Introduction

A toxicity reference value (TRV) is a benchmark established to represent a concentration or dose of a contaminant that is expected to produce no observable effects. The effects that are included in this derivation are not reported as part of the TRV, nor are the error terms or uncertainties included in the data set. Essentially, to establish a TRV, a substantial amount of information and data need to be collapsed into a point estimate, entailing the loss of considerable information. A TRV is a number taken out of context with the conditions and data used to generate it; it has no environmental or ecological context. The loss of information and unreported uncertainty are not only a feature of TRVs but also apply to other point estimates such as sediment quality guidelines, aquatic life criteria, or an ecological soil screening level (Eco-SSL).

The environment in which a contaminant is found influences its chemical form and often its uptake and toxicity. A contaminant exists as part of a mixture with many other compounds, which have varied uptake rates, modes of action, different concentration–response curves, and half-lives. The organisms exposed to the mixture are also exposed to pathogens, competitors, and changes in environmental resources. These same organisms have a variety of life-history strategies, can be dramatically transformed in size, shape and metabolism during their life-cycle, and have wide ranges in mobility throughout the landscape.

The rest of this brief communication provides examples of the importance of context. The first example describes the finding of synergism between carbamates and organophosphates in acetylcholinesterase inhibition. The second example discusses the potential interaction between a persistent organic contaminant, disease, and the decline of Pacific herring in Puget Sound, Washington, USA.

Acetylcholinesterase inhibition in vivo

Laetz et al. (2009) have shown that mixtures of carbamates and organophosphates demonstrate additivity and synergism in acetylcholinesterase inhibition in vivo with juvenile coho salmon. Pairing of two organophosphates produced greater synergism than mixtures containing an organophosphate and carbamates. Both classes of pesticides are found within the range of endangered salmon populations along the west coast of the United States.

The implication is that a single TRV has a likelihood of underestimating toxicity when exposure to mixtures of acetylcholinesterase inhibitors occurs. And, of course fish are exposed to chemicals in addition to acetylcholinesterase inhibitors and to stressors other than chemicals.

Pacific herring and multiple stressors

Pacific herring in the Puget Sound region are one of the icons of the region. Historically, large commercial fisheries existed, but the numbers of herring are now at low levels. Puget Sound has two genetically distinct herring populations, one that spawns at Cherry Point, near Bellingham, and one in lower Puget Sound that has multiple spawning sites. In the 1970s, both populations were characterized by a broad age structure with fish living to be at least 9 years of age. However, by the 1980s, the age structure of both population groups in Puget Sound demonstrated a collapsed age structure. The Cherry Point population also declined so that, by the 1990s, the run was a fraction of its historical maximum (Landis 2008). A critical question emerges: what could have caused a collapse in age structure in two distinct populations over the entire area of Puget Sound and the Cherry Point region?

In collaboration with colleagues, I have suggested that the stressors had to be able to operate over a broad geographic area. Two candidates that fit the geographic requirement and that are known to be present in both Pacific herring populations are disease and persistent organic contaminants.

Hershberger et al. (2002) found that the incidence of the parasite Ichthyophonus hoferi increases with age in Pacific herring from the Puget Sound region. Viral hemorrhagic septicemia virus (VHSV) and other pathogens can also be found in Pacific herring in the Puget Sound region. VHSV has been linked to the reduction of recruitment of Pacific herring in Prince William Sound (Marty et al. 2003).

Persistent organic contaminants also occur within Pacific herring of both populations. PCB concentrations (ng/g lipid) varied from 1200 to 2500 (West et al. 2008). One value exceeded the salmonid larval TRV of 2400 PCB ng/g lipid developed by Meador et al. (2002).