INSECTICIDES: Conceptual diagram narrative

High concentrations of insecticides in aquatic systems can have lethal and sub-lethal effects on aquatic organisms, potentially changing community structure and ecosystem function. This conceptual diagram illustrates linkages between insecticide-related stressors (middle of diagram), the human activities and sources that can increase those stressors (top of diagram), and the biological responses that can result (bottom of diagram). In some cases, additional steps leading from sources to stressors, modes of action leading from stressors to responses, and other modifying factors also are shown.

This narrative generally follows the diagram top to bottom, left to right. For more information on interpreting CADDIS conceptual diagrams, see the Conceptual Model Library homepage.

Linking Sources to Stressors

Certain human activities and land uses, such as agriculture, urban and suburban development, and industry, can introduce insecticides into surface waters. Insecticide manufacturing plants, other industrial facilities, and wastewater treatment plants may directly discharge effluents containing insecticides into streams; accidental or unpermitted discharges also may occur (e.g., due to washing of spray equipment in streams). Insecticides may be applied to residential, municipal, or commercial structures, golf courses and lawns, forests, and cropfields and orchards, to control a variety of insect pests. In some cases, insecticides applied in one area may be transported atmospherically to other areas in spray drift. These applied insecticides may enter streams via stormwater runoff or via leakage or leachate into groundwater. Stored insecticides, both at sites where they are used and at sites where they are manufactured, also may be transported to streams via runoff or groundwater transport. The extent to which these transport pathways occur depends upon several factors, including timing and rates of application, precipitation patterns, and environmental persistence of the insecticides.

Linking Stressors to Biological Responses

In streams, insecticides may be dissolved in the water column or associated with sediments, and the effects they have will depend upon the medium in which they occur. Exposures may be episodic (e.g., pulsed deliveries of insecticides with stormwater runoff) or sustained (e.g., long-term exposure to insecticide-contaminated sediments), and the bioavailability, uptake, and toxicity of insecticides during these exposures will depend upon factors such as temperature, suspended sediment concentrations, and dissolved organic carbon concentrations.

Insecticides may affect aquatic biota via several different modes of action, and in many cases mode of action will vary with the type of insecticide. For example, organophosphates and carbamates increase cholinesterase inhibition, while pyrethroids disrupt the functioning of sodium channels in neuronal membranes. Other insecticides can regulate growth, or act as GABA blockers.

These different modes of action all may contribute to decreased condition, decreased growth, altered behavior, and increased susceptibility to other stressors in affected biota. For example, exposure to increased insecticide concentrations may lead to elevated tissue concentrations, respiratory distress,

and changes in development. Possible changes in behavior include increased invertebrate drift and increased coughing, yawning, nudge and nip, fin-flicking, and jerk behaviors in fish. Ultimately, these effects may result in increased mortality, decreased reproductive success, and changes in population and community structure and ecosystem function. For example, macroinvertebrates may be especially susceptible to insecticides, so they may decrease in abundance and richness. Sensitive life stages may decrease, while tolerant taxa and life stages become more prevalent.