Impact of climate change on a risk assessment for intersex in fish due to steroid estrogens

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1. Introduction

Over the recent years, it has become acknowledged that some level of climate change is unavoidable. Climate change will affect river flows and thus impact water quality via the dilution of contaminants. The steroid estrogens estrone (E_1), estradiol (E_2) and ethinylestradiol (EE_2) were identified as the main chemicals causing intersex in male fish , which is a widespread issue in the UK[1]. Williams *et al.*[2] assessed the risk of fish intersex induced by these steroid estrogens for the UK under current flow conditions. The objective of the present study is to use these mthods to characterise how this risk is likely to change assuming impacts of climate change on the UK[]. The potential risk under climate change impacted flow is derived by comparing predicted environmental concentrations (PECs) with threshold levels defined by environmental effect levels.

2. Materials and methods

2.1. Predicted environmental Concentrations under future flow scenarios

Concentrations of estrogens for each river in England and Wales were estimated using the LF2000-WQX (LowFlows2000 Water Quality eXtension) model. LF2000-WQX is a mixed deterministic and stochastic model that combines hydrological models and water-quality models to produce spatially explicit statistical distributions of “down-the-drain” chemicals in surface waters across England and Wales[2].
Prudhomme *et al.*[3] estimated changes in flow for Britain in the 2050s for 11 different climate change scenarios defined by the 2009 UK Climate Projections (UKCP09). Within this study, 3 scenarios were selected to generate distributions of perturbed future river flows. The 3 selected scenarios were:

- Scenario afgcx: initial or average parameter set from the UKCP09 climate change model,
- Scenario afixa: wettest scenario,
- Scenario afixk: equivalent to the driest prediction of climate change scenario.

Within LF2000-WQX, the emission of chemicals is derived from mean influent load and sewage treatment plants (STPs) characteristics. To reflect demographic changes, the mean influent load used in the orginal study[2] was adjusted using population projections for the UK in 2050[4] and a model to estimate influent steroid estrogen concentrations[5]. The population served by STPs was adjusted to reflect demographic changes using the same population projections[4]. All other estrogen properties remained the same.

2.2. Risk Classification

To allow for comaprison with the previois study, the risk thresholds used within this study are those defined in the original risk assessment[2] and related to reproductive endpoints. For each scenario, all river reaches within England and Wales were then classified into risk categories based on potential steroid estrogen impacts: no risk, at risk and high risk. The boundaries of these classes are defined in terms of E_2 equivalents: $[E_2 \text{ eq}] = [EE_2]/0.1 + [E_2]/1 + [E_1]/3$, (brackets denote concentrations). The risk class boundaries were defined as: i) no risk: $[E_2 \text{ eq}] < 1$ ng/l, ii) at risk: $1 \leq [E_2 \text{ eq}] < 10$ ng/l and iii) high risk: $[E_2 \text{ eq}] \geq 10$ ng/l.

3. Results and discussion

The risk assessment for England and Wales was conducted region by region for each scenario. Risk maps were then generated to identify areas of potential risk and compared with the current risk map. As an example, the risk maps derived from mean concentrations for scenarios afixa and afixk are presented for the Thames region (*Fig 1*). The Thames region has a surface area of about 12,900 km^2, and a high population density of about 447 inhab/km^2.
Within the Thames region, the spatial distribution of the predicted risk categories are fairly similar with many reaches being at least “at risk” in both scenarios. However, the scenario afixk seems to present increased risk in the north west part of the region.

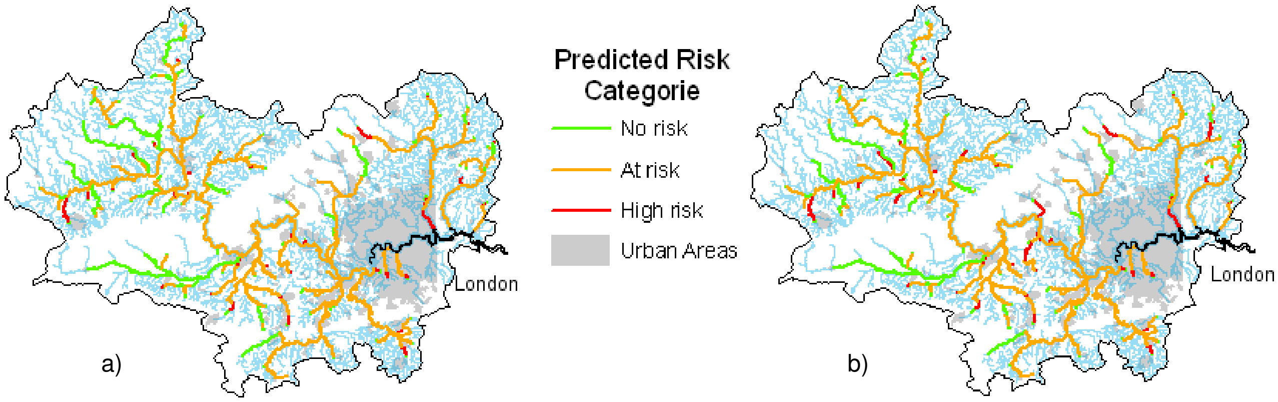

Figure 1: Spatial distribution of predicted risk categories in the Thames region for scenarios: a) afixa and b) afixk.

The extent of the risk level in the Thames region and in Wales was quantified in terms of percentage of total length (TL) of river modelled (Table 1). These regions are presented because they showed a great contrast in terms of overall risk levels under both current and future flow scenarios. Wales has a much lower population density (≈ 50 inhab/km^2) and therefore more water *per capita* than the Thames Region.

	Thames (TL = 1660 km)				Wales (TL = 2731 km)			
	afgcx	afixa	afixk	Current	afgcx	afixa	afixk	Current
No risk	21.9	24.5	21.4	**30.0**	92.9	93.9	90.9	**95.0**
At risk	71.5	70.2	70.6	**67.0**	7.0	6.1	9.1	**5.0**
High risk	6.6	5.2	8.0	**3.0**	< 1	< 1	< 1	**< 1**

Table 1: Percentage of total length of river modelled per risk categories for Thames and Wales in future scenarios and current risk assessment as predicted by Williams et al.[2]

All the future scenarios predicted higher levels of risk then those currently predicted under curent flow regimes by Williams *et al.*[2]. Within the Thames region the category that changes the most significantly was “high risk” going from 3% of TL up to a maximum of 8% for the driest scenario (afixk) due to lower dilution (lower flows, increased population). It is in this category that highly intersex male fish would be expected to be found. For Wales, all scenarios predict less than 1% of TL estimated to be at “high risk”; it is the “at risk” category that presents the most changes (afixk scenaro). Within Wales little change is predicted between the current risk assessment and the one based on the wettest future scenario (afixa).

4. Conclusions

This exercise presented a range of possible changes in risk for intersex in fish due to steroid estrogens for the 2050s. The risk levels do seem to increase across all regions of England and Wales. However the level of changes will vary according to the regions and the scenarios selected. This work warns regulators and policy makers that risk assesments could look different under a changed climate.

5. References

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