Conceptual Model of Major Factors Controlling the Sources, Fate and Effects of Persistent Organic Pollutants in the Estuary

Mike Connor, Jay Davis, Jon Leatherbarrow, Don Yee, Daniel Oros, John Ross, Chris Werme

Persistent organic pollutants (POPs), which include PCBs, DDTs, chlordane, dieldrin, and dioxins, are responsible for a large majority of the failures of Estuary waters to meet water quality standards. The San Francisco Estuary Institute (SFEI) has monitored Estuary water, sediments, bivalves, and fish since 1993. We have combined these data with simple mass balance models to develop a general conceptual model that illustrates the major factors controlling the environmental fate of these POPs and another group of organic contaminants, polycyclic aromatic hydrocarbons (PAHs).

Sources

The use of all these chemicals (except dioxins and PAHs) has been banned or restricted for decades, and the loadings of all of these pollutants (including dioxins, but not PAHs) have declined significantly. They share four general patterns of loadings to the Estuary:

- Agriculture-Dominated (DDTs), where loadings and distribution are dominated by San Joaquin Valley sources
- Industrial-Dominated (PCBs), where loadings and distribution are distributed around specific industrial hot spots
- Urban-Dominated (Dioxins, PAHs), where loadings and distribution are associated with high population densities and
- Mixed Sources (chlordane, dieldrin), where loadings and distribution are associated with both agricultural and urban/suburban uses.

These contaminants share similar chemical and biological properties, but small differences in solubility, volatility, and biodegradability determine their fate over the long-term:

- PCBs, dioxins, and DDTs have low degradation rates and solubility. They tend to be trapped by the long residence time of sediments in the Estuary system. Degradation in the sediments and volatilization are the major removal processes.
- PAHs, dieldrin, and chlordane are mostly removed by degradation in the sediments.
- Outflow through the Golden Gate is generally negligible, except for dieldrin.

Effects

Most of these contaminants are carcinogenic, developmental toxicants that disrupt the endocrine system at very low doses, which has prompted a consumption advisory for Estuary fish for all the contaminants and poses a threat to higher trophic level wildlife. The highest risk is associated with PCBs and dioxins. PCBs also approach thresholds for bird egg hatching. PAHs show a modicum of exceedances for water and sediment toxicity, but no other ecosystem effects compared to existing guidelines.

