A Two-Tiered Analytical Approach for Testing Contaminant Mixture Interactions

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The study of contaminant effects in mixtures is a growing field of research, and the analytical approaches used are advancing with it. The two most commonly applied methods for mixture analysis either compare empirical toxicity data to theoretical models of additive response (Concentration Addition and Independent Action), or statistically analyze mixtures for interactions, using methods such as multiple logistic regression or generalized linear model analysis. Studies comparing additive models to empirical data are qualitatively useful, but they are not statistically substantiated. On the other hand, statistical approaches are analytically more robust, but they are only conclusive as to the significance of interactions, and do not confirm whether mixtures are additive and if so by which model. The current study employs a unique experimental design that allows for the use of both analytical approaches. Binary mixtures of multiple aquatic contaminants were tested for toxic effects and interactions on the epibenthic amphipod, *Hyalella azteca*. Concentration responses were tested concurrently in each experiment, along with six equipotent and six non-equipotent mixture treatments. Mortality, swimming behavior and growth were measured upon test termination after 10 days of exposure. Significant toxicant effects and interactions were tested by generalized linear model analysis, using the four by four factorial of mixture treatments incorporated into the experimental design. Empirical data were also compared to effects predicted by the two theoretical models of mixture response, made possible by the dose response curves generated within each experiment, and the multiple equipotent mixture concentrations tested. Results obtained both characterized and statistically quantified the interactions occurring among common aquatic contaminants. As such, these methods provide a robust and comprehensive analysis to define the toxicity of environmentally relevant mixtures in order to best predict the consequent effects on resident species.

Keywords: mixture toxicity, *Hyalella azteca*, pyrethroids ammonia copper model statistics

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Utilizing Molecular Biomarkers to Assess Urban Related Contaminant Effects in the Sacramento River

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Approaches to measure the toxicity of chemicals to aquatic organisms typically rely on standardized laboratory toxicity tests, where effect thresholds are expressed as lethal concentrations. However, the toxic effects of contaminants are often subtle, and occur at exposure levels far below the concentrations that cause lethality. The vast urban area that expands the length of the Sacramento River has long been a source of contaminants leading to the presence of a diverse mixture of chemicals, all at sublethal concentrations. To help address potential impacts of the contaminants detected, standard toxicity tests were performed where larval fathead minnow (*Pimephalespromelas*) were exposed for 7days to water collected from the Sacramento River at Veterans Bridge, Garcia Bend, and at the Hood Field Station. In addition to chemical analyses and lethal impacts of collected samples, a suite of 48 genes were utilized to assess potential, sublethal, molecular impacts in exposed fish. Pharmaceuticals and personal care products were among the most commonly detected contaminants at all locations sampled displaying site and seasonal specific differences in chemical profiles. This included a number of antibiotics, the cholesterol drug gemfibrizol, the pain reliever ibuprofen, and the antibacterial agent triclosan. Interestingly, gene responses also displayed site and seasonal specific effects on either neuromuscular or endocrine related pathways, where there were stronger impacts observed in those fish exposed to water collected in the Spring, which contained increased levels of ibuprofen. This data suggests that transcription profiles may be utilized to discern the effect of environmentally relevant contaminant mixtures found in the Sacramento River. This is a highly sensitive approach, which could aid regulatory decisions when determining threats to resident fish populations in the aim of developing total maximum daily loads for water quality purposes in consistently impacted areas.

Keywords: Contaminants Sublthal Effects Pharmaceutical and Personal Care Products Molecular Biomarkers

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North San Francisco Bay Selenium Characterization Study

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North San Francisco Bay Selenium Characterization Study

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Selenium speciation data in the North San Francisco Bay (NSFB) and its major freshwater inflows have not been collected for more than a decade. New information, contributing to the understanding of the behavior of selenium in NSFB, is presented from a characterization study conducted through four sampling events, representing dry and wet-weather conditions between September 2010 and April 2012. Three types of samples were collected and analyzed: (1) Transect samples collected along a salinity gradient in the estuary, including locations in the Sacramento and San Joaquin Rivers, and offshore of the Golden Gate Bridge; (2) Refinery effluent receiving-water samples collected near the effluent outfall to characterize near-field selenium concentrations and speciation; and (3) Refinery effluent samples collected at a fully treated effluent discharge location. The data obtained in this work are compared directly with the prior sampling, and allow interpretation of changes over the preceding decade and are used as the basis for a major reevaluation of selenium speciation in the Bay after a gap of 10 years. New information is presented on the sources of selenium and the seasonally-influenced physical and chemical factors that affect the complex behavior of dissolved and particulate selenium, and the relative efficiency of food webs in concentrating selenium in the Bay-Delta Ecosystem. A revised conceptual selenium model is presented, and the use of these data in the application of a numerical model of selenium fate and transport in the North San Francisco Bay is described.

Keywords: Selenium, North San Francisco Bay, Conceptual Model

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Improved Monitoring of Water Quality and Pelagic Organism Decline in the Delta with Continuous In Situ Sensor Measurements

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Characterizing Delta habitat quality and nutrient availability to Delta food webs is an essential first step to understanding and predicting the success of pelagic organisms. However, water quality and nutrient supply changes continuously as tidal and wind-driven currents move new water parcels into comparatively static geomorphic settings. Newly-developed, commercially-available sensor technology permits real-time collection of a broad suite of water quality data at intervals over which these hydrologic and chemical changes occur. Optical and wet chemistry sensors provide data on organic matter, sediment, nitrogen and phosphorus dynamics that may help identify ecosystem processes related to the health of pelagic food webs and the pelagic organic decline (POD) in the Sacramento – San Joaquin Delta. In particular, the simultaneous collection from multiple chemical sensors – along with the basic water quality variables currently measured such as temperature and salinity - will provide clearer evidence for linkages between physical and chemical drivers and ecosystem dynamics over short time scales, as well as show how short-term events are expressed in long term trends. In December 2011, we deployed a suite of optical and wet-chemical sensors for continuous (e.g. every 30 minutes) data collection from Liberty Island, an area which has received attention as important habitat for Delta smelt and other pelagic fish. Our results show that a variety of physical and biological processes ranging from episodic wind events to tidal dynamics and seasonal patterns affect nutrients, particles (inorganic and organic) and organic matter on time scales that range from minutes to weeks. We view such data as an important component of the long term monitoring program for the Delta, and as critical for evaluating long-term trends, assessing environmental health, and evaluating the effectiveness of habitat restoration and contaminant mitigation programs.

Keywords: Nutrients, organic matter, Delta, water quality, in situ, real time

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Suisun Bay Reserve Fleet - Metals Discharge to Suisun Bay

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The Maritime Administration's (Marad) Suisun Bay Reserve Fleet has been discharging metals-laden paint and stormwater to Suisun Bay for decades due to lack of fleet maintenance. Is this discharge significant and can it be abated? Subsequent to an enforcement action that resulted in a consent decree finalized in federal court between Marad, the San Francisco Bay Regional Water Board, ArcEcology, Natural Resources Defense Council, and Baykeeper, a team including the Regional Water Board, Tetra Tech, and Marad fleet managers worked together to collect the data needed to answer these questions. The data included laboratory analyses of paint and stormwater from dozens of vessels over a period of years. The results of the sampling effort and the analysis of the data trends over time have allowed the team to make the following findings: 1) vessels left with exfoliated paint on the decks and exfoliating paint on the vessel structure discharge significant concentrations and quantities of both total and soluble metals, including lead, copper, and zinc; 2) simple ship maintenance focused on avoiding stormwater contact with paint chips will significantly reduce the discharge of metals to surface water (140 tons of paint were removed from an initial sweeping of 20 vessels); 3) aerial deposition of background concentrations of both metals and petroleum from other sources must be quantified to assess the contribution to the discharge from the vessels; and 4) clean vessels continue to discharge metals to surface water at much lower concentrations. The results of the study show that the proper maintenance of vessel coatings and the proper disposal of exfoliated paint will result in a significant reduction in metals discharge to surface water. Therefore, efforts to require proper vessel maintenance should be supported by both the regulatory and the maritime communities.

Keywords: Stormwater, Suisun Bay, Maritime Administration,

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