**Lab #10 Virtual Population Analysis**

Data for part 1 are from Walleye *Sander vitreus* from Lake Escanaba, Wisconsin, provided by Dr. Mike Hansen at the University of Wisconsin - Stevens Point. Anglers are required to report their catch, and for every year there is a complete census of the catch-at-age. Further, in many years there is a springtime estimate of adult population size with mark recapture. Please build the model and answer the questions.

Data for the second part of this lab are from Black Crappie *Pomoxis nigromaculatus* from Lake Lochloosa, Florida provided by Travis Tuten at the Florida FWC. Angler catch at age information was sampled using fish carcasses and total catch and effort was estimated using creel surveys. Further, the FWC conducts an annual trawl survey, which will be used to fit the model. The model is almost complete, but you will need to finish building it and answer the questions.

Answer **any bullet points** with text, figures, or tables where appropriate. Use Excel to complete all the tasks.

**Part 1. Walleye VPA**

1. Back-calculating numbers at age.
   1. Estimate in each year as ; set the initial guess of (fishing mortality in the terminal year) equal to and convert this it to , assuming a discrete fishery.
   2. After estimating the , work each complete cohort backwards to reconstruct their abundance at age using:

* Plot the abundance at age-1. Does this analysis reveal strong and weak year classes in the time series?

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There are definitely strong and weak year classes.

* 1. Estimate the exploitation rate for complete cohorts as:
  2. Calculate the average harvest rate across ages, , for complete cohorts
  3. Calculate the relative vulnerability of ages to fishing can be found as:
* At what age do you feel that fish are fully recruited to the fishery?A graph of age and age

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It looks like they are fully recruited at age 4

* 1. Set the relative vulnerability of all ages above those fully recruited to 1
* Does the population appear to be heavily exploited in your view

I’d say we have heavy exploitation if entire cohorts disappeared before reaching the older ages. This does happen on occasion, but only with exceptionally weak cohorts. Otherwise, the other cohorts are all making it to age 12 with survivors.

Also it’s worth noting that there are still clear strong classes even in the later years, so it doesn’t seem like recruitment overfishing is happening.

The analysis thus far provides a good catch history and recruitment to age-1 estimates for cohorts that are gone from the fishery, but it does not give information about the cohorts currently in the fishery in 1997. These cohorts are obviously of interest.

* 1. Reconstruct the incomplete cohorts that were in the fishery in 1997 by estimating as:
  2. Reconstruct these incomplete cohorts back in time.
* Re-plot the recruitment time series.

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* 1. Change your estimate of in each year by using , where:

that is the sum of the catch of age 5+ divided by the sum of the numbers of age 5+ fish in each year.

* 1. At Lake Escanaba they also do a mark-recapture of adult Walleye (age 3+) nearly every year. Use a normal likelihood of the log residuals (deviations) (this actual results in a log-normal likelihood) between the VPA predicted age 3+ abundance and the estimates from mark recapture, , to estimate the and (set at 0.5 to start):
* Plot these mark recpature estimates against the VPA predicted population sizes from 1967 to current day.

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* Does the VPA do a good job of predicting the empirical estimates of population size?

It does a reasonably good job. However if we look at residuals plotted against mark-recapture estimates of population we can see that there does seem to be a rising relationship, where residuals are increasing as the underlying population increases. Therefore VPA is generally underpredicted strong year classes.

* What is your estimated ?

F=0.354

* 1. You have assumed a natural mortality ().
* What would be the impact on your conclusions if were over- or underestimated by about 25%?

For M=0.23 we get (after optimization) F=0.322

For M=0.38 we get (after optimization) F=0.400

This represents a swing in F of ~11%.

* What are the implications if your assumption is off by 25%?

Compared to our optimized LL of 2.293

Looking at M=0.3, F=0.27, sig=0.263 we get a LL of 3.172 (40% increase)

Looking at M=0.2, F=0.44, sig=0.263 we get a LL of 2.740 (20% increase)

Alternatively we could imagine solving for M and given an .

For F=0.27, M=0.304

For F=0.44, M=0.318

Both of which are pretty small adjustments to our predicted M.

Part 2. Black Crappie VPA

* 1. The model is almost completely constructed but you will need to complete a few things. You will need to find an estimate of natural mortality for this population, go look in the literature for one.
* What estimate of did you use, where did you find it, and what is your confidence in it?

[Black Crappie Size Selectivity Study (Binion et al)](https://d1wqtxts1xzle7.cloudfront.net/46284413/j.fishres.2008.07.01020160606-2402-mt2hyy-libre.pdf?1465232232=&response-content-disposition=inline%3B+filename%3DDirect_and_indirect_estimates_of_black_c.pdf&Expires=1700452017&Signature=TabqdT0NrTzYiFoxXSjJ7Uxx6jVb--WWRbboEm~taLabpaicw35~hcXkD52VEgaWjgy5kjEJpBw2DLJSjIrWQisIiWLY~K7sG-2KK-9dW45n0h2xBgz2rLfGzoS45Qiu8rgK70y809Uq7eykvJrdskJq8EsFueIhdop0ARxOTXOWgUEzM7xZtFyRVKPSSB-YPETD4yo~bNZZ0euhgJQxsn64mw-PytPk76Fyd1SYUJAHaLnDnldEw2r7s-QFwSbbHAtuj03avRnTJVYRk3J-2lqBjyDbyN3-pltLlAkXivW~TYMwcyuojbXk2dlLpTNUCIPvVrVhw83ywMuLAd3aNA__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA) – found this using scholar.google.com. It seems to be the same study referred to below. Going to use their mid value of age-1+ mortality (M=0.6). They ranged it from 0.4 to 0.8 which corresponds to a 33% swing either way, however given what we saw in the sensitivity above I’m confident this will still give us reasonable estimates of .

* 1. Next you will need to change the vulnerability curve. There is no minimum length limit on Black Crappie in Lake Lochloosa, however anglers do not harvest all ages equally.
* At what age are the fish fully vulnerable to harvest? How did you assess this?

It seems that the AvgU peaks at age 5 so we’ll assume that’s when the fish are fully vulnerable.

* 1. The FWC conducts an annual trawl survey on Lake Lochloosa. Due to dome-shaped selectivity of the trawl, we are using the CPUE of age 1 to age 3 Black Crappie as our index of abundance. To rescale the CPUE to population numbers, we are using the statistic calculation to estimate the average relative catchability coefficient of the trawl survey (; this was already completed for you).
  2. Construct the log-normal likelihood using the rescaled age 1-3 abundance and the estimated age 1-3 abundance from the VPA (see 1.11).
  3. Use solver to find the and (start at 1 for each run to help with convergence).
* Does the VPA do a good job of predicting the empirical estimates of population size? What is your estimated ?

Estimated .

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Several of these residuals are extremely high. I’d say the VPA is having a hard time fitting this data.

* 1. Go all the way back to the likelihood profiling tutorial (Module 1) at the start of the course, and profile .
* Plot the profile of as a line.

A graph with a line

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1. After working with two different VPAs:

* Which assessment do you have greater confidence in, the Walleye or Black Crappie and why?

I have more confidence in the walleye evaluation. Far more data, better fit, and some nice, clear stability around parameters.

* What appears to be a more reliable population index, population abundance or survey CPUE?

I believe population abundance to be more reliable as it is much more direct. Survey CPUE requires that you add an additional parameter q and then assume that it is a constant year over year. Population abundance requires no such extra parameter.