

FAS6337C Fish Population Dynamics

Lab #6 Yield Per Recruit Model

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Data for this laboratory are from Striped Bass *Morone saxatilis* on the Roanoke River, North Carolina. This is an extremely popular fishery in March-May each year, where thousands of anglers target fish during the spawning run. The anglers are asking the state fisheries agency to reduce the minimum size limit of 550 mm TL so they can keep more fish, but also show interest in catching trophy fish.

The objectives of this laboratory are to:

- 1) Build an age-structured model to predict Spawning Potential Ratio and Yield-per-Recruit of striped bass to a range of minimum size limits,
- 2) Identify levels of fishing mortality and size limits that would cause growth and recruitment overfishing,
- 3) Evaluate the sensitivity of the model output for SPR and yield to changes in M , k , $L_{50,mature}$, and D (discard mortality).

State biologists have measured a wide range of parameters for this (and other east coast) Striped Bass fisheries. The estimates include:

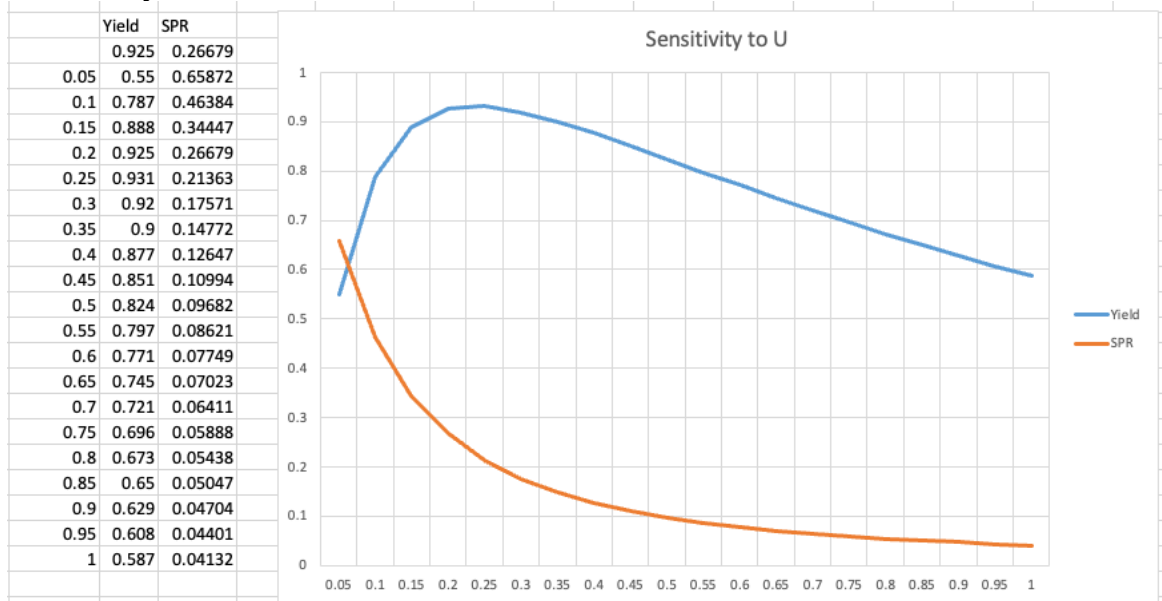
Parameter	Value	Interpretation
A_{max}	35 y	Maximum age
L_{∞}	1032 mm	Asymptotic maximum length
k	0.11 y^{-1}	Brody growth coefficient
a	5.25×10^{-6}	Length-weight scaling
b	3.17	Length-weight allometry
$L_{50,mature}$	450 mm	Length at 50% mature
U	0.2	Harvest Rate
D	0.15	Discard Mortality
$L_{50,cap}$	350 mm	Length at 50% vulnerable to capture
MinLL	550 mm	Minimum length limit

For all vulnerability or selectivity relationships, assume the $\sigma = 0.01 * L_{50}$.

QUESTIONS

Please conduct the following analyses in *Microsoft Excel* and answer the questions. Each question or bullet point should be responded to either with text, a table, or a plot. (You can use Excel to answer the questions below, but students must attach an Excel spreadsheet in their submission for full credit). There is a Shiny app you may find useful to consult as well (https://zsiders.shinyapps.io/Lab_5/).

1. Using the provided parameter estimates, answer the following in Excel:
 - Does this population appear to be undergoing growth overfishing? How did you determine your conclusion?



Given a $U=0.2$ is close to but just slightly under the maximum yield achieved at ~ 0.25 I would say that this population is not undergoing growth overfishing. That would require we were to the right of the maximum yield.

- What about recruitment overfishing? How did you determine your conclusion?
According to my calculations the SPR for the population given the parameters is 0.27 which is below the desired 0.35. Therefore, this population is experiencing recruitment overfishing.

2. Using the provided parameter estimates, answer the following:

- How sensitive is the model to changes in M , k , $L_{50,mature}$, and D ?



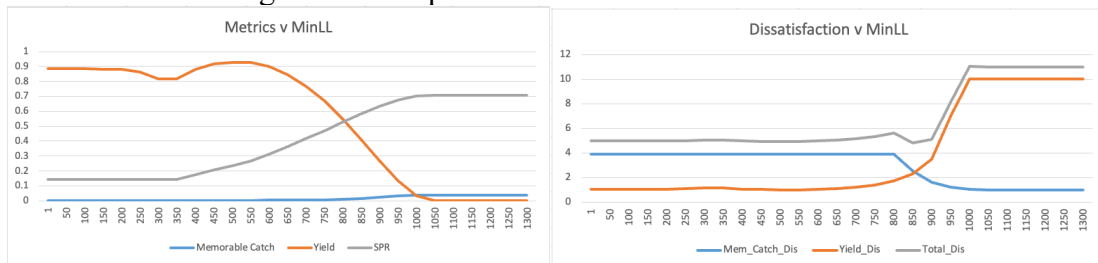
- Which parameter would you recommend for future research to reduce uncertainty?
 M is very important to both yield and SPR. K is also important to both but has a much smaller impact that M does. L_{mat} requires pretty large changes in order to affect SPR dramatically and has no effect on yield (which makes sense given how we've setup the model). D has some impact on yield and little to no impact on SPR.

I would recommend future research on mortality especially given that it wasn't measured in this study but was simply computed from K .

3. Given that various anglers want high harvest and others want catch of large fish:
 - Using the Structural Indices PDF from Lab #1, what is considered a “Memorable” size Striped Bass in millimeters?

$\geq 890\text{mm}$

- What is the minimum length limit that best allows for a high Yield and a high catch of “Memorable” or larger sized Striped Bass?

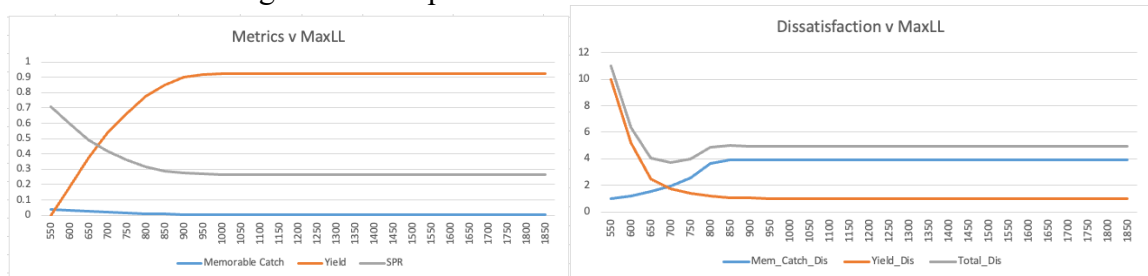


Multi-objectives are always difficult to compute unless you have a comparable metric for each objective. Therefore, I created a dissatisfaction index:

$$Dis = \min\left(\frac{MAX}{ACHIEVED}, 10\right)$$

The idea behind this index is that dissatisfaction is lowest when the maximum has been achieved and is infinite when nothing is achieved. This unitless and normalized quantity allows us to compare the dissatisfaction in distance from maximum yield or maximum memorable catches together. Therefore I can pick the parameters that minimize the sum of dissatisfaction across all groups (assuming even weighting between groups). In this case minimum dissatisfaction was achieved with a minimum length limit of 850. What’s interesting about this limit is that it more or less prevents harvest of bass that are less than memorable size, thereby allowing all fish that don’t die to discards or natural mortality to reach memorable size before they are removed from the population by harvest.

- What is the maximum length limit that best allows for a high Yield and a high catch of “Memorable” or larger sized Striped Bass?



Dissatisfaction is minimized at a MaxLL of 700 holding all else constant (including the present 550minLL). If you relax the minLL then the maxLL that minimizes dissatisfaction is 600.

- What is the minimum and maximum length limit (slot limit or harvest window) that best allows for a high Yield and a high catch of “Memorable” or larger sized Striped Bass? From our Total_Dis we can see that the 600 MinLL with the 750 MaxLL slot limit minimizes the total dissatisfaction.

- Which regulation (MinLL, MaxLL, or slot) would you suggest? Why (justify with Yield and “Memorable” catch metrics)?
Based on the above I’d recommend setting a minLL of 600 and maxLL of 750 as this achieves the minimum dissatisfaction amongst all options considered.

4. Given that various anglers want high harvest, others want to catch of large fish, and the managers want the SPR to be greater than 0.35:

- What is the minimum length limit that best allows for a high Yield and a high catch of “Memorable” or larger sized Striped Bass?
This is the same conclusion as above because the 0.35 SPR is met with a MinLL of 850 (the SPR at minLL of 850 is 0.58)
- What is the maximum length limit that best allows for a high Yield and a high catch of “Memorable” or larger sized Striped Bass?
SPR>0.35 is met in either of our maxLL scenarios above.
- What is the minimum and maximum length limit (slot limit or harvest window) that best allows for a high Yield and a high catch of “Memorable” or larger sized Striped Bass?
Given the SPR for a slot of 600-750 is 0.42 our conclusion doesn’t change here either.
- Which regulation (MinLL, MaxLL, or slot) would you suggest? Why (justify with Yield and “Memorable” catch metrics)?
This is the same conclusion as above because the 0.35 SPR is met with the prior recommendation. I’d go with a 600-750 mm slot limit.