WF4313/6613-Fisheries Management

Class 10–Rates and Size Structure

Announcements

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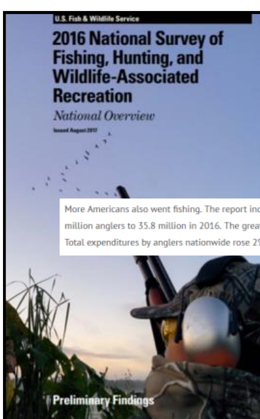
- Exam I September 27th…
- 1 more class lab then outside on 10/3
  - Waders
  - Other stuff you might want sunscreen, bug repelent

In the news



Recreational Fishing Participation Up in Latest U.S. Fish & Wildlife Service 5-Year Survey

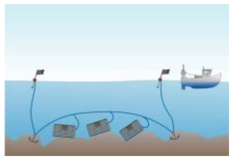
More Americans also went fishing. The report indicates an 8% increase in angling participation since 2011, from 33.1 million anglers to 35.8 million in 2016. The greatest increases in participation—10%—were seen in the Great Lakes area. Total expenditures by anglers nationwide rose 2% from 2011 to 2016, from $45 billion to $46.1 billion.

Lobsterman tagged for fishing untagged traps, faces 10 year suspension

The Marine Patrol has charged a Hancock County lobsterman, William Haas, 55, of Lamoine, with fishing more lobster traps than authorized, fishing untagged gear and fishing more traps on a trawl than allowed.

Under legislation adopted earlier this year, Haas faces a suspension of his license of three to 10 years for fishing 44 more traps than the 800 allowed by law.

Lobster Trap

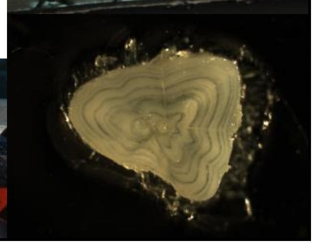


Class Topics

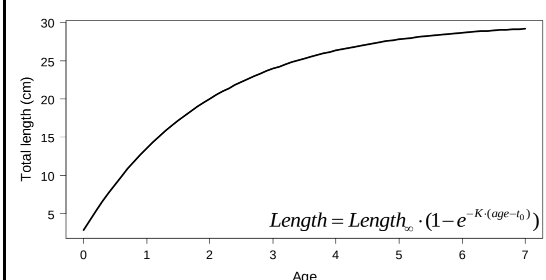
Rates (Finite versus Instantaneous)

Size Structure

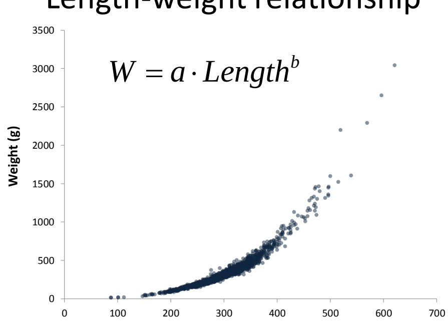
Age & Growth



Age-length



Length-weight relationship



Straightening the curve

Law of logarithms

$$W = a \cdot L^{b}$$

$$\log_{10}(W) = \log_{10}(a \cdot L^{b})$$

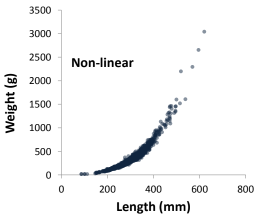
$$\log_{10}(W) = \log_{10}(a) + b \cdot \log_{10}(L)$$

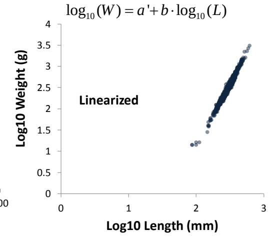
Estimating weight from length

$W = a \cdot Length^{b}$

$\log_{10}(W) = \log_{10}(a) + b \cdot \log_{10}(L)$

$\log_{10}(W) = a' + b \cdot \log_{10}(L)$





A yield predicting primer

Yield(age) = Harvested(age)•Weight(age)

Harvested (age=3.5)

X

Weight(age=3.5)

50 kg

=

Yield(age=3.5)

300 kg

Paddlefish can live up to 21 years (λ_{max})…So how is total cohort yield calculated?

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

Instantaneous mortality rates 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.

10% off per day late!

- 10% off your assignment per day after due date
- What if you are 15 hours late?
- Should you get a full 10% off?
- If 24 hours (1 day) gets 10% off what should 15 hours get you?

If 24 hours (1 day) gets 10% off what should 15 hours get you?

- 10% finite rate (100*(1-0.1))=90 if you got all the points but was 1 day late
- 90*(1-0.1) = 81 if you got all the points but was 1 day late
- 15 hours?
- Convert 10% from finite to instantaneous… actually (1-0.1)

Finite→ Instantaneous

- Convert finite to instantaneous

$$S = -\log(0.9)$$
$$S = 0.10536$$

- We can divide *S* into time intervals

$$S = 0.10536 \cdot \frac{15}{24}$$
$$S = 0.0658$$

- The <u>instantaneous</u> survival rate for 15 hours is 0.0658

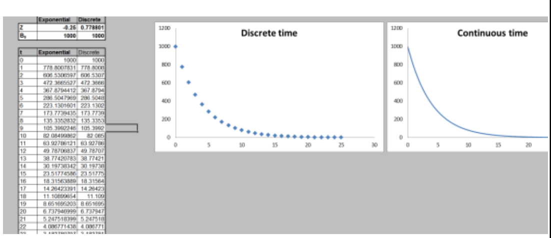
Instantaneous→ Finite

- Now we can convert the instantaneous rate to a finite rate

$$s = \exp(-1 \cdot 0.0658)$$
$$s = 0.936271$$

- So if you were 15 hours late on an assignment but you got all 100 points you would get a 93.6271
- That seems much better than getting a 90!

Types of rates



Worked example

Suppose we had 1000 fish and 700 survive to the next year, the finite morality rate *A* is be 0.3 over the 12 month interval

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

To determine this the easy way we need to know instantaneous mortality

Worked example

First we convert our **finite morality rate *A*** to an instantaneous rate

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

$$Z = -\log_e(1-A)$$
$$A = 1-e^{-Z}$$

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, 1 month

$$Z_{1months} = \frac{0.356}{12}$$
$$Z_{1months} = 0.0297$$
$$A_{1months} = 1-e^{-0.238}$$
$$A_{1months} = 0.0292$$

Worked example

Similarly we can do the same thing for an 3 month interval

$$Z_{3months} = \frac{0.356}{4}$$
$$Z_{3months} = 0.119$$
$$A_{3months} = 1-e^{-0.119}$$
$$A_{3months} = 0.112$$

There are 4 3 month periods in 12 months

A worked example

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

$$N_{1months} = 1000-(1000 \cdot 0.0292)$$
$$N_{1months} = 971$$

And for 3 months

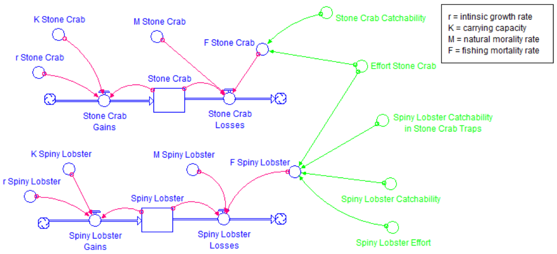
$$N_{3months} = 1000-(1000 \cdot 0.112)$$
$$N_{3months} = 888$$

So there were 29 mortalities in the first month and 112 in the first 3 months

When would these rates make sense?

- Finite?
- Instantaneous?

Control variables



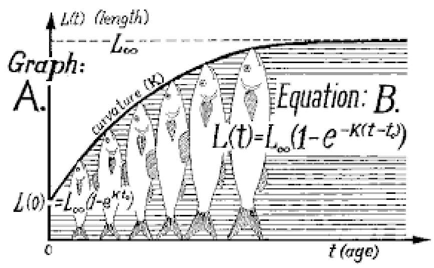
Some management parameters

Management can control*

- Gear-catchability
- Effort
- **Harvested fish size-Minimum length limit**

*Not a complete list

Why set a minimum length limit (MLL)



Cohort based

Follow a cohort over its lifetime

- Recruits: defined by age
- Maximum age (longevity)
- Survival (finite) = 0.20 (0.222 instantaneous)

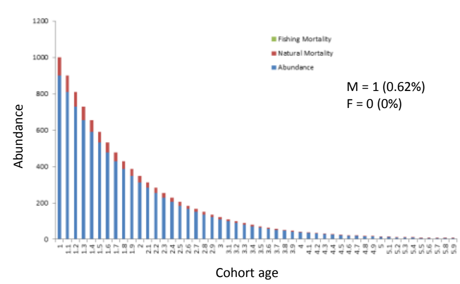
Age-1 Age-2 Age-3 Age-4 Age-5
1000→ 200→ 40→ 8→ 2

Cohort recruited

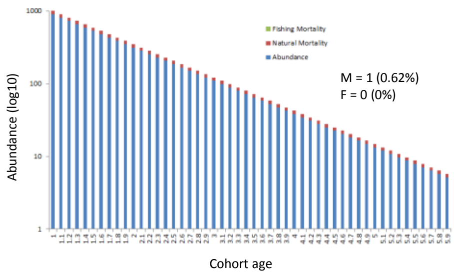
$\boxed{\text{Age-1} \quad 1000\rightarrow}$ Age-2 Age-3 Age-4 Age-5
200→ 40→ 8→ 2

1000 age-1 fish recruited

No fishing mortality



No fishing mortality



Fishing mortality

Minimum length limit-Applies to certain size fish and above

Slot limit-applies to a fish within a minimum and maximum size limits

ISSUE: Cohort dynamics a function of age (or time)…How do we relate length limits to age?

Flip the VBGF

Recall, the VBGF predicts length at age

$$Length_{age} = Length_{\infty} \cdot (1 - e^{-K \cdot (age - t_0)})$$

Can rearrange equation to predict age given length

Proof

$$Length_{age} = Length_{\infty} \cdot (1 - e^{-K \cdot (age - t_0)})$$

$$\frac{Length_{age}}{Length_{\infty}} = (1 - e^{-K \cdot (age - t_0)})$$

$$-1 + \frac{Length_{age}}{Length_{\infty}} = -e^{-K \cdot (age - t_0)}$$

$$1 - \frac{Length_{age}}{Length_{\infty}} = e^{-K \cdot (age - t_0)}$$

$$\log\left(1 - \frac{Length_{age}}{Length_{\infty}}\right) = -K \cdot (age - t_0)$$

$$\frac{\log\left(1 - \frac{Length_{age}}{Length_{\infty}}\right)}{-K} = (age - t_0)$$

$$t_0 + \frac{\log\left(1 - \frac{Length_{age}}{Length_{\infty}}\right)}{-K} = age$$

Example

Proposed minimum length limit

1. 8 inches (203 mm)
2. 12 inches (304 mm)
3. 14 inches (356 mm)
4. 15 inches (381 mm)

$$Length_{\infty} = 400$$

$$K = 0.3$$

$$t_0 = 0.1$$

8 inch limit

$$t_0 + \frac{\log\left(1 - \frac{Length_{age}}{Length_{\infty}}\right)}{-K} = age$$

$$0.1 + \frac{\log\left(1 - \frac{203}{400}\right)}{-0.3} = age$$

$$0.1 + \frac{-3.05}{-0.3} = age$$

$$0.1 + 10.16 = age$$

$$2.46 = age$$

12 inch limit

$$t_0 + \frac{\log\left(1-\frac{Length_{age}}{Length_{\infty}}\right)}{-K} = age$$

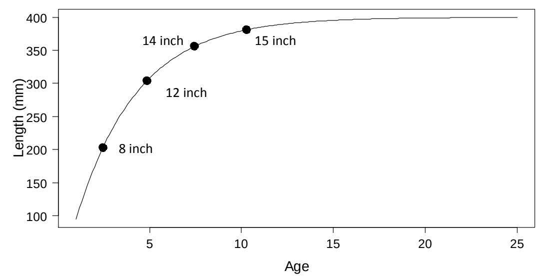
$$0.1 + \frac{\log\left(1-\frac{304}{400}\right)}{-0.3} = age$$

$$0.1 + \frac{-1.427}{-0.3} = age$$

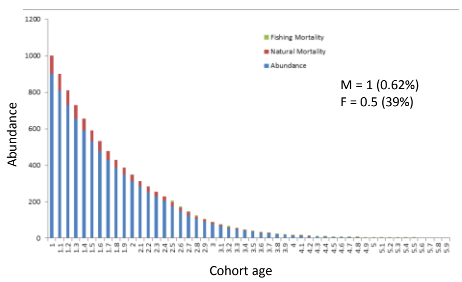
$$0.1 + 4.757 = age$$

$$4.857 = age$$

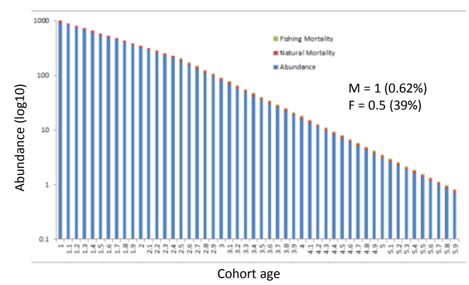
Length limit & growth



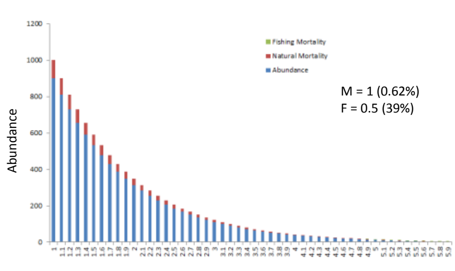
8 inch limit



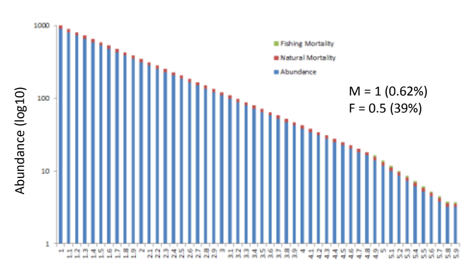
8 inch limit



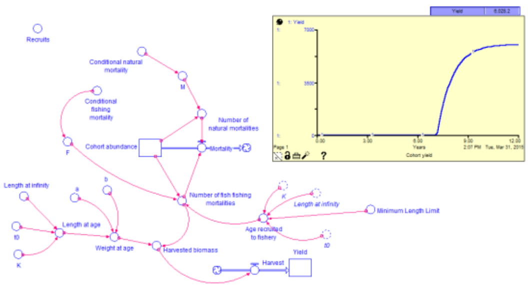
12 inch limit



12 inch limit



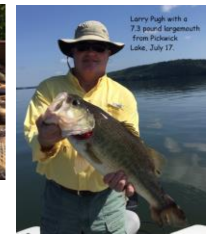
Yield per recruit



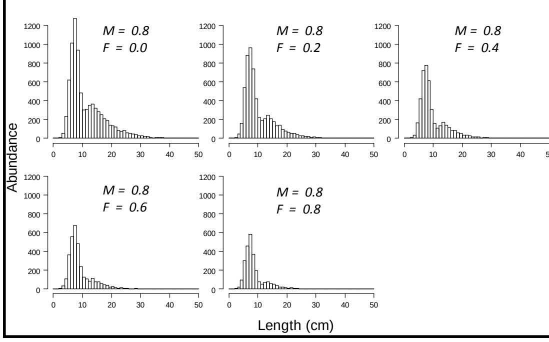
Commercial versus Recreational

Value: Biomass

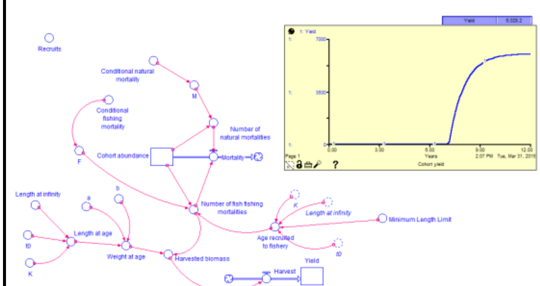
Value: Size



Size structure erodes with *F*



Yield per recruit & size structure



Stock density indices

PSD (which specifically indicates Quality/Stock) is a basic measure of size structure, and thus, balance within fish populations. "Balance" suggests a stable predator prey dynamic with adequate recruitment and growth of both predator and prey.

Proportional stock density (PSD)

$$PSD = \frac{\text{Number of fish} \geq \text{ quality length}}{\text{Number of fish } \geq \text{ stock length}} \cdot 100$$

Where

- Stock length fish = 8 inches
- Quality length fish = 12 inches

For largemouth bass

Stock and quality largemouth bass