WF4113-Fisheries Science

Lecture 8: Recruitment & Survival

Last class

1. Recruitment

This class

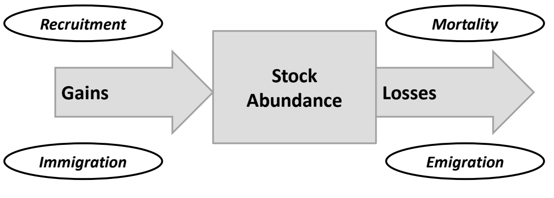
1. Mortality

Housekeeping

- Lab this afternoon!
- Exam I is Wednesday February 15th.

Housekeeping

Fish dynamics

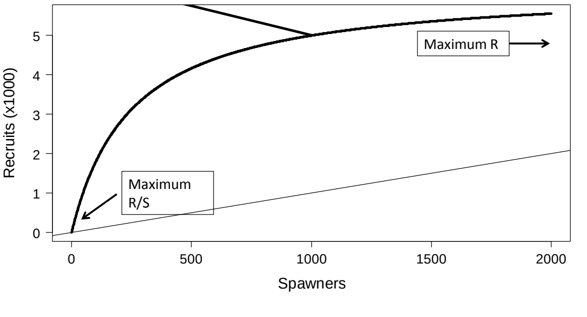


Beverton-Holt

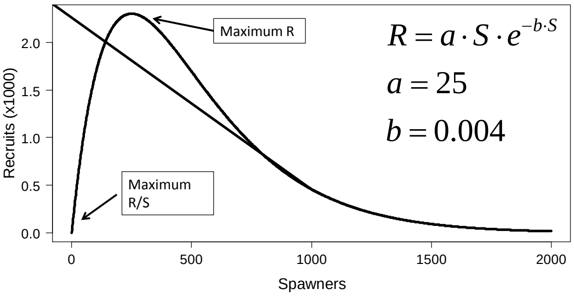
$$R = \frac{a \cdot Spawners}{1 + b \cdot Spawers}$$

$$a = 25$$

$$b = 0.004$$

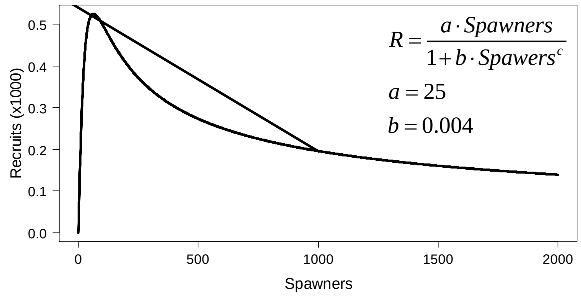


Ricker



$$R = a \cdot S \cdot e^{-b \cdot S}$$
$$a = 25$$
$$b = 0.004$$

Sheperd curve



$$R = \frac{a \cdot Spawners}{1 + b \cdot Spawers^{c}}$$
$$a = 25$$
$$b = 0.004$$

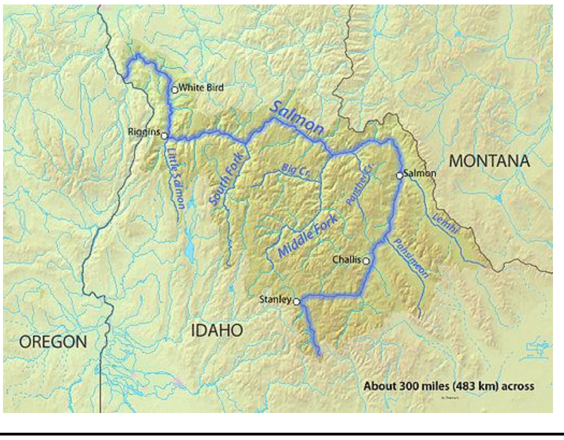
Measure recruitment

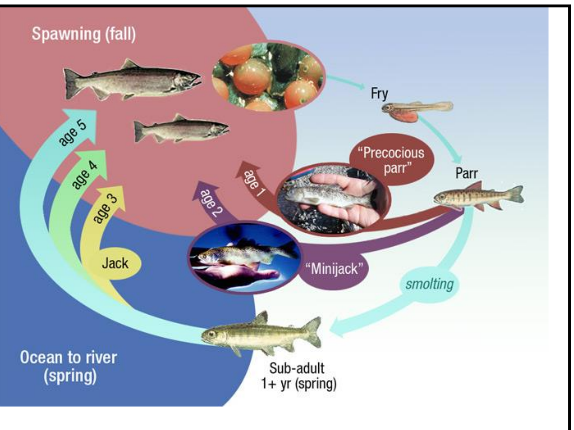
Salmon status

The federal government's plan for dam operations on the Columbia and Snake rivers focuses on seven runs of wild fish listed under the Endangered Species Act that spawn above Bonneville Dam. Adult counts have risen since 2000, but averages of spawning fish reaching their home streams remain short of minimum goals for removing the runs from the endangered species list.

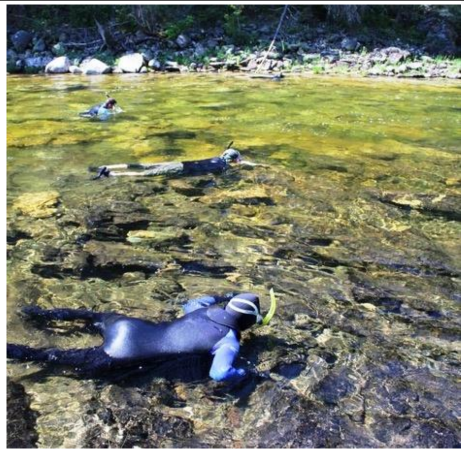
	Chinook salmon Snake River, fall	Chinook salmon Snake River, spring/summer	Chinook salmon Upper Columbia River, spring	Steelhead Upper Columbia River	Steelhead Snake River	Steelhead Mid-Columbia River	Sockeye salmon Snake River
10-year average, natural spawners	1,869	4,688	861	1,522	728	11,217	NA*
Percent of minimum recovery goal	62%	23%	19%	43%	36%	71%	NA*

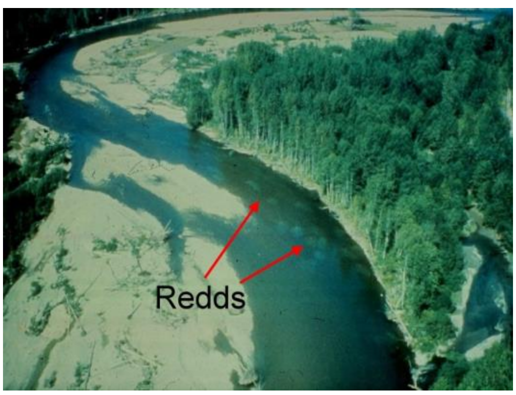
* Snake River sockeye are produced in a captive broodstock hatchery. Fishery managers say they have a high risk of going extinct. DAVID BADDERS/THE OREGONIAN
Source: National Oceanic and Atmospheric Administration.

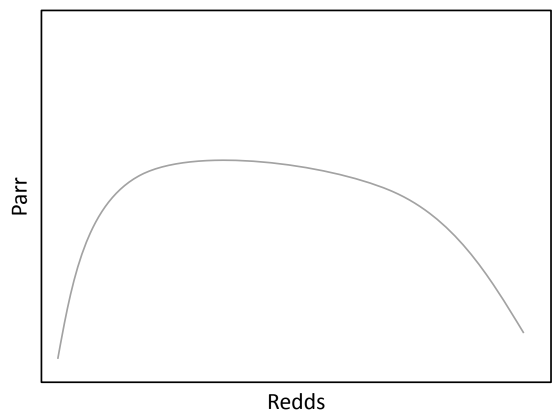




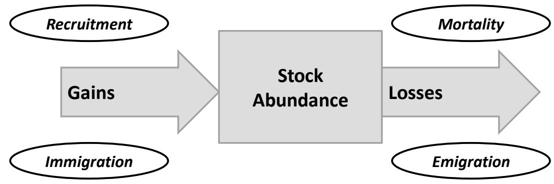
Direct observation

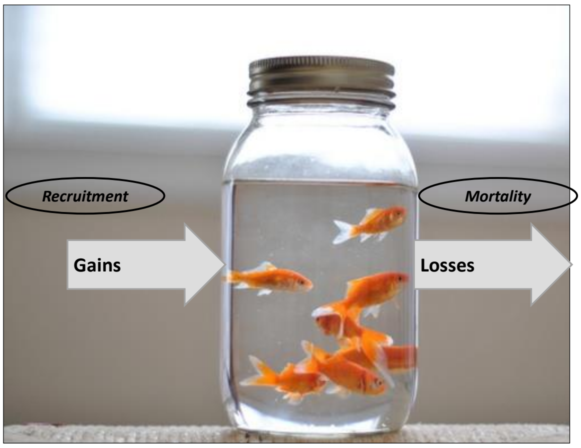






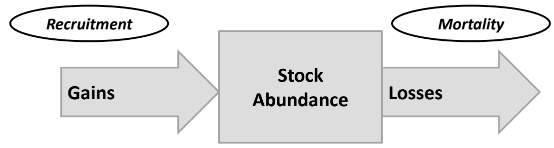
Fish dynamics





Fish population dynamics

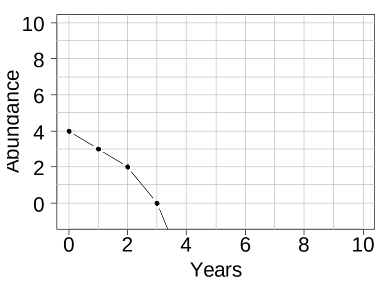
Year	1	2	3	4	5	6	7	8	9	10
Recruitment	3	5	2	3	4	1	1	3	1	1
Mortality	3	3	3	3	3	3	3	3	3	3



Initial abundance = 5

Assumes no immigration or emigration

What's wrong with these dynamics?



What exactly is mortality

The rate at which individuals are lost from the population

Represents the number of individuals that die during a certain time interval

Basic mortality computations

Need to know:

- Number at beginning N_t
- Number at end N_{t+dt}
- Time interval dt

Worked example

Suppose we had 1000 fish on June 1

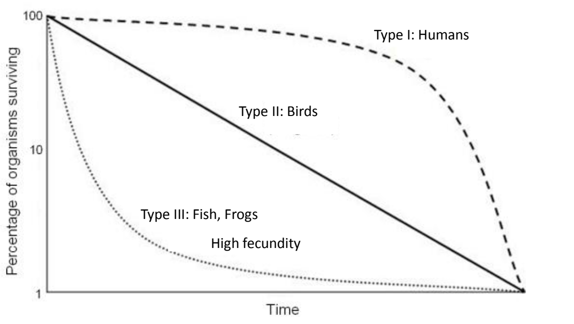
12 months later there are 700

The time interval is 12 months

Mortality over the interval is 1000-700 = 300

Interval morality rate is 300/1000 = 0.3

Survivorship curves



What would type III mortality rate look like?

Exponential Decay and mortality

- So if we have 1000 age 0 fish the number of fish in the next year, age 1 fish would be 1000*0.9 = 900.
- In the next year, there would be 900*0.9=810 age 2 fish
- Assumes mortality rate is constant

Mortality types

Total Mortality (*Z*) is comprised of:

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

Total mortality is *M+F*

Lets talk about rates

- Instantaneous
- Finite

$$\frac{Abundance}{dt} = r \cdot Abundance - M \cdot Abundance$$

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

Types of rates: Instantaneous

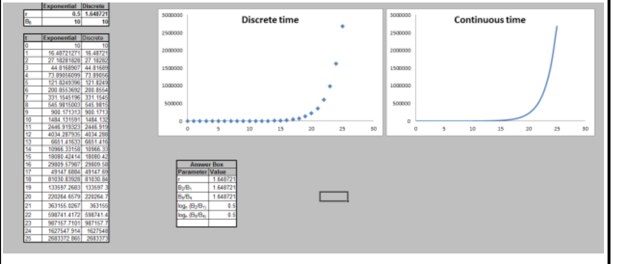
<u>Instantaneous mortality rates</u> are used in many fisheries models. They represent the rate of change over a time period. So, if you could chop up a year into very small increments the instantaneous rate would get applied to that very small time step. In essence the time step would be 0.

Types of rates: Finite

Finite mortality rates are the fraction of fish stock that dies in timeframe (e.g., a year).

- Example: annual total mortality rate (*A*) of 0.2 means that 20% of the fish stock dies over one year. So if we have 100 fish 20 of those fish would die and 80 would survive.

Types of rates



Worked example

In our previous example we found morality to be 0.3 over a 12 month period

Suppose we wanted to know what the morality rate was at 4 & 8 months.

To determine this we need to know instantaneous mortality

Worked example

First we convert our finite morality rate to an instantaneous rate

$$Z = -\log_e(1-[N_t - N_{t+dt}])/N_t)$$
$$Z = -\log_e(1-[1000-700]/1000)$$
$$Z = -\log_e(1-0.3)$$
$$Z = 0.356$$

Worked example

One of the nice properties of instantaneous rates is that we can simply divide them by time to get varying interval rates. For example

$$Z_{4months} = \frac{0.356}{4}$$
$$Z_{4months} = 0.119$$
$$A_{4months} = 1-e^{-0.119}$$
$$A_{4months} = 0.112$$

Worked example

Similarly we can do the same thing for an 8 month interval

$$Z_{4months} = \frac{0.356}{8}$$
$$Z_{4months} = 0.238$$
$$A_{4months} = 1-e^{-0.238}$$
$$A_{4months} = 0.212$$

A worked example

So at 4 months past June 1 we would expect the population abundance to be:

$$N_{4months} = 1000 - (1000 \cdot 0.112)$$
$$N_{4months} = 888$$

And for 8 months

$$N_{8months} = 1000 - (1000 \cdot 0.212)$$
$$N_{8months} = 788$$

So there was 112 death in the first 4 months and 100 in the second 4 months

When would these rates make sense?

- Finite?
- Instantaneous?

Thinking in terms of fish year class

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

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

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

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

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

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

$$Z = 0.25$$
$$A = 1 - e^{-Z}$$
$$A = 1 - e^{-0.25}$$
$$A = 0.22$$

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	

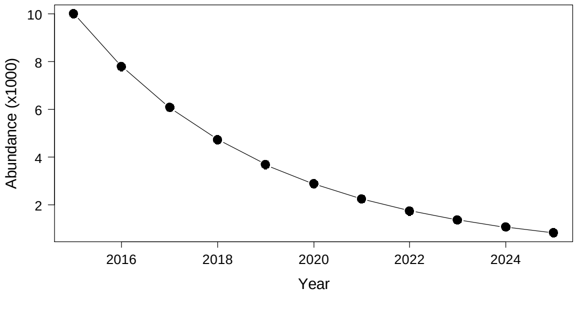
Year class dynamics

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

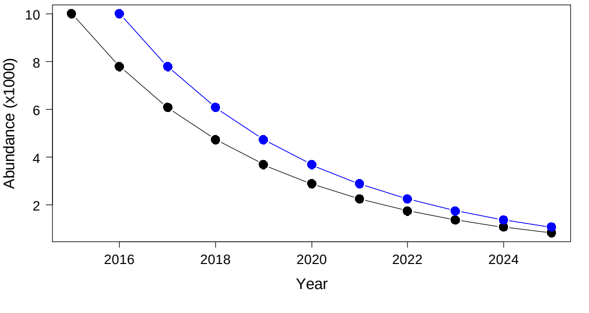
Year class dynamics

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

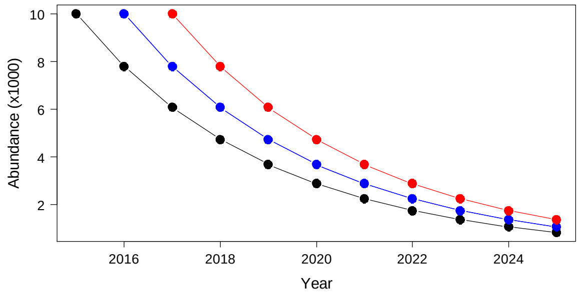
Year class dynamics



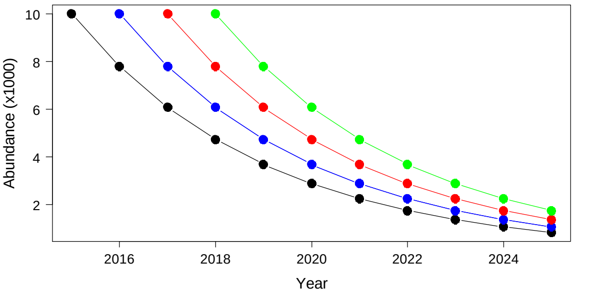
Multiple year-classes



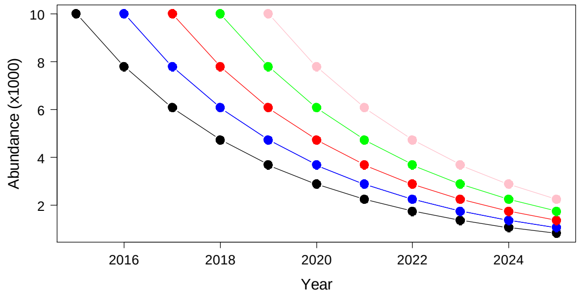
Multiple year-classes



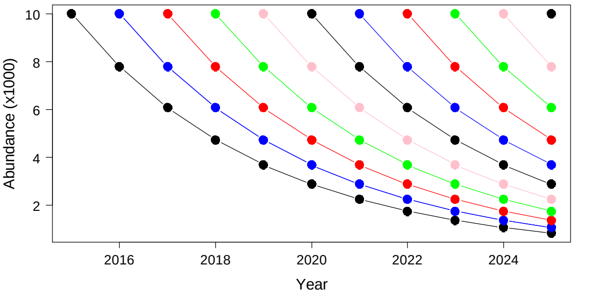
Multiple year-classes



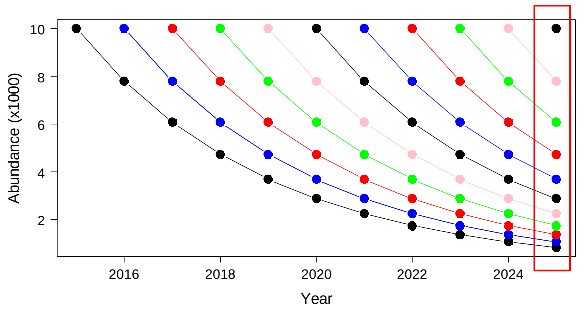
Multiple year-classes



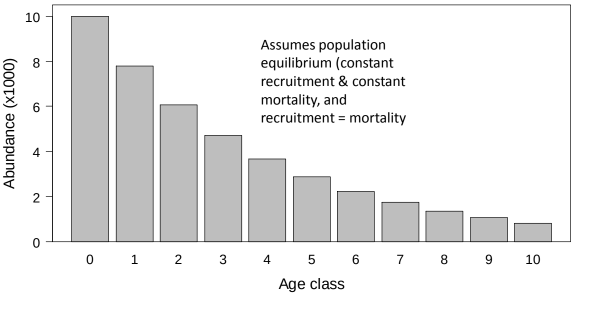
At any given year



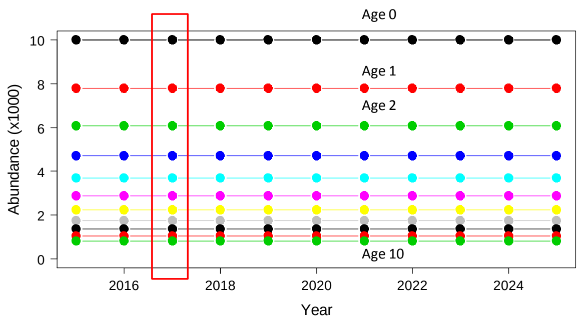
At any given year



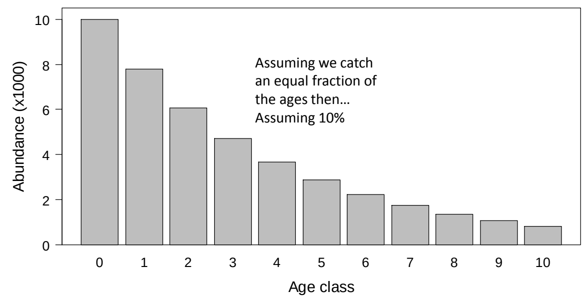
Stable age distribution



Equilibrium age distribution

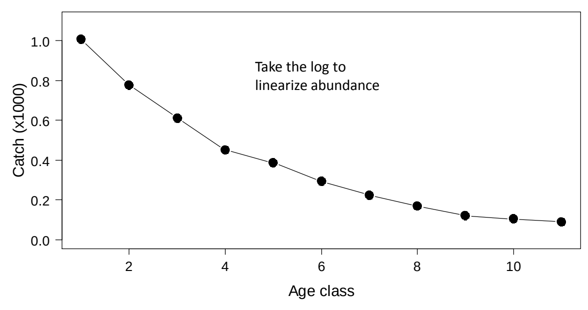


How do we estimate mortality?



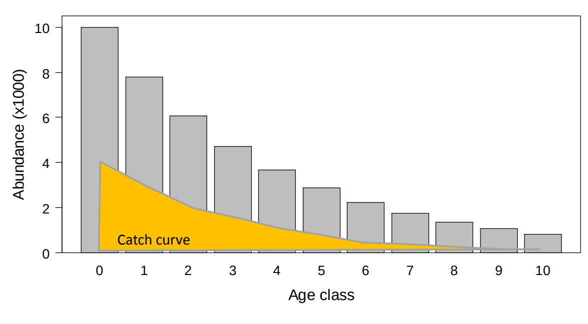
How do we estimate mortality?

Catch curve



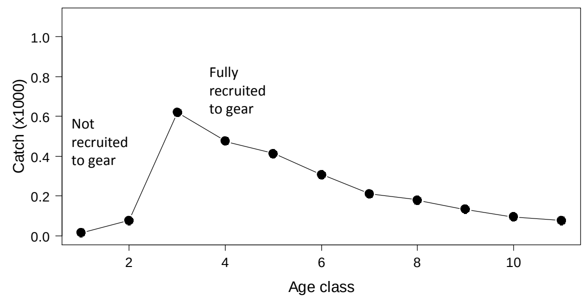
Catch curve

Perfect world



The practical realities

Practical realities: catch curve



Practical realities: catch curve

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