

## **Simulation Models: Monk Seals, Part 3**

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Which of the management actions did you decide to recommend?

Well you've probably learned by now that when I ask you a question, I don't really want to hear your answer, and that's the case here. The point in asking you to do that was to come back at you and say, "Really? You know, that's not the right approach to take to a problem like this." This is a problem where there are multiple objectives, multiple stakeholders. And you really don't want to have a decision process where one person goes off and makes the decision.

So we are going to rather try and say, "What kind of structured decision process could we develop for reaching a decision?" I'm not saying your decision wasn't good. I'm saying it's the process that's important.

So I said there were multiple stakeholders. Who are the stakeholders? Well, obviously, there's a conservation community at large, in particular, scientists that are involved with conservation of monk seals, some of them academics, some of them at various institutions, some of them federal or state employees. So that's one group of stakeholders. We could possibly divide them into more than one group.

Then there's the management team and the manager, who's responsible for the Hawaiian monk seals. And then there are people like animal rights groups and friends of the seal who have concerns about the mobbing deaths and general concern about Hawaiian monk seals.

What are the issues that each of these groups have? They all have one thing in common. They want to see the Hawaiian monk seal population increase, and they definitely don't want to see it decrease. The manager, in addition, is probably worried about the bad publicity due to mobbing deaths.

And the manager is also worried about money. And if you question the manager about the cost of management, it turns out the largest part of the cost is getting a ship organized to go to the island to either remove males or to move females onto the island. So it's the expedition that is

expensive. And so as a proxy for management costs, one can look at the number of times when you run the model that you have to intervene and go and do something at the island.

And then the animal rights people, in particular, will be concerned about mobbing deaths. And they will want to keep the number of mobbing deaths to a minimum.

So your issues relate back, pretty much, to the table [Table 2, in paper about 'Mobbing' in Hawaiian Monk Seals] that you were looking at, at the end of the last lecture. You want to see the population double, rather than stay fixed. You don't want to see the population halve. You want to limit mobbing deaths, and you want to minimize the number of times you have to intervene.

How can you develop an approach for addressing these issues? Well, if you stop to think about it, this sounds very much like the car problem [Buy Car Model]. This is a problem that seems to be right for SMART. Remember, SMART was the one technique we developed for multi-objective problems. But the problem was it was for deterministic problems. But let's push on a bit and think about this.

SMART, you remember, kicked off with a broad goal. A broad goal, in this case, is to try and get the population to grow as quickly as possible at minimum costs, so with minimum interventions and with a minimum number of mobbing deaths. Sounds very good but hard to do.

So we break down the broad goals into specific objectives. And what we are going to do is come up with four specific objectives. And, again, these relate to the table at the end of the paper. We're going to have two objectives that relate to the population. The one is, that we're going to try and prevent the population from dropping below 100. And the other is, we're going to try and encourage the population to double to 400. Okay?

Now there's a little problem with having two objectives that both relate to the population, because your objectives are supposed to be independent. But let's hang in there with those for the moment, and we'll come back to that.

Then we are going to try and keep the number of interventions down to, at most, one intervention in a 20-year period. And finally, we are going to try and keep the number of mobbing deaths below 40 over a 20-year period. So those are our four goals.

The next step in a SMART process is to have imaginative options. We have the eight options spelled out in the paper. So now we have eight options, four goals. What we would do in the SMART technique is now tie the options into the goals. We create a matrix, or a set of thermometers for each goal, and we would enter the options, or score the options on the thermometers. That's in a deterministic model.

The breakthrough we had here was to say, "Well, we can't score the options, but we're going to proxy for scoring the options," and that is the probability. So if we have a desirable objective, an objective like, "We want the population to be 400," we could score the various options by seeing what the probability was that we would reach that objective.

And so we came up with the idea of using the SMART technique but scoring the actions, or the options, against the objectives by using the probabilities generated by the model. And remember now, we had various versions of the model. And so we could do this with various versions and see how sensitive our conclusions were to which version we used.

Now, I mentioned there was a difficulty that we had two objectives that related to the population. And one of the reasons why this is a no-no is because it gives you unfair weighting. And we haven't talked yet about weighting the objectives. But what we decided to do was use the SMART technique and say, "Cost and mobbing deaths each had a weight of 1 or 100, or whatever." And then we would give both population objectives the same weight, which meant, in effect, we were saying that the population was twice as important as anything else.

But a couple of very definite, robust conclusions came out of the follow-up paper. The first was that it was a bad idea not to do anything. The second was that it was a bad idea to wait and then take action. And the third was that it was a bad idea to move females. So you were left with five of the eight options that involved moving males. And it turns out that sometimes one of those options came out on the top, and sometimes, another. But generally speaking, the consensus was, "Remove males," and it didn't matter much whether the trigger for removing males was the sex ratio or the number of mobbing deaths.

So what do we have if we go back to our diagram of tools?

What we have done is we've taken SMART from the deterministic side and turned it into a stochastic tool. It is SMART with probabilities. And where do the probabilities come from?

They come from a model. In other words, we have, in essence, taken SMART from there and simulation, which is modeling, from there, and combined the two to develop a “SMART with probabilities” technique using models to develop the probabilities.

So let's sum up what we've learned from this exercise. And, perhaps, I think the most important lesson was that the model was absolutely essential.

Remember, when we set out to develop a model, we weren't quite sure whether it was what we needed to do, but it was the only thing we could think of doing. Turns out to be absolutely essential because the only way we have of linking the options to the objectives is via the probabilities generated by the model. And if you think about it, there's no way you're going to be able to collect that kind of data in a real world. So modeling, as a link to the SMART technique to figure out how you can evaluate your alternative management options in relation to your objectives, is a very powerful technique. Modeling and structured decision-making go together hand in glove. The structured decision-making provides the objectives for a modeling exercise, and the modeling results provide that link to make SMART really work.

I must tell you a quick story. When I was teaching, I used to give students roles to play when we talked about monk seals and had them go and develop their own facilitated workshop to decide which of those eight options to go for. And I left it to them to find a facilitator and to come up with, what I hoped, was a unanimous conclusion.

Somewhere in one of the groups that tried to do this, there was a student who was playing the role of scientist and said, “What are we doing with this paper by Starfield et al? It's just a model. Who believes it? I don't believe in models. We can't use those results to make a decision.” And he managed to persuade everybody else it was a bad idea to use the results from the modeling paper.

Without those results, they had no way to link their objectives and their options. So the rest of the meeting was involved in just discussing the options. And what happened was that, purely from a gut feeling of the roles they were playing, some people wanted no action, and other people wanted to remove males. And the poor facilitator was left with a split group which couldn't reach consensus. And she said, “Can't we agree on anything at the end?” And they agreed to move females. And the reason for removing females was that neither of the group wanted to do that, and so that was the one thing where they didn't lose face, as it were, and so that's what they recommended.

And my reaction when I heard that this is what they had done was, “How horrific.” And then I had an even worse reaction, which was, “I wonder how often something like that happens in the real world.” So the model is essential because the link between options and objectives is essential.

Okay. The second point I want to make is to talk a bit about the sensitivity analysis.

Remember, with the mobbing response, we found that the final population was very sensitive to the slope of the mobbing response. And at that point, we might well have given up, but we used the heuristic of, “Press on regardless.” And we decided to carry all three results. And that turned out to be very important because, although the model was sensitive to the slope, the ranking of the options was pretty much insensitive to that slope.

If you want to think about it, the slope had a big effect on the outcomes for the models in each of those options, but it didn't change the rankings. So the key lesson here is that when you do a sensitivity analysis, you need to make sure that you carry it all the way through to see whether your final decision is sensitive to what you don't know or to what you're uncertain of in the model. It's no good stopping just because your model results are sensitive.

The third point I wanted to make was that we were working with others here, and there was a lot of to-and-fro-ing. We were told we couldn't build a model because there was not enough data, and it turned out people were right, and we had to deal with this.

While we were developing the model itself, we were making a number of assumptions about how mobbing might work, and so on. And each time we made an assumption, we developed a prototype of the model, and we bounced it off people who knew more about monk seals than we did. And they came back with criticisms. And we dealt with each criticism by doing an assumption analysis. Some of the criticisms were just, “Yes, obviously, they are right.” We didn't know that. And others were ones that we felt weren't that important.

And what we would do was do a sensitivity analysis and be able to go back to the people who made the criticism and show them, from a very, very simple experiment on the model that this wasn't important. The result of doing this was that we had the trust of the people that we were working with.

And the final point I want to make is if you go through a process like this, how do you know that you've reached a good decision?

Suppose you go ahead and implement one of these techniques, and suppose it doesn't work. Does that mean you made a bad decision? Remember, everything here is stochastic. You might've made a bad decision, but it could be that you just had bad luck. In a stochastic situation, you cannot rely on the outcome of what amounts to one replicate to decide whether a decision was good or bad. So you have to fall back and say, "Was it a good decision process?" And if you have a strong, logical process for reaching the decision with buy-in from stakeholders, then that is about as good as you can do.

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