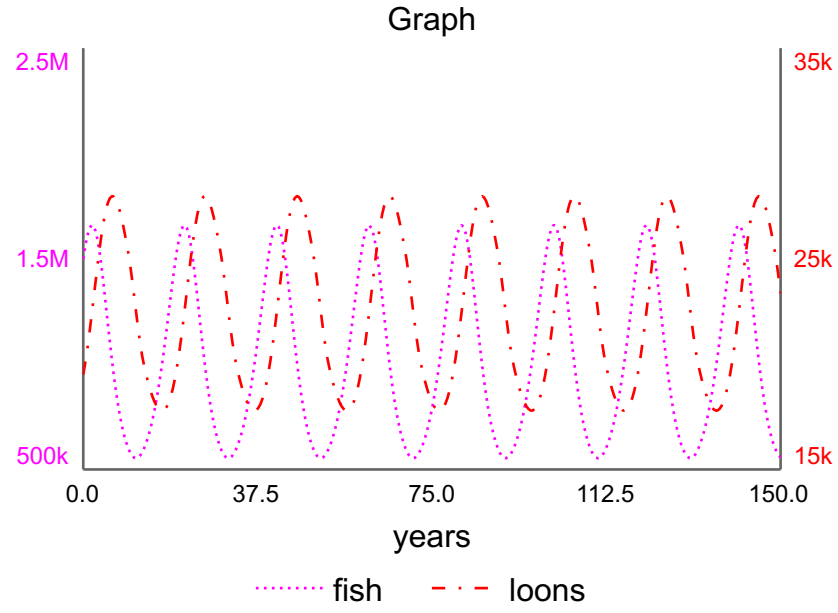
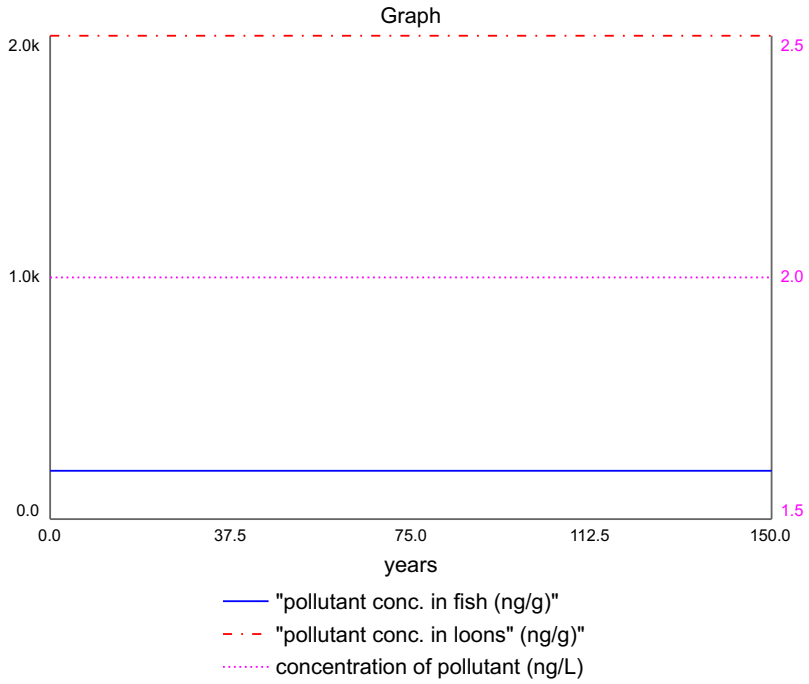
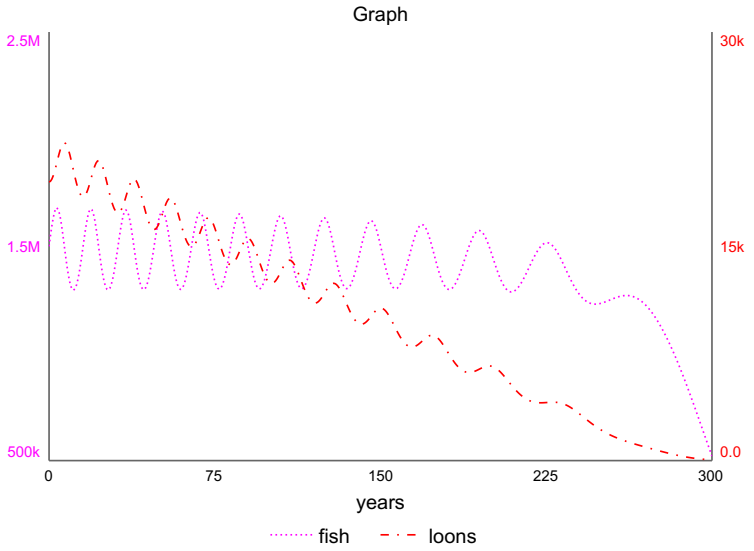
Boundary waters modelling answer key

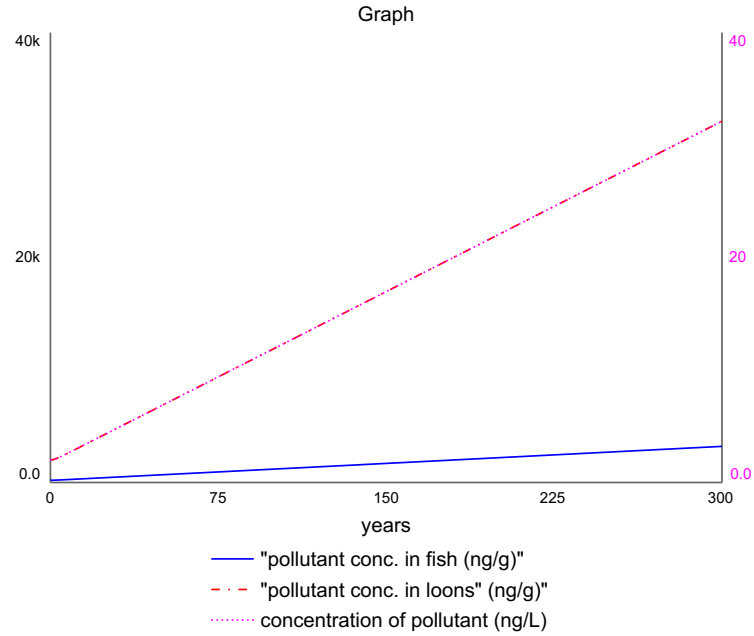
4. Regular fish and loons:





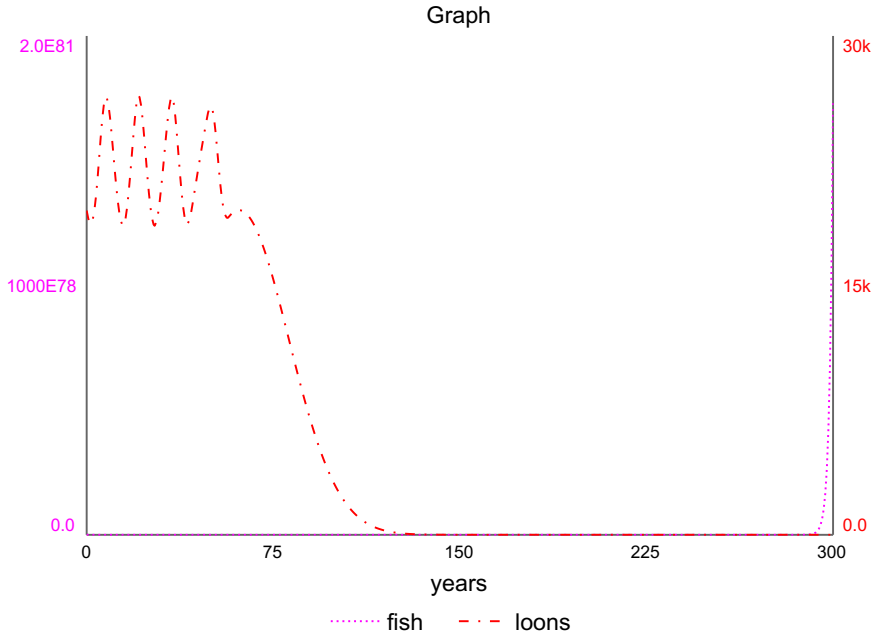
6. Gradual increase in Hg, only fish directly affected:





It takes ~30 years for the fish to be above the threshold for human consumption. Notice the amplitude of the fish peaks and troughs decreases drastically compared to the control, making the “lows” low enough to just push the loon death rate (which depends on fish density) above the birth rate, starting their population decline. Less predation allows the fish to survive longer than they might, but in the end there is too much mercury.

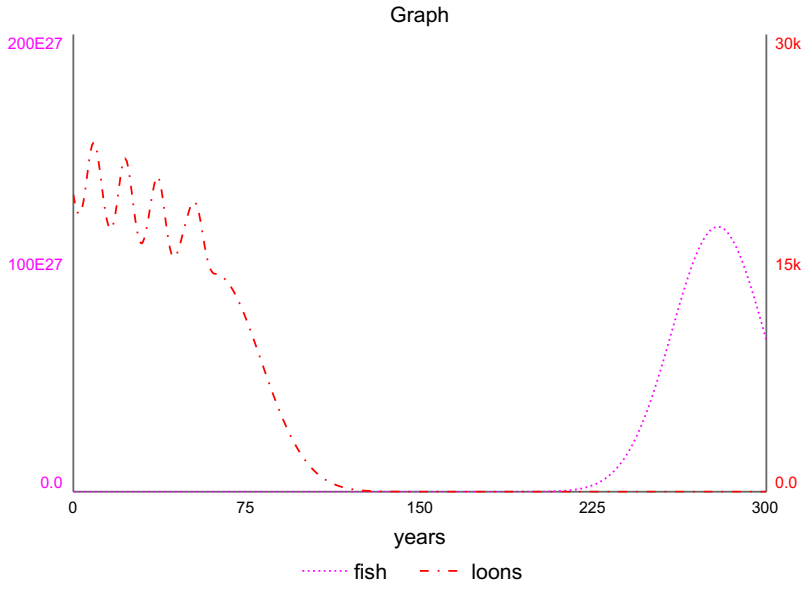
7. Gradual increase in Hg, only loons directly affected:



Concentrations are the same as before.

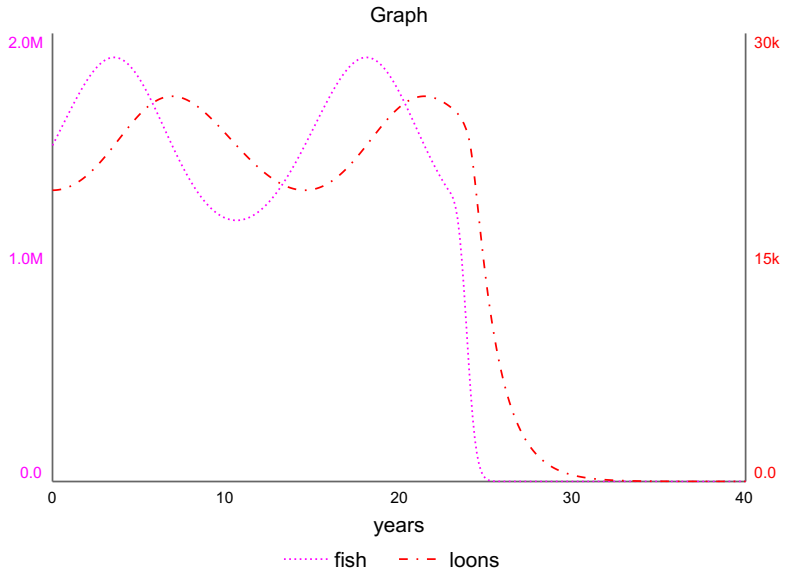
The loons have plenty of fish to eat, but are poisoned by mercury very early on. This is telling us something about the biomagnification process, as well as the loons' position in the food chain (there's no predator above them declining, helping their own numbers via less predation). The fish population explodes with no loons to eat them! This is likely not realistic- they'd run out of food, space.

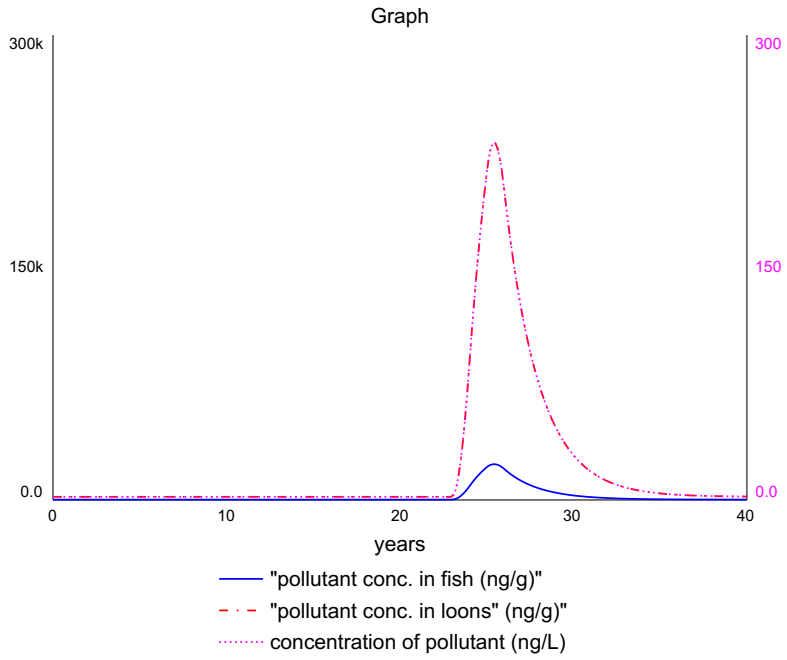
8. Gradual increase in Hg, both species affected.



Here we see a combination of the last two- except this time the fish are eventually poisoned instead of seeing the population explosion.

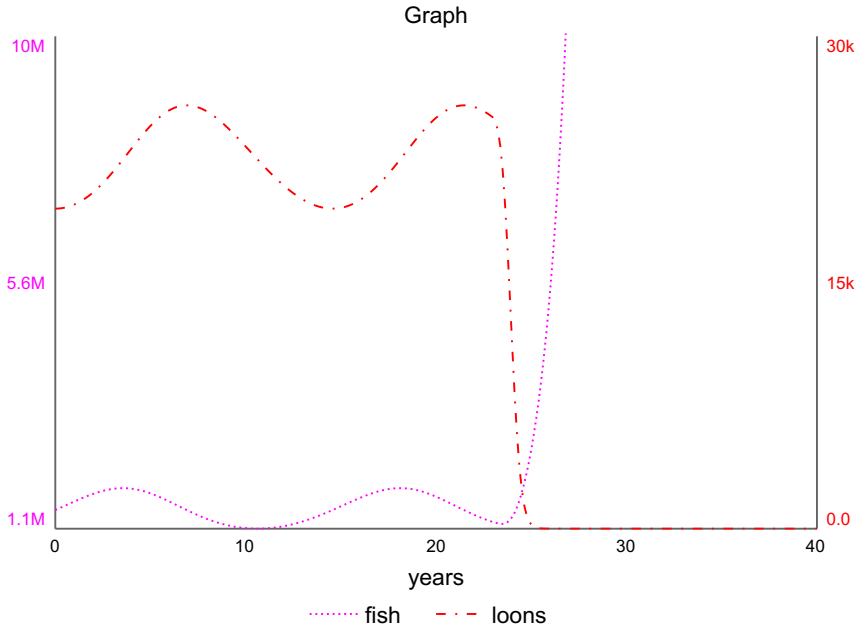
9. Rapid, large spill – fish only





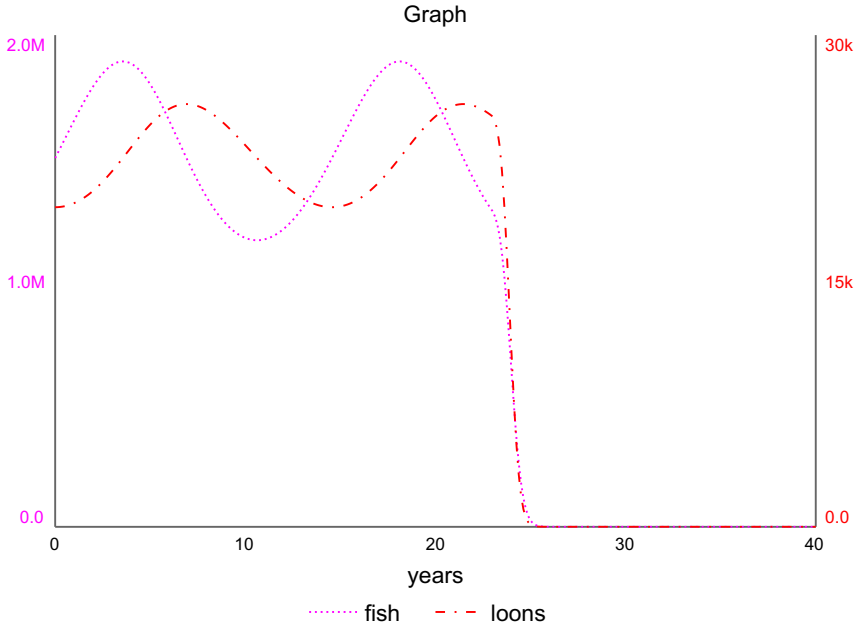
The threshold for no more fish and loon birth could reasonably be set to 2; students could also reasonably argue that it might be slightly higher. In reality, new loons or fish could move in eventually, but this eliminates some funny model behavior where it lets a fraction of an animal reproduce… The threshold for killing fish is a pulse of 2 years of 10^12 ng, or 1000X the current inflow. Here the fish are quickly poisoned, and the loons die soon thereafter because they have no food.

10. Rapid, large spill – loons only



The threshold for loons turns out to be the same- students may realize that this would be the case because of the way we built the model, where the slopes of the death rate due to poisoning are the same for each species relative to their starting concentrations. The loss of loons leads to another fish population explosion!

11. Rapid, large spill – both



The main difference here is in the timing- both species feel the effects of the mercury at the same time, so there's no time for anyone's food supply/predation to be affected.