**Remedial Decisions For Estuarine Sediment At Navy Base Depend On Chronic Amphipod Testing**

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An estuary on a naval facility in Virginia consists of creek channels, mudflats, large *Spartina alterniflora* marshes, and the edges of several waste sites. Remedial decisions for the sediments associated with each site will be based on the ecological assessment of the entire estuary. Sediment chemistry, macroinvertebrates, and toxicity have been measured, as well as contaminant concentrations in small fish (mummichog). A risk assessment indicated that sediment invertebrates were in more danger than fish or wildlife. Among the measurements pertaining to invertebrates, reproductive output of the test amphipod *Leptocheirus* provided the greatest range of response to sediment conditions. The initial list of chronically toxic sampling locations did not occur in the most contaminated areas. However, organic carbon (OC) content of the sediment was significantly correlated with amphipod reproduction in control and reference samples. After adjusting for this relationship, significant correlations were found between reproductive output and the concentrations of several contaminants in sediment. These relationships offer flexibility to sediment risk management. In the absence of acute (lethal) effects, chronic effects may be acceptable in relatively small areas. If large areas are contaminated, remediation goals may be set to assure adequate levels of invertebrate reproduction in the estuary.

Remedial decisions are forthcoming for the sediments of the creek and associated tributaries and wetlands on the naval facility. Several past waste sites border the creek system, including landfills, metal storage areas, an oil farm, and a burn pit. The system is dominated by extensive *Spartina alterniflora* marshes, which grade into freshwater marshes at the upper ends of the tributaries. Creek salinity is highly variable, although usually it is brackish. Tidal range is about 0.5 meters. Although remedial decisions have been made and implemented for soil at some sites, decisions about sediment are pending the results of the Phase II assessment. This is a system-wide study of sediment chemistry, sediment toxicity, and fish tissue chemistry.

There are a number of issues that make sediment remediation a challenge at this facility and many other installations. It can be difficult to assess risk from sediment contamination. Modeling contaminant uptake by wildlife and humans is speculative and the assumptions made in the process are difficult to verify. Although the risk in the Creek appears to be higher for sediment-dwelling invertebrates than for fish or wildlife, establishing the level of risk is daunting. Counting sediment-dwelling organisms gave equivocal results regarding the likelihood of impacts and community metrics like species richness or diversity were not related to contaminant concentrations. Another set of

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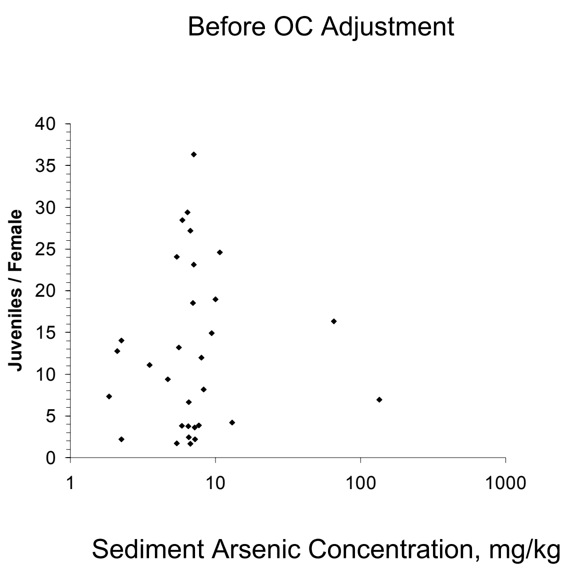
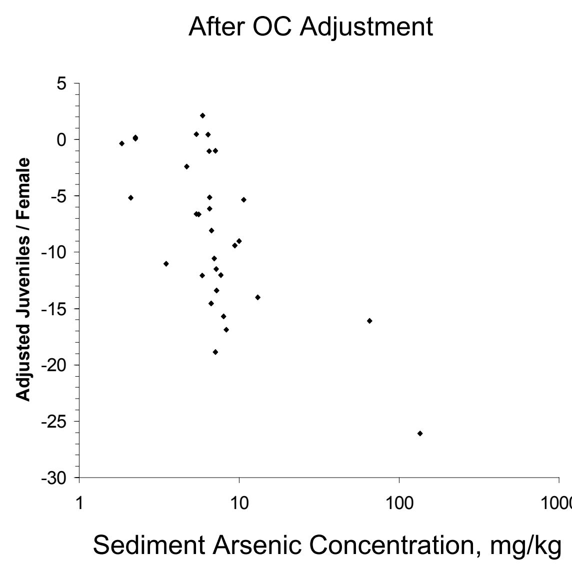
issues surrounds remedial actions. Sediment removal can harm the environment in terms of habitat disruption, habitat loss, and reintroduction of buried contaminants to aquatic life. Sediment capping or burial can have similar effects. In sensitive habitats like wetlands, the potential benefits of these activities have to be carefully balanced with the environmental costs.

The use of chronic amphipod testing for sediment toxicity in Phases I and II of the assessment has provided some insight into risk levels and setting remedial goals. While an acute test lasts 10 days and measures survival, chronic testing proceeds for 28 days and includes growth and reproductive endpoints as well as survival. Survival was not different from controls in any sample. In many programs, such as NOAA's National Status and Trends, this would result in finding the sediment not toxic. Use of the chronic endpoint data, however, has provided more information and flexibility for the risk assessment and feasibility study process than a simple yes/no approach.

Analysis of the chronic testing data revealed the importance of sediment OC to amphipod reproduction. In both Phase I and II tests, reproduction was significantly ($p = 0.05$) correlated with OC in reference and control sediments. These relationships were used to predict sample fecundity and the predicted value was subtracted from the test data as an adjustment. The adjustment removed significant differences among reference and control sediments and dramatically improved relationships between fecundity and concentrations of sediment contaminants.




Relationships between sediment contaminant levels and toxicity data allow for flexibility in setting cleanup goals, or preliminary remediation goals (PRGs). Without a clear relationship, choices may be restricted to methods such as the apparent effects thresholds (AET) or effects range–median (ER-M). The AET is the highest contaminant concentration associated with lack of effects. In the figure below, the horizontal line labeled “toxic” is the adjusted fecundity value beneath which the data are significantly different from the lowest control value. For arsenic, the AET would be about 10 mg/kg. The ER-M is the median of the values associated with effects. In the figure, the ER-M is the median of the eight values below the “toxic” line, or about 8 mg/kg. The regression line in the figure is based on the relationship between fecundity and arsenic concentration in sediment. The point where the regression line crosses the “toxic” line is a more logical choice for a PRG than the AET or ER-M because it uses the relationship, taking all of the data into account. If more or less conservativeness is desired, the points at which the lower or upper 95 percent confidence interval bands (for means) cross the “toxic” line may be used to establish goals.

More flexibility in setting goals comes from adjusting the horizontal line that is considered “toxic.” The line could be based on a reproductive rate that will sustain the population. This would require some understanding of the population’s natural rates of increase and mortality in order to provide a realistic estimate. Note that the negative fecundity on the vertical scale in the figure is an artifact of the OC adjustment; all of the samples supported some amphipod reproduction, including those considered chronically toxic. This is shown on the first fecundity graph (not adjusted) on the previous page.

Spatial scale will be an important consideration in management decisions regarding risk to sediment invertebrates. In small areas all the tested Creek concentrations may be associated with acceptable risk, because no significant mortality occurred in testing. In larger areas the ability of benthic invertebrates to reproduce successfully is important and should be protected by remedial goals.