Contaminant monitoring and risk assessment in the Sacramento San Joaquin Delta to inform environmental management

Draft Prospectus

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Motivation

Thousands of contaminants enter the Delta waterways primarily via urban and agricultural stormwater and irrigation runoff, industrial and municipal wastewater effluents, and atmospheric deposition. They include metals, pesticides, pharmaceuticals, industrial chemicals, tire-wear constituents and microplastics. Many have been shown to pose ecological risks in aquatic and riparian environments. However, the sheer number chemicals and the complexities of assessing and measuring their toxic effects in ecosystems present significant challenges for monitoring, ecological risk assessment and management of chemicals.

Well-designed monitoring programs are vital for understanding the sources, distribution and risk of chemical contaminants. Equally important is the subsequent synthesis and assessment of monitoring data in order to identify and quantify risk and potential threats to the ecosystem. Both are essential components of developing effective management actions to minimize the impacts of contaminants in the Delta.

In 2014, the Delta Regional Monitoring Program (Delta RMP) was initiated by the Central Valley Water Board with the primary goal of tracking and documenting the effectiveness of beneficial use protection and restoration efforts through comprehensive monitoring of water quality constituents and their effects in the Delta. Efforts have been significantly expanded since its initiation to prioritize contaminants of concern and monitor a number of selected chemicals. While the Delta RMP is a big step in the right direction, achieving adequate temporal and spatial coverage for the multitude of chemical contaminants present in the Delta continues to be a challenge.

Previous reviews of the Delta Independent Science Board (Delta ISB) focused on water quality monitoring with respect to chemical contaminants including nutrients. Published in 2018, the Delta ISB's review titled Water Quality Science in the Sacramento – San Joaquin Delta: Chemical Contaminants and Nutrients identified data and information needs of the entities responsible for the management of contaminants and nutrients in the Delta (Delta ISB, 2018). The review found that the Delta RMP was insufficiently comprehensive in terms of the contaminants monitored, the temporal and spatial coverage of its measurements, and its consideration of how contaminants affect ecosystem processes. The review further concluded that it was unclear how contaminant data entered into management decision-making; that adaptive management was rarely

built into monitoring programs; that the link between water supply and contaminants was rarely explored; and more resources were needed to support coordinated and integrated monitoring and science efforts. In addition, the review identified the need to assess the effects of contaminants on the Delta ecosystem through holistic studies that combine toxicity testing and chemical analyses with fish and food-web monitoring, and to pay increased attention to interactions among contaminants, as well as interactions between contaminants and other stressors. The second Delta ISB review titled Review of the Monitoring Enterprise in the Sacramento – San Joaquin Delta published in 2022 (Delta ISB, 2022), concluded that "mercury and methylmercury seem to be monitored extensively in the Delta, whereas other chemical contaminants receive considerably less attention for informing management decisions", and there is not enough information to identify sources, fates and effects of contaminants on the Delta ecosystem.

In response to identified needs, we propose a Delta ISB review that will assess current contaminant monitoring programs in the Delta in greater detail with special emphasis on data collection, synthesis, and interpretation focused on the needs of environmental managers, i.e. how contaminant data inform managers and enter into decision-making, and if and what improvements may be needed.

Background

The Delta is designated as an impaired waterway under Section 303(d) of the US Clean Water Act, meaning that the allowable total maxima of daily loads of some contaminants or certain toxicity measures are chronically or repeatedly exceeded. Current listings of Delta waterways are for metals (primarily mercury), insecticides (primarily dichlorodiphenyltrichloroethane (DDT), pyrethroids, and organophosphates), polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and toxicity. However, even when waters are legally impaired based on exceedances of regulatory standards, it is challenging to attribute ecological responses of species to individual contaminants (Brooks et al. 2011, Fong et al. 2016).

Establishing a monitoring program capable of quantifying environmental risks of contaminants to wildlife is challenging (Connon et al. 2019), especially when monetary resources are limited. Conventional contaminant monitoring involves laboratory (chemical and/or toxicological) analyses of field-collected water, sediment, or tissue samples. Ecological risk is commonly assessed by comparing measured environmental concentrations of individual chemicals to their respective toxicity thresholds (e.g. environmental quality standards, criteria, or trigger values). While this type of risk assessment aims at identifying specific contaminants for regulatory purposes, it is easy to miss chemicals of toxicological importance, either due to method limitations or because analyte lists are outdated. This approach to risk assessment also is limited in how the risk results relate to the responses of individuals and populations in nature. Laboratory toxicity tests that expose individuals to environmental samples from the system and measure their responses provide more comprehensive information on the toxicity of contaminant

mixtures, but it is difficult to attribute responses to specific toxicants. These "effect-based" tests are further limited by the small number of species (e.g. water flea, fathead minnow, green algae) and endpoints (mortality, growth, reproduction, behavior) for which standard protocols exist.

Current regulatory practices may greatly underestimate the ecological effects of contaminants. In the environment, organisms are generally exposed to mixtures of many contaminants along with other stressors, such as pathogens, hypoxia, temperature stress, or algal toxins. Exposure is often variable over time and localized, and toxic effects are largely species specific. While regulation is generally aimed at identifying the impacts of individual chemicals on a few test species, sublethal effects often occur as subtle or cryptic impairments such as altered behavior or suppressed immunity, which are difficult to relate to ecological endpoints such as growth and mortality. Moreover, contaminants may negatively affect the food web by disproportionally affecting sensitive groups (e.g. insects, crustaceans) with potential food web-level consequences.

Advances in analytical methods have been made in detecting contaminants and their effects in the environment (e.g. Wernersson et al. 2014, Escher et al. 2014, Connon et al. 2019). Quantitative structure-activity relationship (QSAR) modeling and large-scale collaborative projects such as the US "Toxicity Testing in the 21st Century" (Tox21) strategy and the European Union's "ToxRisk" established to integrate new concepts for regulatory chemical safety assessment are designed to screen chemicals for their toxic effects potential. These efforts are primarily aimed at preventing toxic chemicals from entering the market. Some of the high-throughput tools applied in these projects are well suited for environmental monitoring (e.g. Koenemann et al. 2018, Kienle et al. 2019, Kienle et al. 2022), especially when combined with information gained through "Adverse Outcome Pathways" linking effects at the cellular level with whole organism toxicity.

Approach and Products

The review aims to answer the following main questions:

- Are current contaminant monitoring programs able to provide a comprehensive picture of the ecological risks of contaminants in the Delta?
- How is the resulting data used in designing and taking management actions?
- What are the gaps and what can be done to fill them?

This review will work to address management needs and several science action items outlined in the 2022-2026 Science Action Agenda (DSC, 2022). Specifically, Management Need 1 to improve coordination of data collection and evaluation of data needs across the Delta region and evaluate the individual and institution factors that "present barriers to coordination, learning, trusting, and using scientific information to inform decision-making and resource sharing within and among organizations." Additionally, it addresses Management Need 2 to enhance monitoring integration in the Delta with a call to evaluate

and update monitoring programs to ensure their ability to inform management decisions related to climate change impacts and emerging stressors.

The review will consist of three phases. Phase 1 will consist of a series of interviews with experts involved in water quality regulation, and contaminant monitoring and risk assessment in the Delta or other surface water bodies. We aim to gain an understanding of the regulatory landscape driving contaminant monitoring, and approaches and design of current programs, including how data are synthesized and communicated. In Phase 2, we will review and evaluate these programs using available scientific information on chemical pollutants in wastewater treatment effluents and stormwater/irrigation runoff to determine if chemicals identified as "bad players" elsewhere are being monitored in the Delta, and if not, whether this is for good reason or should be considered a critical "gap". We will potentially compare available use data (e.g. from the pesticide use database of the Department of Pesticide Regulation) with analyte lists, unless this has been done already. Phase 3 will focus on chemical mixtures, and how advances in effect-based methods as well as risk-assessment methods could be integrated into monitoring programs to provide a better understanding of the risk of contaminants in the Delta.

The final report will include (i) an overview of the regulatory system driving contaminant monitoring and risk assessment in the Delta; (ii) a summary of a series of interviews with experts in the field identifying gaps and needs in existing programs; (iii) a review of existing contaminant monitoring programs in the Delta; (iv) a review of contaminants potentially entering the Delta based on existing data bases and the scientific literature; (v) recommendations for future contaminant monitoring efforts to increase our confidence in screening and assessment analyses of ecological effects. A seminar series will inform on state-of-the-art toxicological and analytical tools for monitoring and risk assessment throughout the review.

Scope of this review

Unlike the Delta ISB's 2018 Water Quality review, which was broad in scope, we will focus on chemical contaminant and toxicity monitoring in surface waters, sediments, and wastewater treatment effluents. Less focus will be placed on nutrients, HABs, and drinking water-associated contaminants as either significant work has already been or is being done on these topics, or they would warrant separate in-depth reviews. Nevertheless, we will discuss HABs and nutrients in the context of multiple stressors.

This review will not generate new data on contaminants or their toxicity nor derive toxicity thresholds. Instead, we will rely on expert interviews, publicly accessible databases and available scientific literature to identify possible gaps in current Delta monitoring programs. These gaps will be critical information needs in the context of assessing the ecological effects of contaminants in nature, however, the extent of this effort will be limited by the lack of toxicological data on a great number of chemicals and their metabolites and degradation products entering the Delta. We will therefore explore how

effect-based methods could be integrated into future Delta monitoring programs to measure the effects of contaminant mixtures including unknown chemical constituents.

Intended Audience

Agencies and other parties who are conducting contaminant monitoring, creating legislation for contaminant regulations, and those interested in creating risk management plans, including the public.

Timeframe

The prospectus will be finalized by the end of April 2025 and below is the timeframe for completing all phases of the review.

Key Task	Target Date
Finish prospectus	April 2025
Phase 1: Research interviews to understand the regulatory landscape, and approaches and design of current programs	Winter/Spring 2025
Phase 2: Assemble and evaluate current monitoring programs to determine if chemicals identified as “bad players” are being monitored	Summer/Fall 2025
Phase 3: Research chemical mixtures, and how advances in effect-based as well as risk assessment methods could be integrated into monitoring programs	Winter/Spring 2026
Workshop/Seminars	Fall 2025-Spring 2026
Release initial draft report for public comments	Spring 2026
Finalize report	Summer 2026

Expected products and outcomes of the review

The product of this review will be a formal Delta ISB Review document that describes the motivation, methods, and findings. We will also create a short summary document that highlights key findings. Potential sections of this review would include an overview of the regulatory system driving contaminant monitoring and risk assessment in the Delta, an assessment of the approaches and potential gaps in existing monitoring programs in the Delta, an overview of risk assessment and high-throughput monitoring methods suited to establish better links to ecological impacts of contaminant mixtures, and a strategic plan for analyzing ecological effects and adaptive management of existing and newly emerging contaminants.

Previous reviews pertinent to the subject to be reviewed that the Delta ISB is aware of

Relevant literature, along with information on current contaminant monitoring programs, are being compiled in a literature review document. These resources and expert interviews will be used to inform the scope and direction of the review. Identified monitoring programs will be candidates for assessment in the final review to understand the effectiveness of current monitoring strategies.

- Constituents of Emerging Concern (CECs) in California's Ambient Aquatic Ecosystem: Occurrence and Risk Screening of Key Classes (2023), which provides a proof-of-concept for a tiered risk-based screening approach focusing on key classes defined by chemical properties/structures or by use/function. A class based approach can provide more efficient methods to evaluate potential environmental impacts of compounds with limited data.
- Monitoring Strategies for Constituents of Emerging Concern (CECs) in California's Aquatic Ecosystem: Recommendations from a Science Advisory Pannel (2023) and the previous 2012 report, provides a proposed approach and recommendations for CEC monitoring and risk-based screening frameworks. The report proposes four products to assist the State of California in monitoring CECs, including: 1) guidance on prioritization for monitoring program design; 2) guidance on incorporating new CEC data sources; 3) risk-based approach to assess and identify CECs; and 4) to establish a state-wide and regional CEC monitoring program.
- Review and Recommendations of bifenthrin Mixtures in the Sacramento – San Joaquin Delta for a Changing Future (2024), which proposes recommendations to reduce bifenthrin concentrations in the Delta to preserve fish populations from pesticide exposure risk.
- Contaminant Effects on California Bay-Delta Species and Human Health by Fong et al. (2016) published in SFEWS as part of the State of Bay-Delta Science, shows correlations between pyrethroid use and declining abundance of species that have undergone Pelagic Organism Decline (POD), including threatened and endangered species. Additional stressors such as climate change and disease can exacerbate the effects of contaminants. The article proposes approaches to assess risks and effects of contaminants on species.
- Delta Science Programs Independent Review of the Delta Regional Monitoring Program. The Initial Review (2016) concluded that the monitoring design was probably inadequate to answer the management and assessment questions, mainly due to a lack of focus on establishing scientific criteria for distributing limited resources towards monitoring. The Final Review (2017) addressed 1) if the recommendations are incorporated into the Delta RMP, will it be able to link monitoring design to management decisions and 2) will additional statistical expertise be sufficient to guide the program? Email reviewadvice@deltacouncil.ca.gov to request a copy of the reports.

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