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Development of a Sediment Quality Assessment Framework for Human Health Effects

Steven M. Bay[1], Ashley N. Parks[1], Aroon R. Melwani[2],and Ben K. Greenfield[3]

[1]Southern California Coastal Water Research Project Authority
[2]Applied Marine Science
[3]Southern Illinois University Edwardsville

EXECUTIVE REPORT

This report describes a proposed assessment framework and tools for assessing the effects of sediment contaminants in enclosed bays and estuaries on human health. This framework was developed to assist the State Water Resources Control Board in implementing California's narrative Sediment Quality Objectives for human health (HHSQO) that states: Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. This narrative objective focuses on the pathway of humans consuming seafood (fish or shellfish) that have accumulated contaminants from the sediment. The intent of this framework is to provide a standardized assessment approach that is feasible for application to a variety of regulatory and monitoring programs.

The HHSQO assessment framework was developed based on a general conceptual model of sediment-associated contaminant exposure to humans, through the indirect pathway of food web trophic transfer. In this conceptual model, contaminants in sediment and the water column transfer through a food web which includes invertebrates and finfish. Humans are then exposed to these contaminants when they consume the invertebrates or finfish. The assessment framework addresses food web bioaccumulation of contaminants using a mechanistic model of contaminant trophic transfer. To address the complexity of bioaccumulation in food webs, the framework includes eight seafood dietary guilds to address variation in diets of commonly consumed fish. Depending on the exposure dose and toxicity of the contaminant, there is potential for effects to humans.

The focus of the conceptual model establishes the direction of the framework. The conceptual model focuses on the sediment as a potential route of exposure to biota, rather than other potential routes, such as watershed loading, atmospheric deposition, or discharges from upstream water bodies. The HHSQO assessment framework considers spatial scale by requiring a description of the site boundary and forage range of the seafood. Scale is also incorporated into several aspects of the assessment framework, including probability based sampling and analysis of multiple stations within a site, and in later Tiers, explicit consideration of off-site movement by fish.

Evaluation of HHSQO involves two assessment questions: • Do pollutant concentrations in seafood pose unacceptable health risks to human consumers? • Is sediment contamination at a site a significant contributor to the seafood contamination? These questions are evaluated using two indicators: Chemical Exposure and Site Linkage. For the chemical exposure indicator, seafood contamination measurements from the site are compared to advisory tissue levels designed to protect human health. For the site linkage indicator, the same seafood contamination measurements are compared to estimated seafood concentrations that would result from local site exposure. Estimated site exposure is calculated using a bioaccumulation model.

As with any sediment quality assessment, the first step is the development of a conceptual site model (CSM), which summarizes understanding such features as the site area and boundaries,

ii

seafood species present on the site, and the people that consume seafood captured from the site. The framework includes three tiers, with increasing data requirements, complexity, and sophistication in each tier. Tier 1 is a rapid screening assessment to address the question: Do the sediments at a site pose a potential human health hazard, warranting further evaluation? Tier 1 identifies contaminants that do not pose unacceptable hazard to seafood consumers on the site. For contaminants that pose a potential hazard based on Tier I, a Tier 2 evaluation is performed. Tier 2 is a complete site assessment that consists of an evaluation of both tissue data and sediment data to determine potential risk to human health, using available site-specific information. Tier 2 results in site categorization into one of five categories, based on integrating the information from the chemical exposure and site linkage indicators. If a Tier 3 analysis is employed, further site-specific modifications to the approach are employed, based on site characteristics and study objectives.

The approach to addressing uncertainty and variability differs for each tier: Tier 1 addresses uncertainty and variability by making conservative assumptions, Tier 2 includes a Monte Carlo Simulation to generate a cumulative distribution function that describes uncertainty and variability, and in Tier 3 more sophisticated methods may be employed, incorporating sitespecific data and methods.

The assessment framework includes data collection and evaluation for contaminant concentrations in sediment and fish, and other site attributes. In Tier 1, only contaminant concentration data and sediment TOC are needed. Frequently this data will already be available from previous monitoring surveys. Tier 2 requires collection of seafood, water column, and sediment contaminant concentrations, seafood lipid content, sediment total organic carbon, and site area and length. Water quality parameters are optional for Tier 2 local data input. If local data are available, the following parameters are used: dissolved and particulate organic carbon, total suspended solids, temperature, dissolved oxygen, and salinity.

To facilitate Tier 2 data analysis and interpretation, a spreadsheet-based analysis tool, referred to as the Decision Support Tool (DST), was developed. It is designed to efficiently perform the complex calculations in the Tier 2 assessment. Available local site data is integrated into the DST calculations. The DST analyzes site information using bioaccumulation and risk models to determine chemical exposure and site linkage. It uses and presents probability-based information, which provides additional information to aid in interpreting the results.

Full text:
http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/1000_SQOHumanHealthFramework.pdf