**Email from Ben:**

Hi John,

Good news! I've made a fair bit of progress on the model and, more importantly, figured out *why* the pre-print equations didn't work.

It essentially boils down to the influence of survival on the age distribution of the adult population. When there's no skip-spawning that doesn't really matter because they're one homogenous group that's represented by N. However, when we break them into two groups and introduce gaps into one of them (i.e., a spawning cycle) the interaction of that gap size and the survival rate becomes a big deal for the relative proportions of the two groups. For example, if you have a 90% survival rate and a two-year cycle you'll still have a fair number of skip-spawners around at age-of-maturity+2 and even age-of-maturity+4. However, if survival is 10% there's essentially no hope of them still being around at age-of-maturity+2. This is in contrast to the annual-spawning contingent, which will include all ages >= to maturity. So the proportion of the spawning pool that's annual/skip spawners is indeed a function of psi, but also phi and a.

With that in mind, I'm tempted to explore whether this could make a nice, quick, little conceptual/simulation paper. Something to think about once you've put this through its paces and Anthony has returned and done the same. We should probably also start thinking about how to handle the likely-flawed pre-print that's already out there (should we reach out to them?)

I've attached a Word doc and PDF (the latter in case formatting gets weird) with the equations and some figures showing the dynamics. I've also included updated scripts for simulation/estimation functions as well as the one I used to generate the figures in the doc.

Currently the model seems to estimate things very well if psi is fixed, but has a tougher time estimating psi. I suspect this is because there's a lot of wiggle room between it and Nf in a sex-specific, HSP-only model. At some point in the near future I'll integrate POPs and see if that helps. Alternatively, switching to a single N adjusted by a sex ratio (either estimated or provided) might do the trick. The Nf estimates also seem to be a bit low if survival gets low and/or a gets large (regardless of whether psi is fixed). I suspect this is not a bug in the code but rather the effect of some cyclic spawners never having the ability to spawn at all, effectively removing them from the adult breeding population. Incorporation of POPs will probably fix this too, but it may also just be a matter of redefining how we calculate the true adult breeding population. Or it's an error in the model that I've missed, that's always possible too...

Best,

Ben

Ben MQ

8/29/22

Cyclic skip-spawning in half-sibling close-kin mark-recapture models

When breeding on-cycle, the pool of potential parents includes the proportion of adults breeding annually (1-*ѱ*) plus the proportion of skip breeders on that cycle *ѱ*/*a*. Howeve*r*, it is important to remember that the true number of available breeders integrates multiple year classes. This means that survival () will also affect the breeder pool and will disproportionately affect the number of skip breeders available because, by definition, to be present they will have had to survive more years than annual breeders.

E.g., when there is no skip-spawning (*ѱ* = 0) the number of potential parents for a given total adult N and age-at-maturity *M*:

Whereas if all adults skips-spawn on a two-year cycle (*ѱ* =1, *a*=2) number of potential parents is:

And, therefore, the effect of mortality means that when the two are mixed the pool of potential parents is more heavily weighted towards annual spawners than would be expected at first glance. For example, if half of parents skip-spawn of a two-year cycle (*ѱ* = 0.5, *a*=2), the pool of potential parents will be:

Or, broken down into the annual and skip spawning components as a function of *a*:

Which, given a stable survival rate, is equivalent to:

And:

Which is equivalent to:

With both naturally combining to equal :

Thus, the probability that any two individuals are half-siblings differs depending on whether or not their age difference is on-cycle (making skip-spawning parents available). If they are in on-cycle, the probability is a relatively simple function of and the probability that the older individual’s parent died before the younger individual was spawned

I.e., the number of adults that spawn annually plus the number of adults that skip spawn on that breeding cycle. However, if the two individuals are off-cycle (meaning that a parental match must necessarily involve an annual spawner) the probability is a function of the proportion of the yearly spawning pool that is annual spawners, the probability that the older individual’s parent died before the younger individual was spawned, and the overall number of annual spawners present:







