Systems in action: Modelling a muddle
Part 2

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GINA LANDOR: This represents the fate of a single generation of fish recruits over one year. We can use the physical model to follow these fish over five years. The result, fewer and fewer fish survive to become large fish that can reproduce. These large fish are known as the spawning stock biomass.

But what if we assume no fish are caught in their first year? Some of these first-year fish will die from natural causes, but there are also more fish reaching maturity than before. Although the total number of fish caught under this new regime is smaller, the total mass of fish is greater. In other words, this model can be used to test different ways of intervening in the system. But a model needs to have data fed into it.

GINA LANDOR: How exactly do you go about making an assessment of the spawning stock biomass of all the species that are fished for, especially, when you can't actually see the whole population because it's hidden underwater?

5:00 AM, Lowestoft. Ministry officials are making an assessment of the place immediately after landing and before they are sold off through the auction. On a regular basis at all the major fishing ports in Britain, samples of all the fish landed are sexed and measured.

In addition, the otilith, the so called earstone is removed. They are packaged up for analysis in the laboratory. The ear stone is a key to the precise age of the fish and is collected from all landed bony species.

At a very fine scale, they show growth rings, like a tree that can be counted to give an age in years. All the information for all the regulated species is collated and is used to estimate spawning stock biomass. The data is used in the model. How is the proposal for fishing effort arrived at?

DR KEVIN STOKES: One thing we want to do when we manage a population is to set ourselves some strategy for our management. What we're going to do here is use a very simple model which will run on the computer, which should give us some idea of how we can increase the yield that we get from a fishery relative to where we are now by changing our levels of effort or other values.

What I have here is a spreadsheet, which is going to do what the physical model did. In the physical model, we had the fishing mortality, which I would call F, which is for every age. We have the natural mortality, which I call M, again for every age. And also each ball bearing had a particular weight. I'm actually going to have a weight which changes at every age which is just the same as happens to real fish. Also in my spreadsheet, I've got the percentage of fish which are mature at every age. I'm going to start with one recruit. I could start with the 1,000 recruits 150 recruits, or whatever.

What I'm going to do on the computer is multiply by fishing mortality by some factor. And I'm going to keep doing that so that I can build up a graph. But we now have two graphs which plotted up from the results in the spreadsheet, on the bottom for both graphs the F factor. One is our current level of fishing effort, zero is no fishing effort at all. In other words, we stop fishing. Points in between a reduction of effort relative to the current level, and points above between one and two are increases in effort relative to the current level.

If you look at yield per recruit, YPR first, what we find for this particular stock of fish is that at some low level of fishing effort relative to the current, we have a maximum yield that we could obtain for every fish that's recruited to the fishery.

What we might want to do, therefore, is to evolve a strategy whereby we decrease our fishing effort gradually so that we increase in time our yield per recruit. If we look to the graph on the right, which is spawning stock biomass per recruit, we get some other idea of how doing this might help in the long run, and also why it's happening.

Currently with an F factor of one, we have a very low spawning stock biomass per recruit. Somewhere around here, an F factor of about 0.2, we're not being too accurate on this spreadsheet, is where we would like to be to get our maximum yields per recruit.
Over here, an F factor of about 0.2 would give us a spawning stock biomass per recruit of about six. That's very much higher than where we currently are. If you think about it, what this says is for the particular fish, if we fish less severely, we will allow a lot of young fish to escape. They will therefore grow bigger, they will therefore contribute to our spawning stock, and they will allow us to catch them when they're big, at which point they contribute more to our catch than they would as small fish.