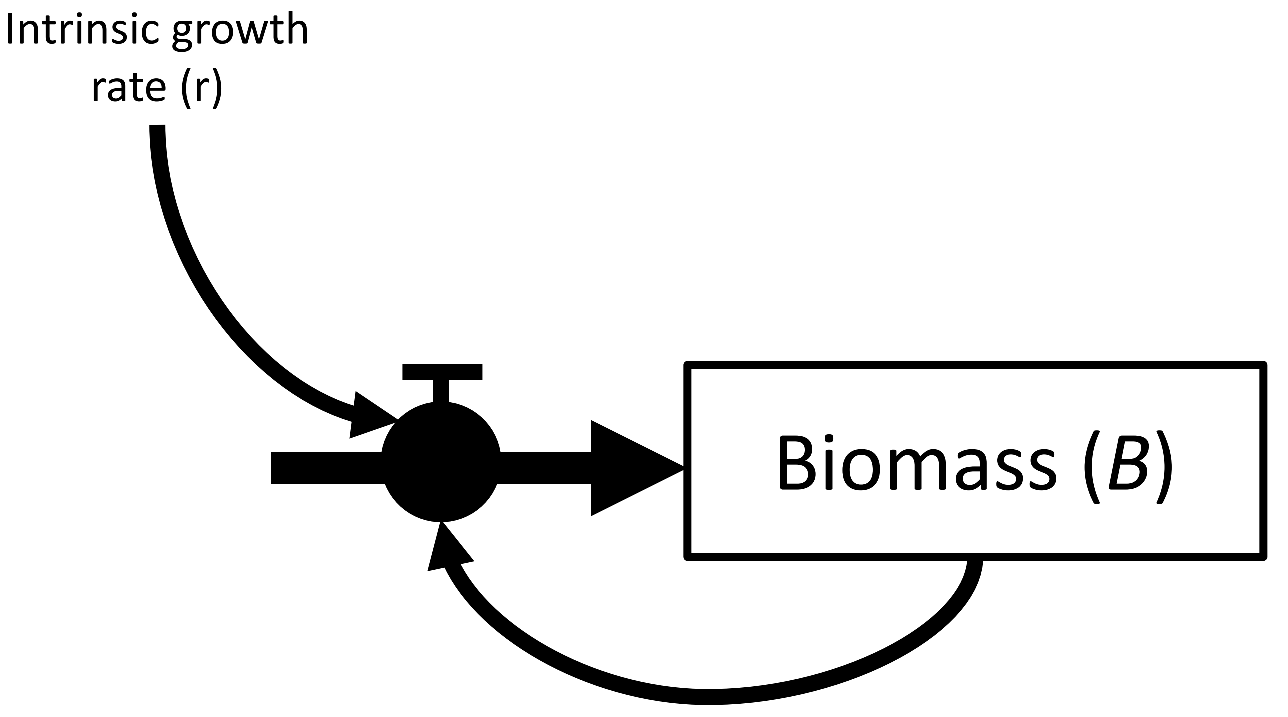
$$\frac{dAbundance}{dt} = \left(recruitment + stocking + immigration\right) - \left(mortality + emigration\right)$$

WFA 4313/6613
Why do we talk about biomass all the time?

Some biomass dynamics

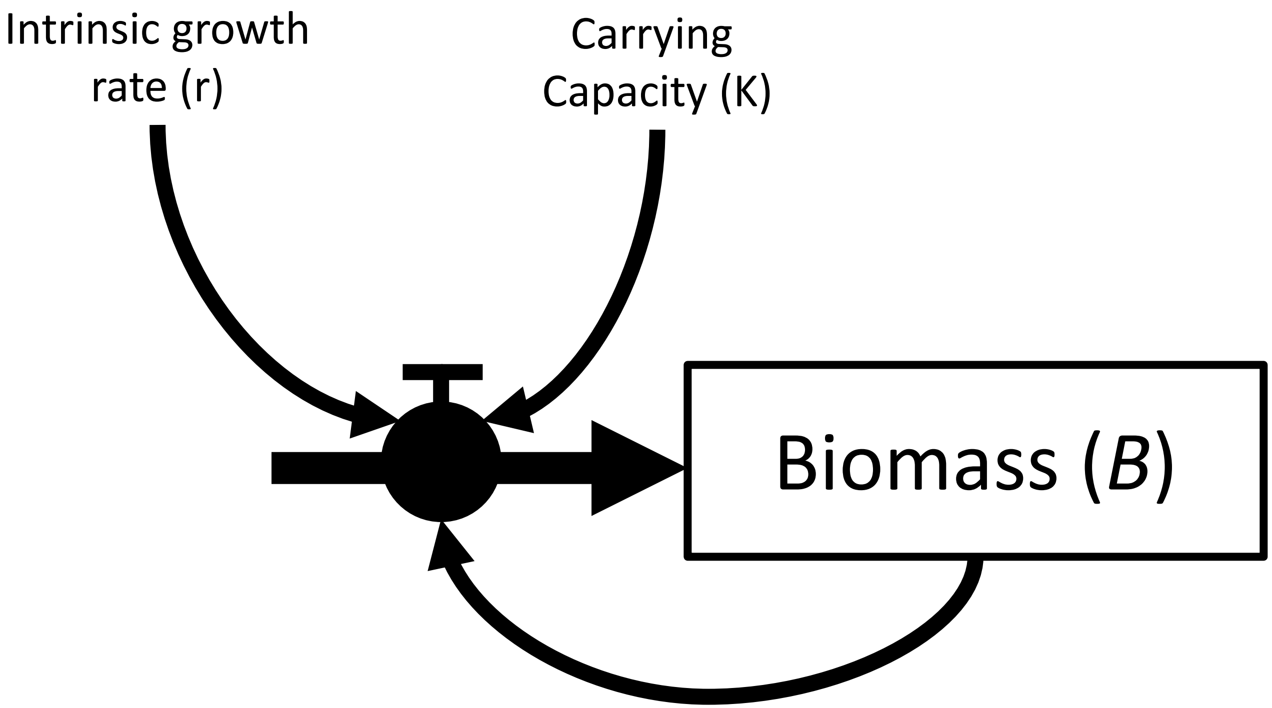


Exponential population model



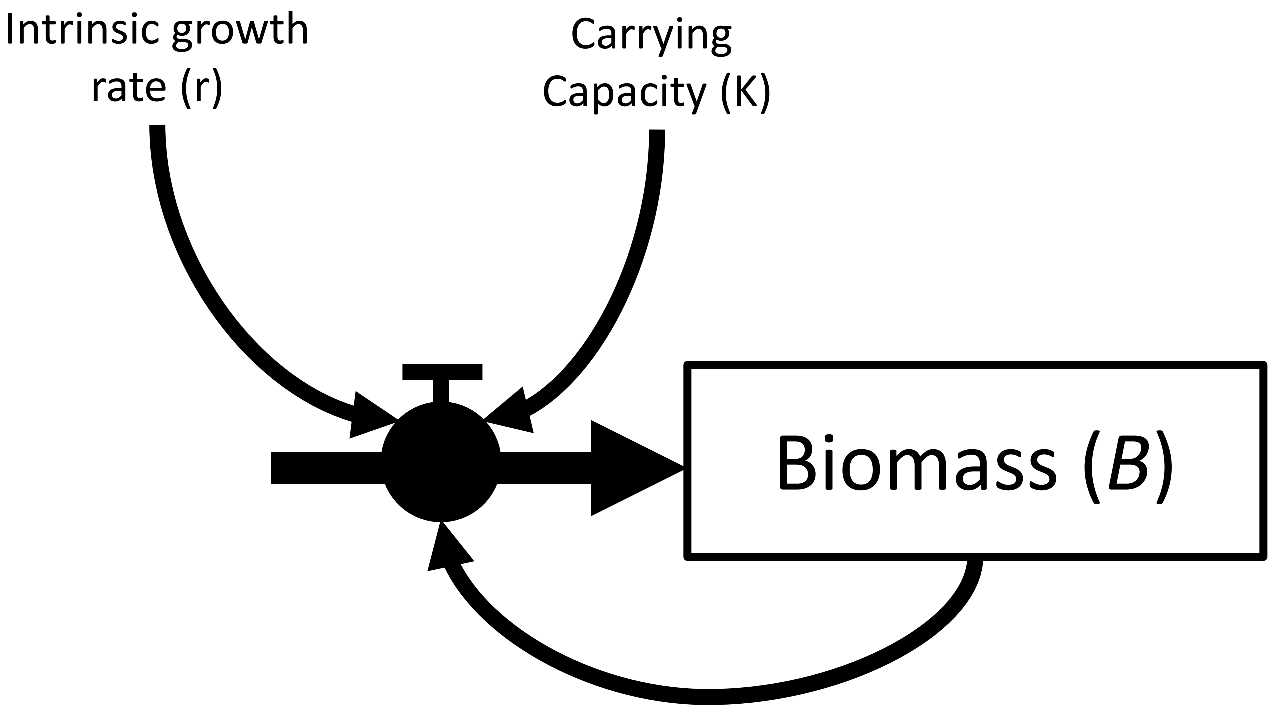
$$\frac{dB}{dt} = r \cdot B$$

Graham-Schaefer model



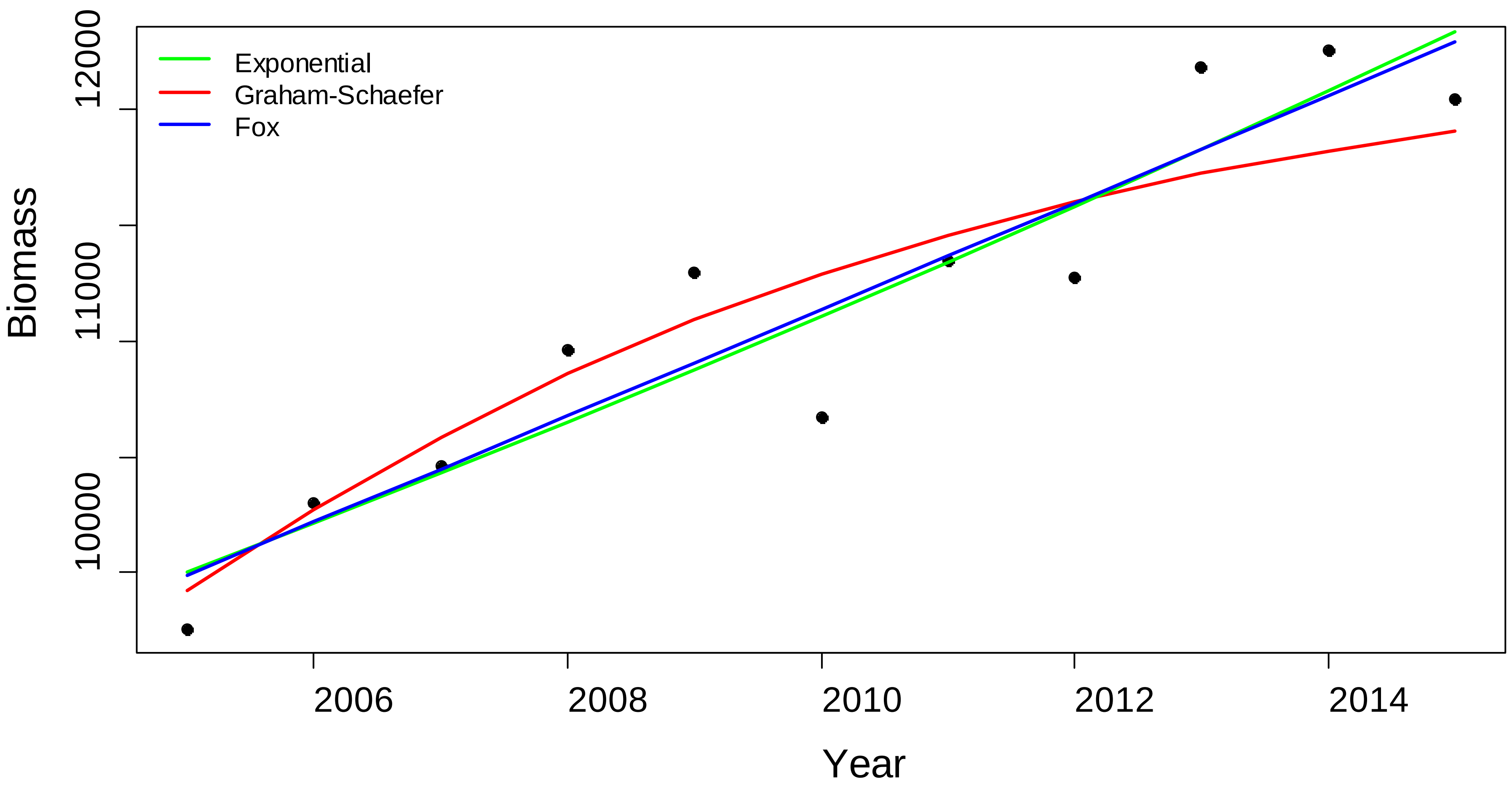
$$\frac{dB}{dt} = r \cdot B \cdot \frac{K - B}{K}$$

Fox model



$$\frac{dB}{dt} = r \cdot B \cdot \left(1 - \log_e \frac{B}{K}\right)$$

Fitting models to the data…



Management Objective: Maximize sustainable harvest

$$\frac{dB}{dt} = r \cdot B - F \cdot B$$

$$\frac{dB}{dt} = r \cdot B \cdot \frac{K - B}{K} - F \cdot B$$

$$\frac{dB}{dt} = r \cdot B \cdot \left(1 - \log_e \frac{B}{K}\right) - F \cdot B$$

Management Objective: Maximize sustainable harvest

$$\frac{dB}{dt} = r \cdot B - \boxed{F \cdot B}$$

Amount harvested!

$$\frac{dB}{dt} = r \cdot B \cdot \frac{K - B}{K} - \boxed{F \cdot B}$$

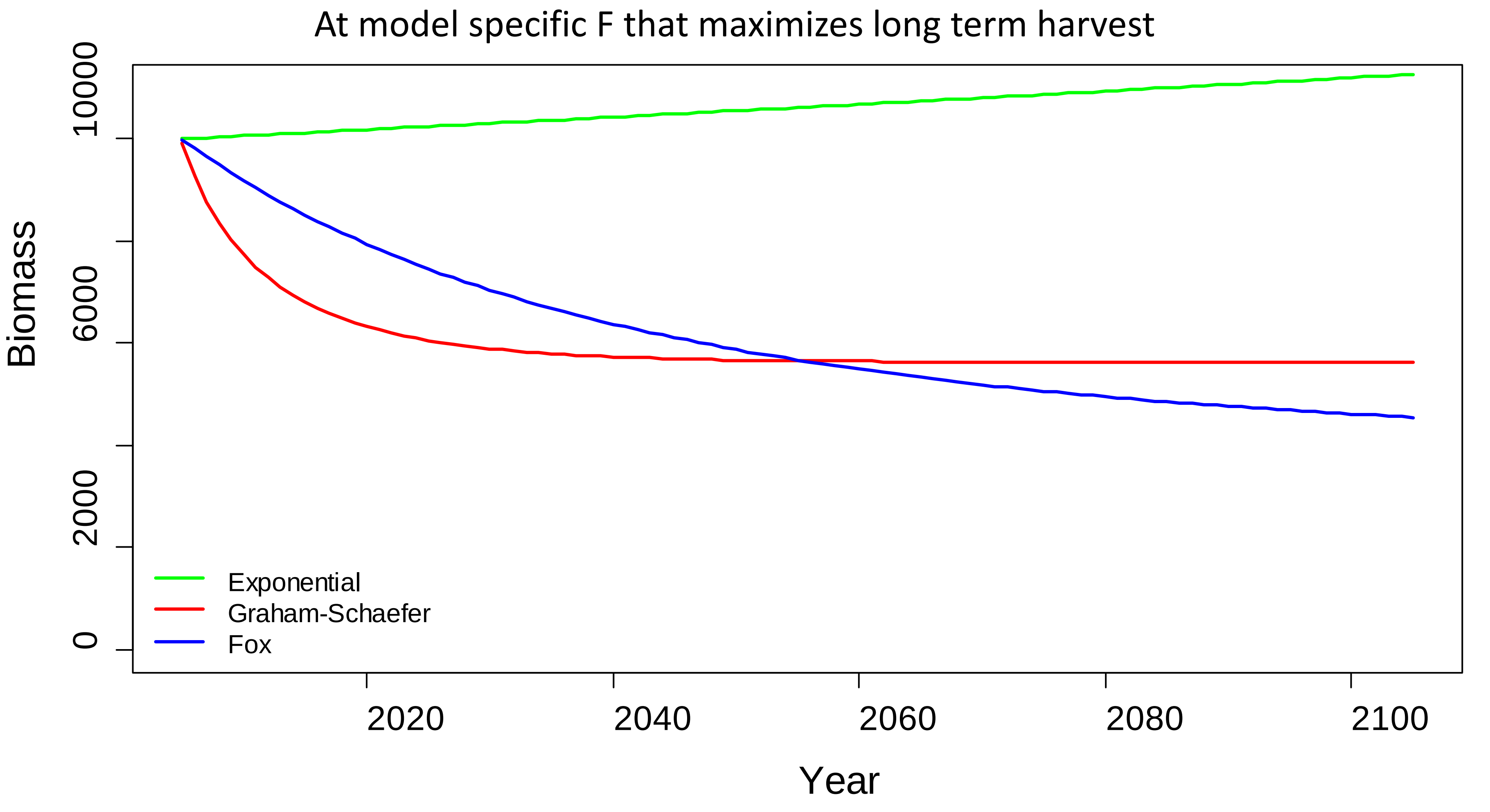
$$\frac{dB}{dt} = r \cdot B \cdot \left(1 - \log_e \frac{B}{K}\right) - \boxed{F \cdot B}$$

What is the best *F*?

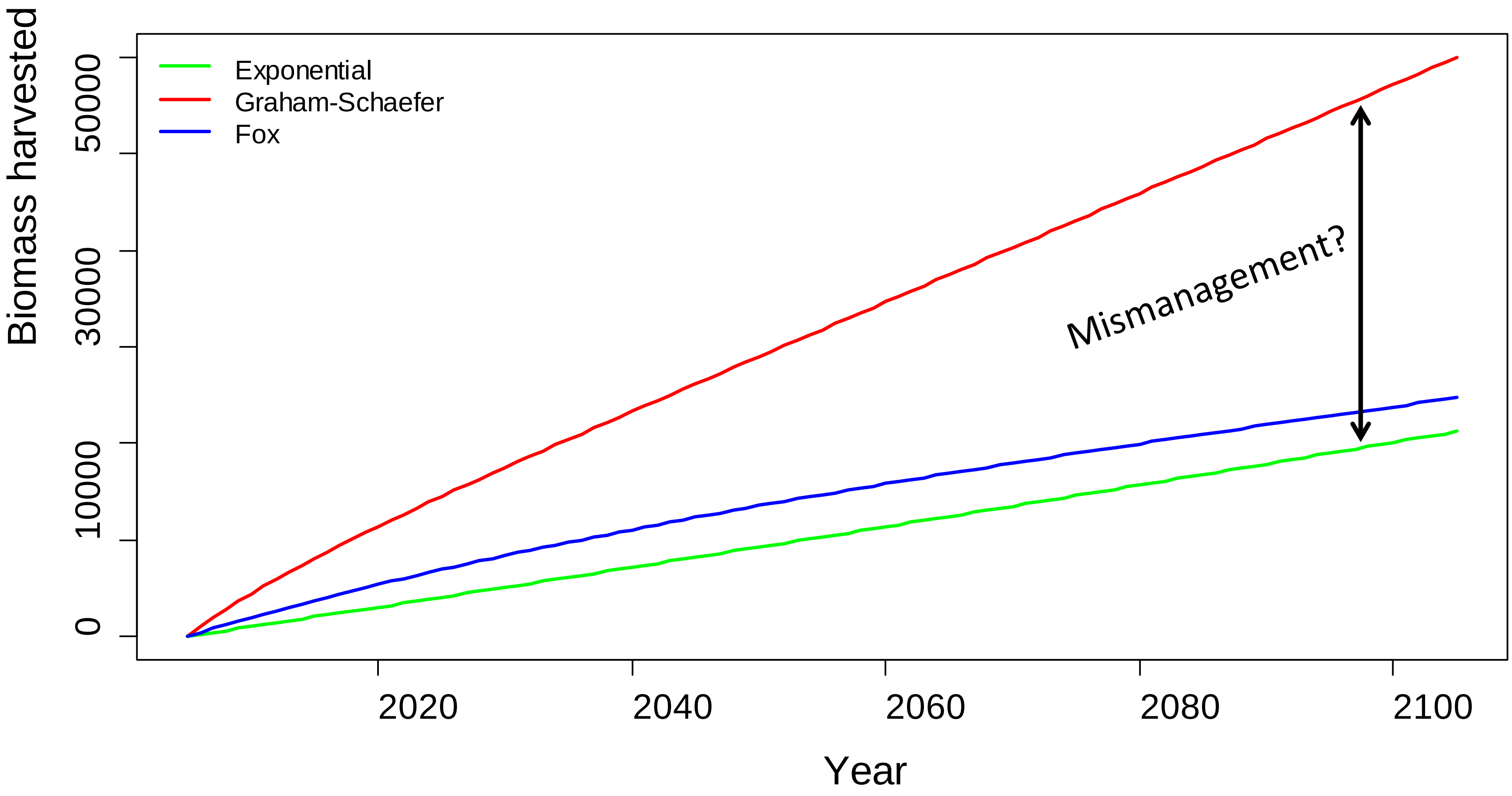
- Maximizes long term harvest-management objective
- Use fitted models to forecast
- Evaluate *F* for 0 to 0.5 by values of 0.02

	F	gs	exp	fox
[1,]	0.00	0.00	0.00	0.00
[2,]	0.02	21779.79	21224.10	21646.35
[3,]	0.04	38577.48	18080.53	24713.71
[4,]	0.06	50464.39	15164.34	22688.42
[5,]	0.08	57546.80	13571.16	19928.11
[6,]	0.10	59994.16	12685.12	17609.71
[7,]	0.12	58101.77	12144.02	15893.78
[8,]	0.14	52437.50	11783.38	14672.49
[9,]	0.16	44146.05	11526.45	13805.45
[10,]	0.18	35243.40	11334.22	13180.18
[11,]	0.20	27959.85	11184.99	12718.09
[12,]	0.22	23121.18	11065.78	12367.03
[13,]	0.24	20132.50	10968.37	12092.99
[14,]	0.26	18218.05	10887.27	11873.68
[15,]	0.28	16903.07	10818.70	11694.29

Forecasted biomass dynamics



Forecasted biomass harvested



Key point

- The optimal management decision depended on the model, was not the same!
- Structural uncertainty: we do not know with certainty the model governing biomass dynamics
- Working off of one model, mathematical or in your head, can lead to mismanagement!

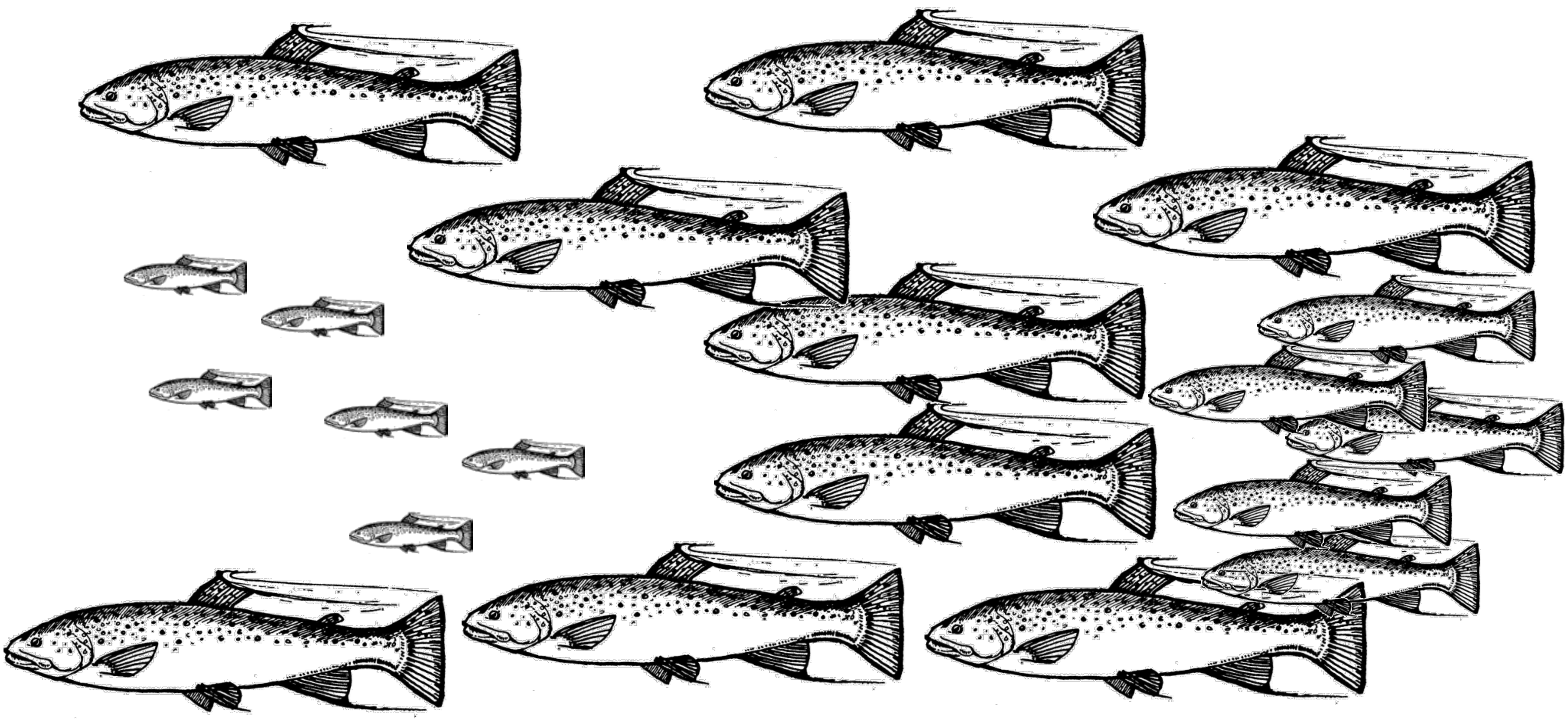
Commercial versus Recreational Objectives

Objective: Biomass

Objective: Size, Catch rate

A Population

Unstructured or structured?

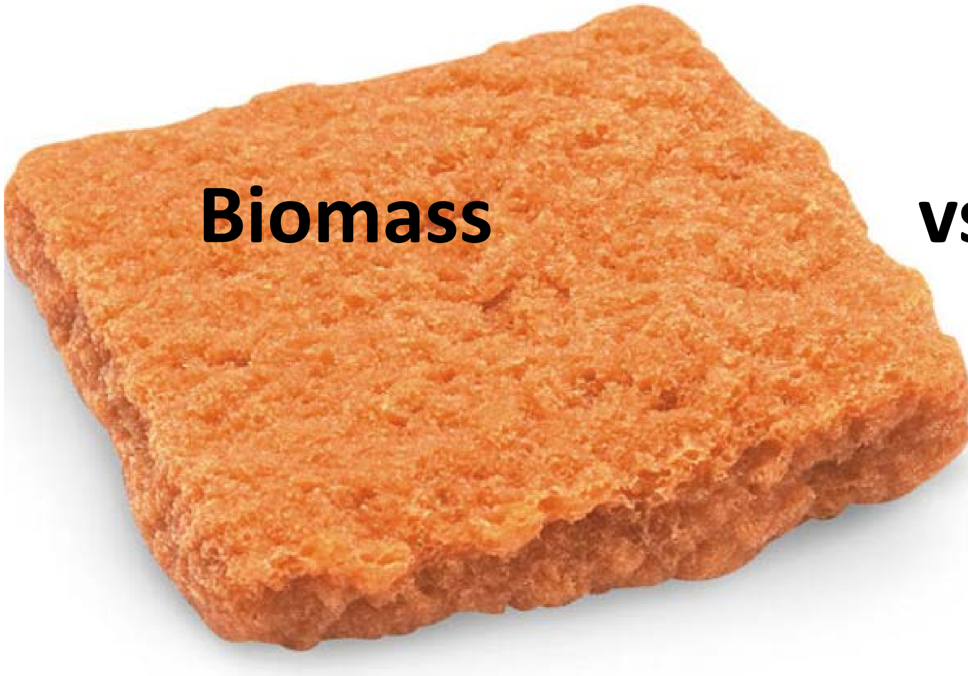


$$Biomass = \sum Abundance \cdot Weight$$

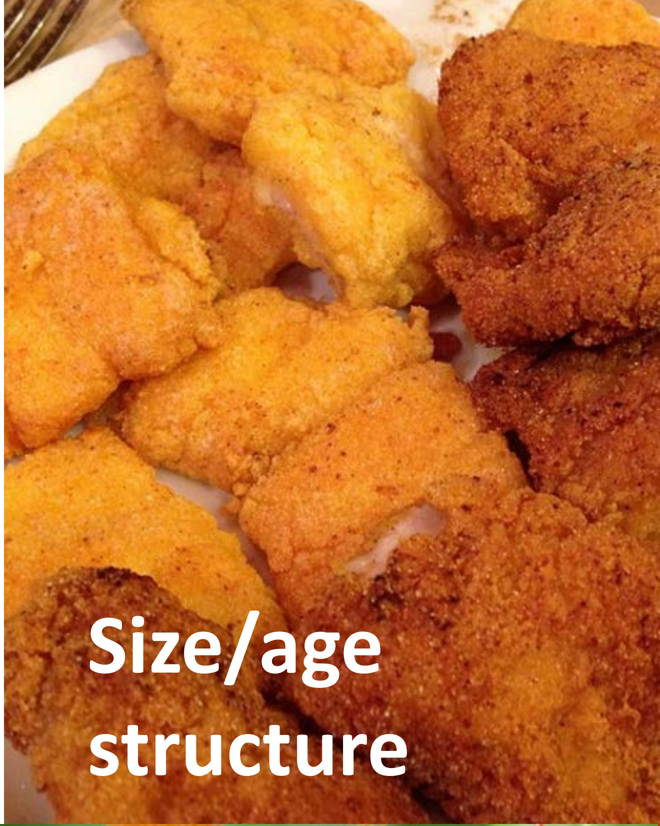
Or

$$Biomass = \sum Abundance_{age} \cdot Weight_{age}$$

Biomass is a function of number of fish and the size of those fish which varies by age



vs.



Thinking in terms of fish year class

$$\frac{dN}{dt} = -Z \cdot N$$

Where,
N_{t+dt} = number alive at time *t*
N_t = number alive at time *t*
Z = instantaneous total mortality rate
dt = time units

$$\frac{N_{t+dt} - N_t}{dt} = -Z \cdot N_t$$

$$N_{t+dt} - N_t = -Z \cdot N_t \cdot dt$$

$$N_{t+dt} = N_t + (-Z \cdot N_t \cdot dt)$$

Mortality types

Total Mortality (*Z*) is comprised of:

- Natural (*M*)
    1. Predation
    2. Disease, contaminants, toxicants
    3. Senescence
- Fishing (*F*)

Total mortality (*Z*) is *M*+*F*

Cohort: definition

1. In a stock, a group of fish generated during the same spawning season and born during the same time period;
2. In cold and temperate areas, where fish are long-lived, a cohort corresponds usually to fish born during the same year (a year class). For instance, the 1987 cohort would refer to fish that are age 0 in 1987, age 1 in 1988, and so on. In the tropics, where fish tend to be short lived, cohorts may refer to shorter time intervals (e.g. spring cohort, autumn cohort, monthly cohorts).

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

Year Class: definition

Fish in a stock born in the same year. For example, the 1987 year class of cod includes all cod born in 1987. This year class would be age 1 in 1988, age 2 in 1989, and so on. Occasionally, a stock produces a very small or very large year class that can be pivotal in determining stock abundance in later years.

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

Year class dynamics

$$Z = 0.25$$

$$A = 1 - e^{-Z}$$

$$A = 1 - e^{-0.25}$$

$$A = 0.22$$

Longevity ~ 10 years

Year	Abundance
2015	10000
2016	
2017	
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	

Year class dynamics

Year	Abundance
2015	10000
2016	10000-2200
2017	
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	

Year class dynamics

Year	Abundance
2015	10000
2016	7800
2017	7800-1716
2018	
2019	
2020	
2021	
2022	
2023	
2024	
2025	

Year class dynamics

Year	Abundance
2015	10000
2016	7800
2017	6084
2018	6084-1338
2019	
2020	
2021	
2022	
2023	
2024	
2025	

Year class dynamics

Year	Abundance
2015	10000
2016	7800
2017	6084
2018	4745
2019	3701
2020	2887
2021	2252
2022	1757
2023	1370
2024	1069
2025	833