

Simulation Models: Monk Seals, Part 2

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recorded: March, 2011

Let's run through the issues we need to consider in designing the model world for the monk seals. Stochastic or deterministic? Obviously, we have to go with a stochastic model because the problem of mobbing develops from having too many males, which develops from having demographic stochasticity in a small population.

Spatial or non-spatial? The whole population is on one island, in fact, concentrated on one beach on that island. We don't need a spatial model.

Do we need to include both males and females? Yes, because the sex ratio is so important. In fact, it is the size of the sex ratio that leads to mobbing.

Density dependence. We're dealing with a very small population. Doubtful if we would need to worry about density dependence.

How do we represent the population? I think it's pretty obvious we need an age-structured population. We need an age-structured population because the age determines how likely a female is to be mobbed and because age determines whether or not a male is likely to be a mobber. And if we're considering management options like moving young females, we need to consider the age at which they're going to reproduce.

So, really, what we need to do is develop an age-structured model containing both males and females and including demographic stochasticity. So this is going to be rather like the elephant model. Fortunately, monk seals live for a much shorter time period than elephants, so it's not going to be such a big model. But we have both males and females in their age classes, and we're going to have to introduce demographic stochasticity.

But before we did that, if that was our goal, we decided we need to, first of all, develop a deterministic model. And the purpose of that was to calibrate the model.

The next step was to put in the demographic stochasticity to explore how likely the small population was to develop a biased sex ratio. And the thinking there was that if we couldn't develop a model that caused the problem, we wouldn't want to use that model to try and fix the problem.

And then, finally, we took that model, added in mobbing and added in the management actions to actually address the problem.

What I'd like to do, again, knowing that I don't need to go into details on the model because you've got the paper, I'd like to talk a bit about the difficulties we ran into, particularly from lack of data, and how we dealt with them.

So remember, we first developed a deterministic model to try and calibrate the model. And we ran straight away up against the problem that we had no estimates at all of adult survival. Sub-adult survival data were pretty good. Pup survival data were pretty good. Fecundity data were pretty good. But, as with elephants, we had no idea what the adult survival rate was.

And we approached this and solved the problem in exactly the same way as we did with elephants. We said, "What is a long-term, stable growth rate for most pinniped, or seal populations?" And people came back with various answers. One was 1.06 in a really good population with a good food base. And the other was more like 1.03, and there was some thought that the food base at Laysan wasn't that good, and so 1.03 might be more suitable.

How did we deal with this? We developed two versions of the model. We calibrated the model twice, once to get a growth rate of 1.03 and the second time to get a growth rate of 1.06.

Now one of those serendipitous things that happens when you start modeling is you discover things that you wouldn't have discovered before. And the mere fact that we ran with two models with different growth rates gave us a big payoff because when we added stochasticity, we discovered that populations with slower growth rates were more likely to develop a biased sex ratio than populations that were growing at a healthy rate. And that was a very interesting insight to get out of the model, so interesting that we developed a third version of the model where we assumed the population wasn't growing at all. So we now had a third version where lambda was 1.0. And under those circumstances, the chances of getting a skewed sex ratio were really very, very high.

Okay. So that's what we learned from our first two versions of the model. Then we tried to add in mobbing deaths. And we looked at the data on mobbing deaths, which showed a sort of fuzzy trend associated with the sex ratio. There were no recorded instances of mobbing deaths with a sex ratio below one male to one female. And above that, it looked as though this probability of mobbing deaths increased somewhat as the sex ratio went up.

So we put in some kind of response curve with a slope. And there was a large possible variance looking at the data in that slope. So we came up with three estimates of the slope, and we kept our fingers crossed and hoped this wouldn't make a difference to the model. And, in fact, it made a big difference to how fast the population grew, or whether it grew at all, depending on the form you took for this mobbing-response curve.

So we had a problem. How did we deal with it? Well, we ran with all three values. We ran with all three values with the idea of saying, "This makes a difference to the population, but is it going to make a difference to our decision in the long run"?

So now we have nine versions of the model, three lambdas and three slopes. In fact, we had 12 because we also came up with a more stochastic version of the mobbing-death-response curve.

So at this stage, we added the management actions, which are described in the paper, and we started running the model to see what might happen. In effect, we were hard-wiring the management strategies into the model. And we got tons and tons of output. Remember each time we did something, we had to do it a number of times because this is a stochastic model. We ended up getting distributions for various outputs from all those replicates.

And if you've looked at the Figure 4 in the paper, you will see that they were messy distributions. And we were running with 12 versions of the model.

So we decided we've got to concentrate on what we think are important aspects of the output. And what we did was we identified four outcomes that we thought were desirable outcomes for the model, or rather, for the seals than for the model, and four outcomes that we thought were undesirable for the seals. And using our various versions of the model, we estimated the probabilities of those outcomes. And that information, you will find in Table 2 at the end of the paper.

And looking at the information in Table 2, you can probably have a very good sense of what you, if you were a manager, would do in terms of choosing a management action.

So I'd like to break here and have you look at Table 2, and you decide what management action you would implement.

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