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10-Day survival of *Hyalella azteca* as a function of water quality parameters

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ABSTRACT

Estuarine systems are among the most impacted ecosystems due to anthropogenic contaminants; however, they present unique challenges to toxicity testing with regard to varying water quality parameters. The euryhaline amphipod species, *Hyalella azteca,* is widely used in toxicity testing and well suited for testing estuarine water samples. Nevertheless, the influence of relevant water quality parameters on test endpoints must be quantified in order to efficiently use this species for routine monitoring. Here, we studied the influence of five water quality parameters: electrical conductivity, pH, unionized ammonia, dissolved oxygen and temperature, on *H. azteca* survival in a water column toxicity test. A model was developed to quantify and predict the independent and interacting effects of water quality variables on 10-day survival. The model allows simultaneous assessment of multiple potential predictors recorded during the tests. Data used for modeling came from 1089 tests performed on ambient water samples over a period of three years (2006–2008). The final model reflects significant effects of predictors and their two-way interactions. The effect of each level of all predictors on survival probability of *H. azteca* was examined by comparing levels of each predictor at a time, while holding all others at their lowest (reference) level. This study showed that predictors of survival in water column tests should not be evaluated in isolation in the interpretation of *H. azteca* water column tests. Our model provides a useful tool to predict expected control survival based on relevant water quality parameters, and thus enables the use of *H. azteca* tests for toxicity monitoring in estuaries with a wide range of water quality conditions.

1. Introduction

Estuaries around the world are among ecosystems that are impacted and threatened by anthropogenic activities. The ecological effects of contaminants are difficult to determine and quantify, especially when multiple stressors are exerting joint effects (Sorensen and Fresquez, 1991, Scholz et al., 2000, Sandahl et al., 2005, Clifford et al., 2005). Available ecotoxicological tools include laboratory toxicity tests that use sensitive model species (bioassays), and toxicity identification evaluation (TIE) methods. Standardized bioassays are widely used for testing freshwater and marine samples; however, few water column tests are available for brackish waters, in particular for low salinity zones (Ingersoll et al., 2000).

In estuarine environments, water quality is variable and organisms must be able to tolerate a large range of physicochemical conditions. Depending on their tolerance, water quality parameters such as pH, dissolved oxygen (DO), temperature, and salinity may affect the results of toxicity tests. In order to determine the effects of contaminants within laboratory-based toxicological assessments, water quality parameters are considered constant, and therefore are generally ignored. When conducting field-based monitoring; however, it is essential that these parameters be taken into consideration, so as to determine their potential interactions with chemical toxicity. Multivariate models that account for confounding effects are thus required.

The Sacramento–San Joaquin River (SSJ) Delta of California is an imperiled ecosystem that has been affected by different stressors such as contaminants, habitat destruction, over-exploitation, invasive species and climate change, which have been attributed to playing a significant role in the precipitous decline of numerous

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fish species (Moyle et al., 1992, Sommer et al., 2007, Geist, 2011), that include species listed under the California State and Federal Endangered Species Acts. The SSJ receives inputs of chemical contaminants from a variety of agricultural, industrial, urban, and mining sources (Werner et al., 2010). The major tributaries in particular, carry contaminants such as heavy metals (Buck et al., 2007, Fleskes and Yee, 2007, Solomeshch et al., 2007, Yee and Juliano, 2007), mercury-enriched runoff from historic mining activities (Conaway et al., 2007), and pesticides (Connor et al., 2007) into the delta and estuary. In addition, herbicides and insecticides are at times applied within the delta, directly to the water surface under aquatic vegetation and mosquito control programs (Orlando et al., 2013). Effluents from numerous industrial and urban wastewater treatment plants are discharged via tributaries or directly into the mainstem Delta waterways. The concentrations of various pesticides and heavy metals are sometimes high enough to exceed water quality criteria (Buck et al., 2007, Werner et al., 2010, Weston et al., 2014), resulting in toxicity to wildlife. However, the distribution, concentration and potential toxic effects of most contaminants that act on the delta ecosystem are largely still unknown.

A large ecotoxicological dataset generated from studies conducted in 2006–2008 on the SSJ Delta was used in this study for the purpose of determining and evaluating how confounding water quality parameters affect test results. These studies utilized *Hyalella azteca*, a euryhaline amphipod species for which water-column toxicity assessment protocols have been established (Ingersoll et al., 2000). This species was chosen based on its tolerance to a broad range of salinities (freshwater to 15 ppt), high sensitivity to contaminants, ease of culture, and routine use in toxicity testing programs (Ingersoll et al., 2000, Brander et al., 2009). Water samples collected at key sites within the SSJ Delta were tested using 10-d tests that were conducted every two weeks over the study period. With each water collection physicochemical parameters were recorded, and this data, along with toxicological data was used to evaluate whether confounding water quality parameters, or effect modification by environmental parameters existed when conducting toxicity tests for estuarine samples. Only data from non-toxic samples; i.e., samples where mortality were not significantly lower than their respective controls (detailed in Werner et al., 2010), were selected for further evaluation. A logistic regression model was developed to quantify and predict the independent and interacting effects of an array of water quality variables on the performance of *H. azteca* in the water column tests. The above dataset also included treatments where non-effective concentrations of piperonyl butoxide (PBO) were added to provide early evidence of the presence of two classes of insecticides; organophosphates or pyrethroids, which are often detected throughout the system (Weston et al., 2014). This described model was used to evaluate data from PBO treated samples, in addition to environmental parameters as PBO is widely used in toxicity testing approaches, and can potentially affect, and be affected by environmental stressors.

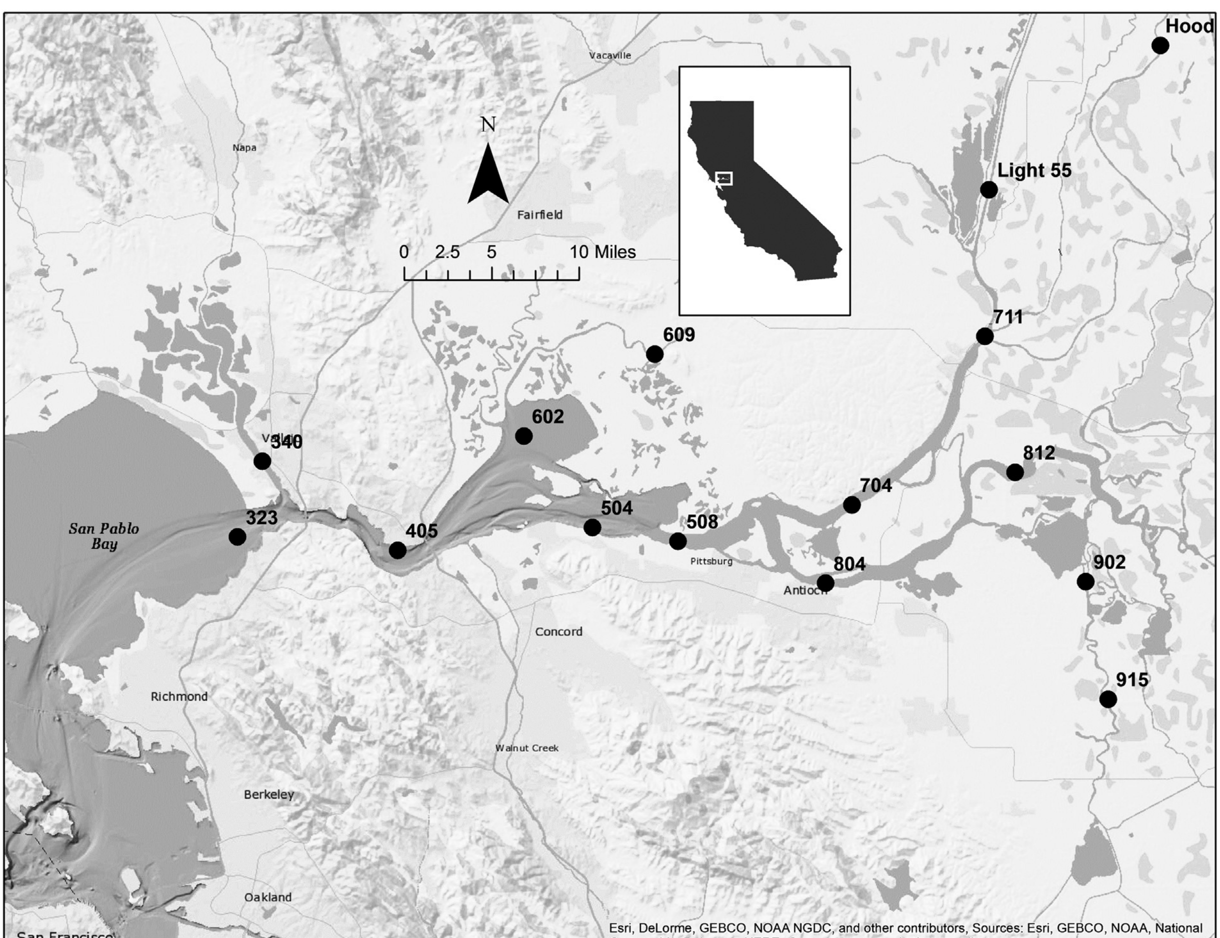

Fig. 1. Location of sampling sites within the Sacramento–San Joaquin Delta, California.