INITIAL STUDY PHASE:
EFFECTS OF AQUATIC CONTAMINANTS ON EARLY LIFE STAGE STURGEON

UC DAVIS WILDLIFE, FISH, & CONSERVATION BIOLOGY

Anna E. Steel[1], Richard Connon[2], Sarah Baird[1], Dennis Cocherell[1], Nann A. Fangue[1]
University of California, Davis

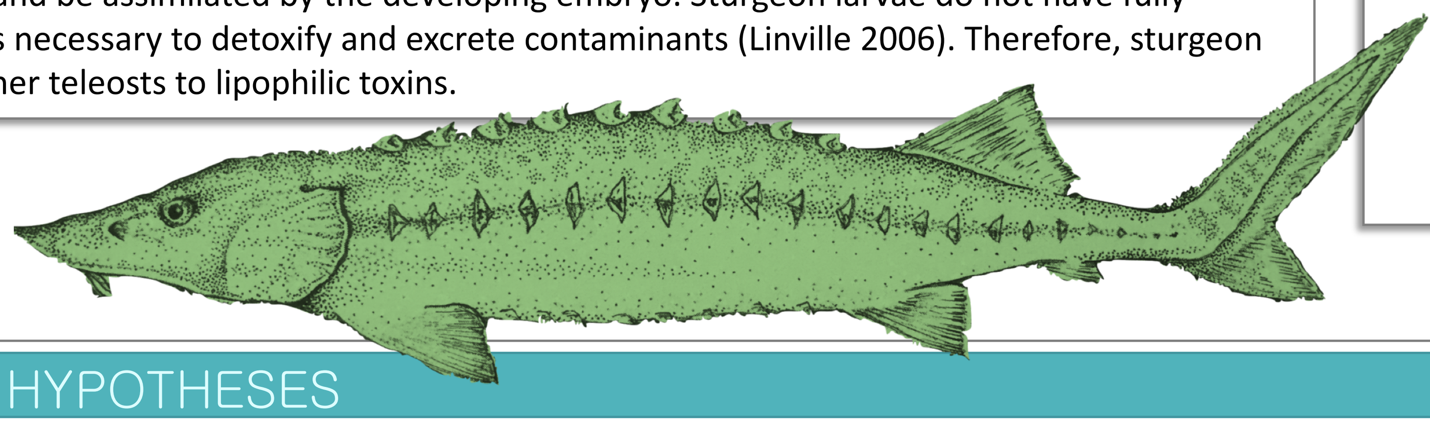
UC DAVIS VETERINARY MEDICINE

BACKGROUND

Contaminants from numerous sources are pervasive throughout the San Francisco Bay-Delta (SFBD) and its watershed (Fong et al. 2016). In their review of contaminant effects in the SFBD, Brooks and her colleagues (2012) recognized that a critical understanding of sublethal effects of contaminants on biota are largely overlooked in this system.

Exposure to contaminants at early life stages can have immediate effects on survival and development, and carryover effects that reduce recruitment into the spawning life-stage.

Survival of young-of-year sturgeon is a key driver of population growth rates (Gross et al. 2002). After hatch, sturgeon rapidly metabolize the yolk-sac (Dettlaff et al. 1993). Lipophilic contaminants (including bifenthrin & fipronil) are likely to absorb to the lipid rich yolk and be assimilated by the developing embryo. Sturgeon larvae do not have fully developed organs and enzymes necessary to detoxify and excrete contaminants (Linville 2006). Therefore, sturgeon may be more sensitive than other teleosts to lipophilic toxins.



BIFENTHRIN | FIPRONIL

In recent evaluations of contaminants in the SFBD watershed, the insecticides bifenthrin and fipronil were identified as posing high overall relative risk to aquatic life (Regional Water Quality Control Board, 2009). They occur frequently at concentrations at or above known toxicity levels.

Bifenthrin is a pyrethroid increasing in use in both urban and agricultural settings. It targets voltage-gated sodium channels, resulting in constant action potentials in targeted insects and is toxic to fishes through this mechanism (Soderlund 2012). Pyrethroids are neurotoxicants, but they also have additional effects on fish development, growth, behavior, osmoregulation, and endocrine systems (Connon et al. 2009; Jeffries et al. 2015).

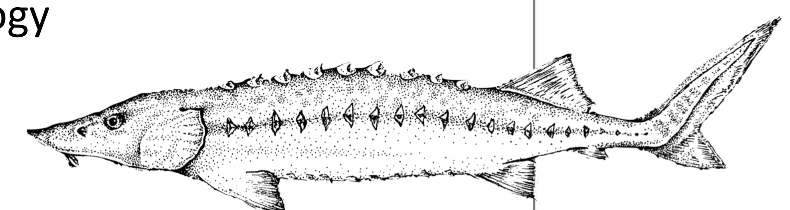
Fipronil is a phenylpyrazole that blocks chloride channels and disrupts the central nervous system. It is commonly used in flea control products for household pets. It has several degradates which are consistently found in surface water and sediment samples (J. Orlando, pers comm; Sanders et al. 2018). Fipronil and its degradates are toxic to fish and aquatic invertebrates (Stehr et al 2006, Baird et al. 2013).

PURPOSE & HYPOTHESES

We will assess contaminants as a stressor on early life stages (larval & juvenile) of green and white sturgeon.

We will consider direct effects on larval survival and development, as well as ecological carryover effects on juvenile physiology (thermal tolerance, metabolic rates), swimming performance, and forging responses.

Research in subsequent years will evaluate the interaction between these contaminant stressors and thermal stress.

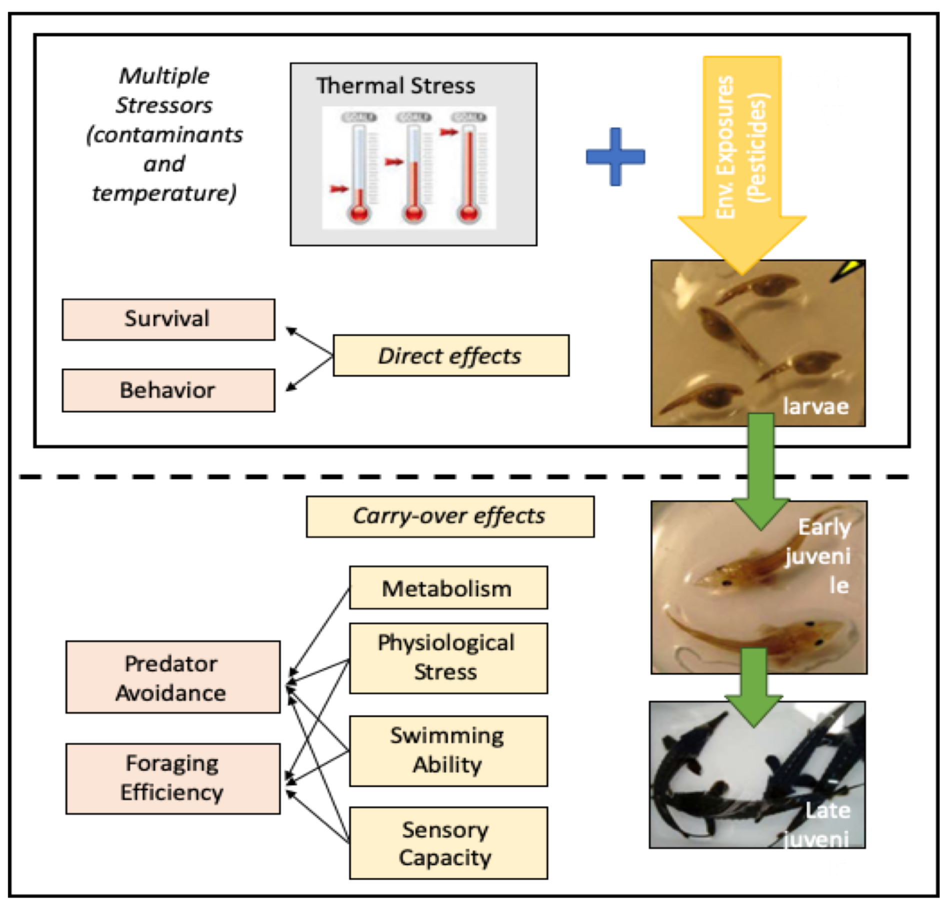


We anticipate exposure to insecticides will impair sturgeons' ability to utilize energy and gather resources.

In laboratory assays, we expect to see increased mortality and altered activity levels when exposed to high concentrations of insecticide. After fish recover in freshwater, we anticipate carryover effects of reduced thermal tolerance, increased metabolic rates, reduced burst speeds and endurance capacity, and a muted response to food cues.

RESEARCH PLAN

Over three spawning years (2020 – 2022) green and white sturgeon larvae will be exposed to multiple common stressors in a controlled laboratory setting: thermal stress (11°C, 15°C, 19°C) combined with multiple concentrations of the pesticides fipronil or bifenthrin. Exposures will be short term (<144 hrs), then larvae will be transferred to freshwater to recover.



During exposures, mortalities will be documented, and behavior will be assessed. A subset of individuals (n~10) will be repeatedly evaluated for abnormal movement and behavior using video tracking software.

After exposures, replicate groups (n~100) will be reared until approximately 9-12 weeks post hatch. Mortality and growth will be monitored. During this period of recovery, juveniles from different treatments will be assessed for variation in thermal tolerance, metabolic rate, burst and endurance swimming performance, and behavioral response to food cues.

In the spring and summer of 2020, due to limitations caused by the pandemic, pilot exposures were completed at 15°C to evaluate a broader range of nominal concentrations of bifenthrin, including those greater than expected in natural systems (>500ng/L). Individual behaviors during the exposure period were evaluated for both species, and carryover effects were evaluated for white sturgeon (thermal tolerance, burst swimming, foraging response).

PRELIMINARY RESULTS

EXPOSURES

Mortality during exposures was very low for both species, with no detectable trend across concentrations

- Morality was 1.9% for green sturgeon larvae and <1% for white sturgeon larvae

Behavioral impacts were apparent during exposures for both species, although they were apparent more rapidly in white sturgeon. Independent evaluations by two observers indicated increasing abnormal behavior over time (Fig 1).

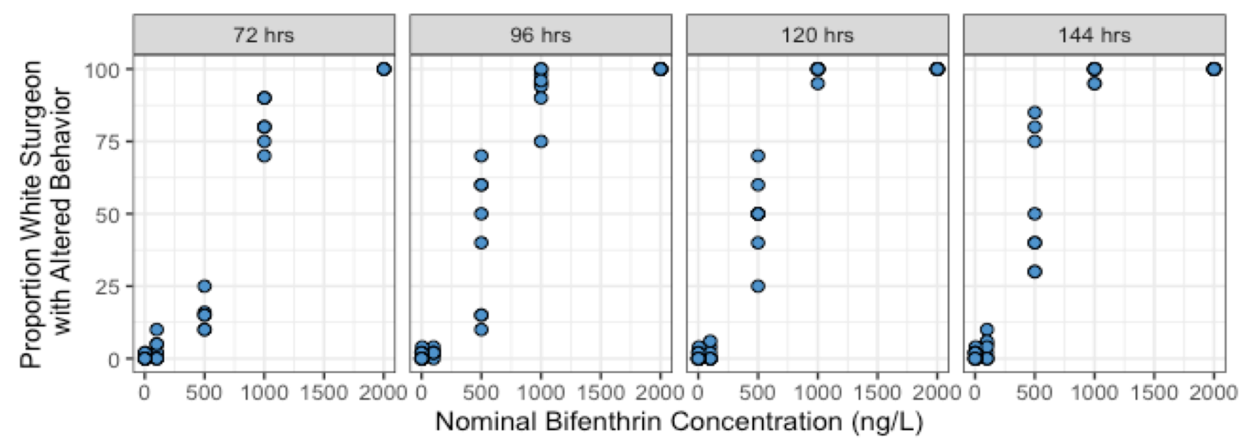


Figure 1: Estimated proportion of white sturgeon larvae displaying altered behavior. Estimates completed for each of four replicate dishes per treatment, with 50 larvae in each dish. Estimates made by two independent observers.

Additionally, video analysis of both species indicated decreased mean swimming velocities with increasing bifenthrin concentrations, alongside an increase in the percentage of time fish were inactive (Fig 2).

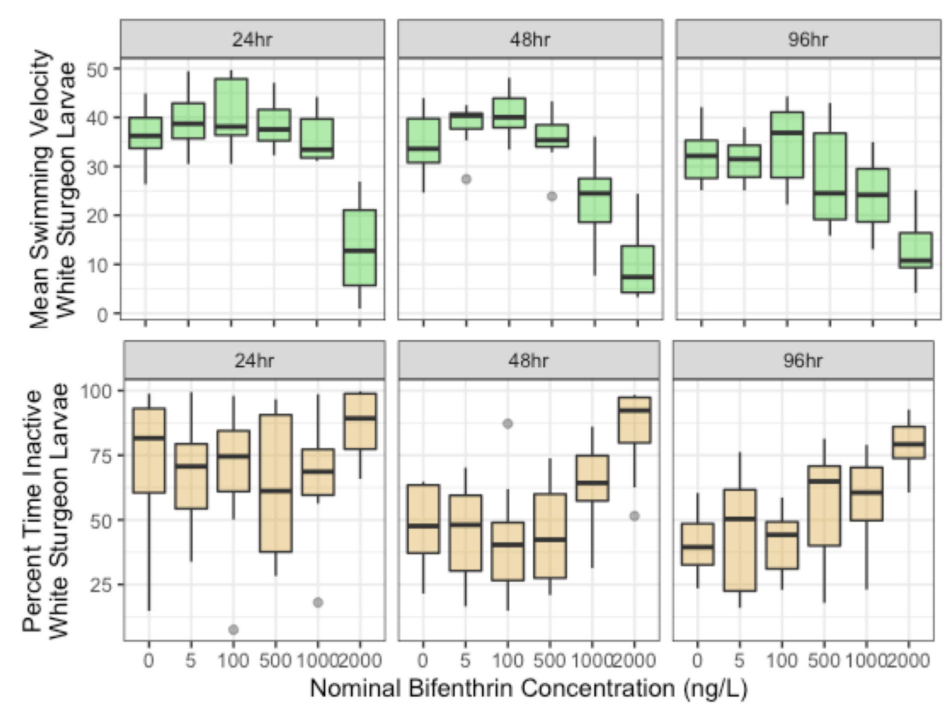


Figure 2: Movement parameters of larval white sturgeon during exposure to bifenthrin. Eight individual sturgeon in each concentration treatment were recorded for 20 minutes at three time points during the exposure period (24, 48, and 96 hours).

GROWTH

From exposure to six weeks post hatch, growth was similar for the two species, with no detectable effect of bifenthrin concentration.

THERMAL TOLERANCE

White sturgeon were evaluated for thermal tolerance within 72 hours after exposure (n=8), and five weeks later (n=10). Standard CTM methods were used. The highest three exposure concentrations initially showed reduced thermal tolerance (Fig 3).

Fish exposed to nominal concentrations of 1000 and 2000 ng/L did not transition to exogenous feeding, and were euthanized prior to the second assay. Those exposed to 500ng/L nominal concentration showed recovery in thermal tolerance.

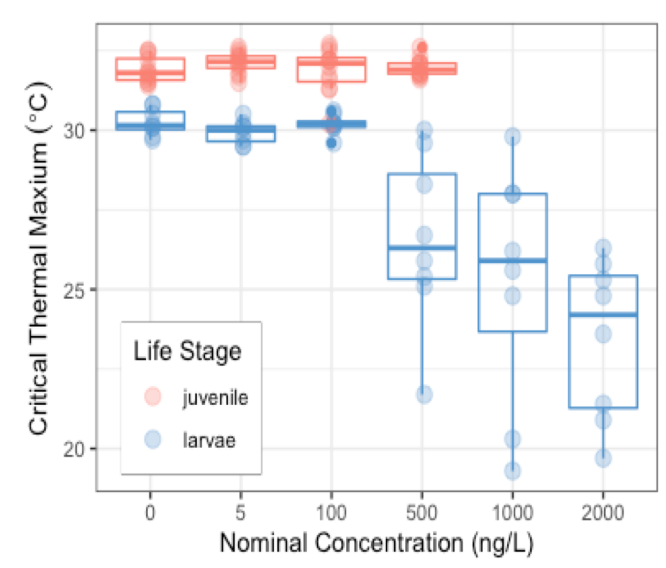


Figure 3: Critical thermal maxima recorded for white sturgeon larvae (n=8, 13-15 dph) and juveniles (n=10, 42-43 dph) after exposure to various bifenthrin concentrations.

Swimming and foraging assays have not yet been analyzed

MANAGEMENT APPLICATIONS

This work will contribute to our understanding of variable recruitment patterns of sturgeon, and the potential role of multiple stressors in recruitment success and population bottlenecks. Thus, our results will help prioritize management actions, and inform water quality criteria. They will also form a basis for continued exploration of the sensitivity of sturgeon to stressors, and the mechanisms underlying ecologically relevant effects.

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For more information, contact Anna Steel, aesteel@ucdavis.edu

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[1]Department of Fish, Wildlife, and Conservation. [2]Dept. of Anatomy, Physiology and Cell Biology