Case study: Regulation of estrogen in water management facilities

By Helen Smith

Currently, Europe is debating on whether to expand filtration in wastewater and drinking water management facilities to uniformly include pharmaceuticals and endocrine disruptors.

In the State, you are part of a panel for the National Institute of Health to investigate the potential regulation of estrogen in the water supply. Your panel is tasked with determining if there is sufficient data to warrant regulation of estrogen (or estrogen-like compounds) in the water supply. If so, what regulations would your panel suggest; if not, what data would be sufficient to warrant federal regulation.

I have provided you with three different sources of information and questions to help understand what processes environmental exposure to estrogens (or endocrine disruptors) alter. The first two articles relate to estrogen (or endocrine disruptor exposure) changing male fish to become more 'feminine' (or having more female characteristics) and how that relates to population size. Why fish? Fish are used as a freshwater equivalent to a 'miner's canary'.

1) What processes (in the cell and in an organism) does estrogen directly regulate? (Hint: estrogen is lipid-soluble)

2) Does estrogen effect all the cells in our (or other animals) bodies? Why or why not?

Source 1: (Kidd et al. 2007) Title: Collapse of a fish population after exposure to a synthetic estrogen. In this paper the authors, "describe the results of a 7-year, whole-lake study to assess the effects of the potent synthetic estrogen EE2 on fathead minnow."

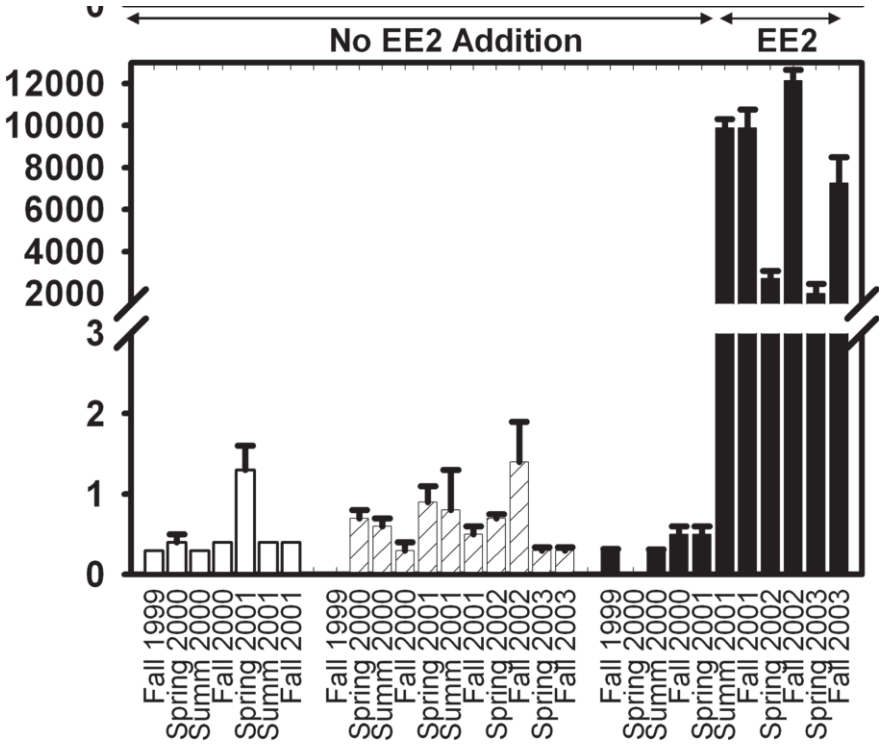


Figure 1 shows mRNA levels of vitellogenin (VTG) in male fathead minnow. VTG is a readout (or indicator) of estrogen exposure. In other words, the VTG gene is transcribed as a result of estrogen signaling. The top indicates exposure to the synthetic estrogen, EE2; the y-axis is in arbitrary units (normalized to body weight of the fish).

3) Draw a diagram of how VTG is regulated (draw a cell, nucleus, receptor, signaling molecule, enhancer sequence and the VTG gene)

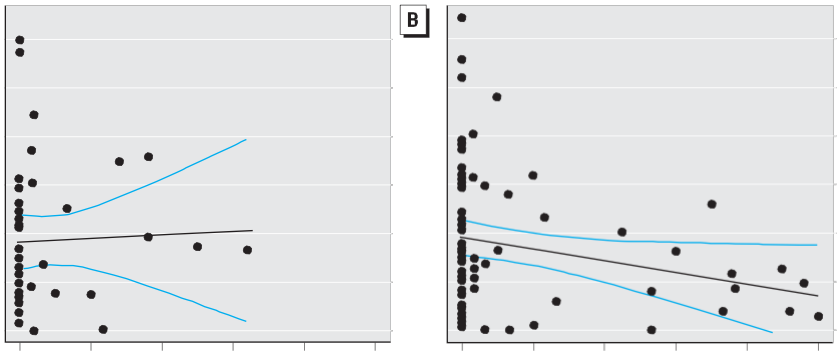
4) Below is Figure 3B (adapted). What happens to the population size during and after exposure to synthetic estrogen?

Year	Control Lake: # of minnow (catch-per-unit-effort)	Lake with Exposure to synthetic estrogen	Exposure # (Catch-per-unit effort)
1999	490 +/- 68.1		180 +/-48
2000	19.1 +/- 10.4		50.3 +/- 43.7
2001	56.1 +/- 39.9	+ Synthetic estrogen	117.7 +/- 20
2002	9.6 +/- 2.2	+ Synthetic estrogen	.7 +/- .2
2003	20.6 +/- 3.8	+ Synthetic estrogen	2.6 +/- .8
2004	51.9 +/- 21.2		.1 +/- .05
2005	355.9 +/-99.6		.1 +/- .01

5) One limitation to the above study is that the fathead minnow has a short reproductive life span. Why is that a limitation? Does that matter to you and your panel?

6) Source 2: Harris et al. 2011. Title: The Consequences of Feminization in Breeding Groups of Wild Fish. Modeling approaches can describe how endocrine disrupting molecules can impact population declines. However it is not known how fish exposed to endocrine disruptors ('feminized' fish) compete with normal fish to contribute to the next generation.

Below is figure 3A and B. Reproductive success is plotted on the y-axis; intersex index (the severity of feminization) on the x-axis. The black line in the middle of the 3 lines shows the 'best fit' line (trend line); the blue lines on the outside represent the 95% confidence limits. 3A (left) represents Study 1 with fewer fish being 'highly feminized'. 3B (right) represents Study 2 with more fish being 'highly feminized'.

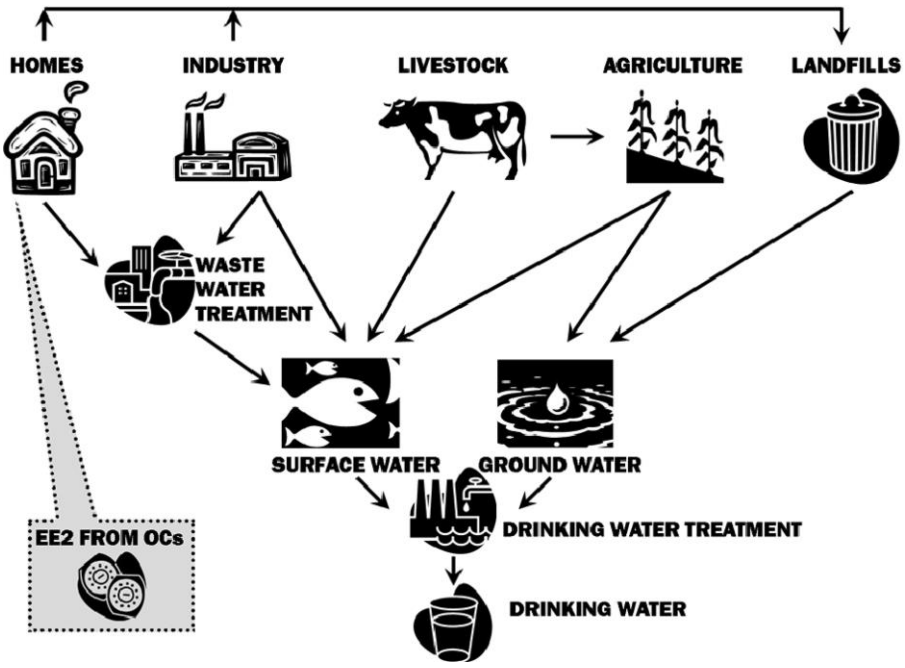


What is the conclusion of 3A and 3B?

Is this data (3A and 3B) consistent with each other? Why or why not?

If there were more 'highly feminized' fish in the 3A population, would you predict it to look like figure 3B?

7) Below, this figure (Wise, et al. 2011) highlights some of the sources of estrogen into the water supply. "EE2 from OCs" stands for the synthetic estrogen found in Oral Contraceptives.



What are the various sources of estrogen (and synthetic estrogen and endocrine disruptors like Bisphenol-A, BPA, found in plastics)?

How might regulating the synthetic estrogen EE2 in oral contraceptives impact society in the US?

What would be the most efficient way of regulating/filtering estrogen from the water supply for humans? For all animals?

So: What is your panel's decision? Is there sufficient data to warrant federal regulation? Why or why not?

If yes: what are your recommendations on what to regulate (indicate any additional information you would want).

If no: what additional data would you need before making a decision?