Physical and Behavioral Effects of Common Endocrine Disrupting Chemicals in Western National Parks on Fish in a Synergistic Manner– Emily Guise

Introduction: Endocrine disrupting chemicals (EDCs) are chemicals that disturb endocrine processes within an organism. Mechanisms of actions and their effects vary widely (1). Due to the complexity of the endocrine feedback systems, EDCs can sometimes have the greatest influence at lower doses (1). Because EDCs are typically synthesized for practical use (such as atrazine, an herbicide), they are often made to be very stable and long lasting. Their persistent nature leads to their appearance in water runoff and precipitation, where they have been known to accumulate in ponds and sediment (2).

Certain fish species are good bioindicators for pollutant exposure (3). Because fish are a food source for many others, it is important to know the potential effects (lethal and non-lethal) of EDCs upon food webs. Fish are often exposed to a chemical milieu, thus understanding the synergistic effects of exposure is also paramount. I propose to measure the levels of polychlorinated biphenyls (PCBs), pesticides/herbicides (like atrazine and endosulfan), polycyclic aromatic hydrocarbons, and the plasticizer bisphenol A (BPA) within freshwater trophic systems and determine the transgenerational influence these EDCs have on fish physiology and behavior.

Mountainous regions are prone to EDC accumulation (4). Some high elevation areas have diurnal mountain winds, increased precipitation, and lower temperatures that increase the delivery and longevity of EDCs. Various EDCs have been measured in the Western National Parks of the US, but the synergistic effects of exposure to those pollutants have yet to be measured multi-generationally in fish. PCBs were banned in 1979 and are still found in Park samples far from their administration sites (2). National Parks were meant to be untouched nature reserves, yet are currently subjected to pollutants via uncontrollable and unavoidable sources such as precipitation. My graduate research proposes to combine the determination of the presence of pollutants with experimental studies to elucidate the impact of these chemicals on wildlife allowing me to assess the short and long-term consequences of multi-chemical exposure.

By elucidating the synergistic effects of these pollutants on some of the primary wildlife affected, we are best able to recognize and prepare for the consequences in terms of environmental changes, bioaccumulation, and policy change. If we are unable to protect our National Parks, then we will be unable to protect some of the last sources of intact nature in existence.

Methodology:

Phase 1: Seasonal samples are taken from polluted Park areas to form a profile of contaminant levels present throughout the year.

Anticipated Results: Seasonal EDC profiles will display an ecologically relevant exposure paradigm to compare to past experimental measurements done by Ackerman (2) to determine if there are any trends of the seasonal effects on contaminate levels. I might expect to see a gradual increase in the amounts of currently used EDCs (such as the plasticizer BPA) but a slight decrease in PCBs due to the 1979 ban.

Phase 2: I will begin captive animal work utilizing common fish of Park lakes (such as *Salvelinus fontinalis)*. Based on the seasonal profiles, fish will be exposed to these chemicals at ecologically relevant combinations and dosages to determine synergistic effects. I will monitor physical changes in basic and sexual morphology (such as overall size and weight, belly coloring *S. fontinalis*), hormone profiles (such as estrogen, testosterone and vitellogenin) as well as behavioral changes in memory and reproductive behaviors. The contaminant levels in the tank will be monitored by gas chromatographic mass spectrometry, high-performance liquid chromatography, and ELISA/EIA as fit for the pollutant and sample type as described by Ackerman in (2) and Bradford in (4).

Anticipated Results: Previous studies find that individual EDCs may be found within "safe" limits (2), but I expect that the synergistic activity of multiple exposure will have unwanted effects on changes in the behavior and physical appearance of the fish. I predict increased feminization of the males, both in appearance and behavior (showing lower motivation to reproduce). I also expect fish to have higher estrogen levels in the experimental group compared to the untreated control, and no effect on testosterone. I expect the memory abilities of second generation of exposed fish will be decreased, as some EDCs can affect brain and development. Overall, I predict a decrease in the ability to reproduce and/or survive based on the treatment.

Phase 3: To determine ecological impact on exposed species, I will measure the pollutant levels within the tissues of wild-caught Park fish as well as determine their reproductive hormone profile. Comparing their physical features and behavior to the captive experiments will allow me to determine biological impacts of the pollutants on individuals within the Park.

Anticipated Results: I expect wild fish to show the same symptoms of the treated fish dependent on location and pollutant abundance. The effects on these fish may be greater/lesser depending how long they have been exposed.

Phase 4: I will mimic the current increasing contamination trends within the seasonal profiles by exposing laboratory fish to increasing levels of contamination until reaching levels predicted in 50 years (if we continue our current trend) and measure the physical effects.

Anticipated Results: I expect the fish will either die from the high levels of pollutants or become unable to survive. Either method impacts the individual and population health of National Park fish and the supported ecosystem.

Preferred Institution: My preferred institution, Oregon State University, has previously collaborated with the National Park Service (NPS) and the Dept. of Fisheries and Wildlife (DOFW) to carry out preliminary work measuring pollutant levels in lakes and sediment (2,4). Here, I will have all the equipment and expertise to measure these pollutants.

Broader Impacts: Working closely with NPS and DOFW will allow me to share my results with Park Officials and participate in fostering management strategies and educational outreach. I plan to research Crater Lake National Park and they have a Science Education Center with programs for elementary and high school students. Here, I can design educational materials for students to learn about the problems with EDCs in our Parks and our own backyards.

Due to the large amount of sampling required for this study, I will recruit undergraduate students to assist me. As a woman in science, I understand the importance of increasing the involvement of underrepresented groups. Therefore, I will recruit undergraduates these groups to assist me in order to foster their interest in science and research.

Citations:

1. Saaristo, M. et al. (2013). An androgenic agricultural contaminant impairs female reproductive behavior in a freshwater fish. PLoS ONE, 8(5), e62782.
2. Ackerman, L. K. et al. (2008). Atmospherically deposited PBDEs, pesticides, PCBs, and PAHs in western U.S. National Park fish: concentrations and consumption guidelines. Environmental Science & Technology, 42(7), 2334-2341.
3. Spearow, J. L. et al. (2010). Environmental contaminant effects of juvenile striped bass in the San Francisco estuary, California USA. Environmental Toxicology and Chemistry, 30(2), 393-402.
4. Bradford, D. F. et al. (2013). Temporal and spatial variation of atmospherically deposited organic contaminants at high elevation in Yosemite National Park, California, USA. Environmental Toxicology and Chemistry, 32(3), 517-525.