

BENTHIC INFAUNAL COMMUNITY, SEDIMENT TOXICITY, AND BIOACCUMULATION POTENTIAL OF PCDD/Fs IN SEDIMENTS FROM ARCATA BAY, CALIFORNIA

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Introduction

Humboldt Bay is one of California's largest coastal estuaries. The wetlands, intertidal mudflats and marshes in the northern portion of the bay, called Arcata Bay, provide habitat for a great diversity of wildlife and supports both a commercial shellfish and recreational fishing industry. The Port of Humboldt Bay is the only deep-water port between San Francisco and Coos Bay, Oregon and one of the largest forest products ports in western North America.

Problems from dredging, industrial discharges, storm water systems, urban development, and ships that began over a century ago have prompted several studies aimed at evaluating environmental quality for wildlife and humans. During the past few years, the contamination of the bay with respect to polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and other persistent organic pollutants has received much attention. The purpose of this study was to evaluate the potential toxicity of surficial sediments in Arcata Bay posed by the presence of PCDD/Fs and to evaluate their potential significance on ecological health.

Methods and Materials

Surficial sediment samples for infauna analysis were collected at 8 locations in October 2002 using either a single 0.1 m² or paired Van Veen grab sampler. All sediment samples were collected from the top 5 cm (i.e., the biologically active zone). Sediments were washed and screened through a 1 mm sieve using filtered seawater and the retained sediments and organisms transferred to Mg₂SO₄ solution for 30 min. before fixing in a 10% buffered formalin solution for preservation. Organisms were sorted into 5 major phylatic groups and taxonomically enumerated and identified. The biomass of each taxonomic group was weighed to the nearest 0.01 g.

Surface sediments (i.e. top 5cm) for bioassay testing were collected at 6 locations in the vicinity of an operating sawmill located at the mouth of the Mad River Slough and at 2 reference sites in Arcata Bay using a petite ponar grab sampler or a single 0.1 m² or paired Van Veen grab sampler. Solid phase (SP) toxicity testing and bioaccumulation potential (BP) tests were performed in accordance with U.S. EPA and U.S. Army Corps of Engineers guidance^{1,2,3,4}. At each location, sediments were tested in 5 replicates of 10-d SP tests using 2 species: an amphipod (*Eohaustorius estuarius*) and a polychaete worm (*Neanthes arenaceodentata*). Test animals and native control sediments were provided by Northwestern Aquatics (Newport, OR). Assessment of BP was performed using the polychaete worm (*Nereis virens*) provided by ARO (Hampton, NH) and the

bivalve (*Macoma nasuta*) provided by Brezina & Associates (Dillon Beach, CA). BP testing was conducted over a 28-d test period. After day 28, animals were placed in sediment-free, flow through aquaria to facilitate purging of their gut contents prior to sacrifice for tissue chemistry analysis.

Whole polychaete worm or bivalve tissues were assayed for 2,3,7,8-substituted PCDD/Fs using USEPA Method 8290 by Alta Analytical Laboratory (El Dorado Hills, CA). In order to reduce the variability in the reported dioxin concentrations caused by the varying lipid content in the test organisms, the dioxin data was normalized to the lipid content measured in each replicate (i.e., analyte concentrations were divided by the lipid concentration in each sample). Dioxin test results were evaluated using the 1997 World Health Organization (WHO) toxic equivalency (TEQ) scheme for both human health (TEQ_{HH}) and fish (TEQ_F)⁵. Resulting tissue concentrations expressed on a lipid normalized TEQ basis were compared to tissue residues of animals exposed to sediments collected from two reference locations in Arcata Bay (i.e., Arcata Bay and North Arcata Bay Reference Stations) and to tissue residues of animals at test initiation (time 0).

Results and Discussion

Infaunal Analysis. Evaluation of the infaunal community indicated distinct differences in the populations found at eight different sampling locations in the Mad River Slough and Arcata Bay; however, these differences appeared to be related to habitat and not contaminant conditions in the sediment. The results are summarized in Table 1. Analysis of 24 infauna samples yielded 110 unique taxa. The average number of unique taxa/sample was 33 and abundance averaged 958 individuals/sample or 9,580 infaune/m². This represents a moderately abundant and diverse community and is typical for coastal bay/estuarine habitats such as those found in Humboldt Bay. Polychaete worms were the dominant taxa (44% of the taxa), followed by crustacea, mollusks, minor phyla, and echinoderms. The infauna community in sediments near the sawmill (stations 2 & 5) was relatively abundant and diverse. Overall, there were no significant differences between sediment stations located adjacent to the sawmill in the Mad River Slough and stations located elsewhere in the bay.

Table 1: Summary of infaunal community measures for 0.1 m² grab samples, n=3.

| Station Designation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--------------------------------|------|------|------|------|------|------|------|-------|
| Number of species | 30.3 | 39.7 | 24.7 | 18.3 | 31.7 | 37.3 | 47.7 | 34.3 |
| Abundance | 819 | 478 | 193 | 378 | 874 | 1235 | 1308 | 2380 |
| Total biomass grams | 2.23 | 9.68 | 8.12 | 2.46 | 2.66 | 7.57 | 5.53 | 59.64 |
| Dominance index | 5.00 | 9.33 | 6.33 | 4.00 | 6.00 | 4.67 | 8.33 | 2.00 |
| Evenness | 0.61 | 0.76 | 0.74 | 0.66 | 0.71 | 0.59 | 0.68 | 0.44 |
| Margalef diversity index | 4.37 | 6.26 | 4.53 | 2.94 | 4.53 | 5.11 | 6.53 | 4.29 |
| Shannon-Wiener diversity index | 2.08 | 2.80 | 2.37 | 1.92 | 2.45 | 2.14 | 2.62 | 1.55 |

Sediment Toxicity Testing. Results from standard 10-d acute solid phase sediment toxicity tests showed relatively high survival in all treatments evaluated (Table 2). Survival ranged from 80% to 97% in tests with the amphipod *E. estuarius* and 88% to 100% for the polychaete *N. arenaceodentata*. Further, survival among animals exposed to sediments collected adjacent to the sawmill (85-91% for *E. estuarius*; 92-100% for *N. arenaceodentata*) were similar to or higher than that of organisms exposed to sediments from the two selected reference areas located in Arcata Bay (80% & 86% for *E. estuarius*; 88% for *N. arenaceodentata*).

Table 2: Percent survival in the 10-day solid phase bioassay and 28-day bioaccumulation potential tests performed using surficial sediments from Arcata Bay, California.

| Sediment Location | Dioxin TEQ _{HH} Concentration (ng TEQ/kg) in Adjacent Sediment Samples | Solid Phase Toxicity Tests | | Bioaccum. Potential |
|----------------------------|---|----------------------------------|--|---------------------------------|
| | | Amphipod (<i>E. estuarius</i>) | Polychaete (<i>N. arenaceodentata</i>) | Polychaete (<i>N. virens</i>) |
| | | % Survival | % Survival | % Survival |
| Control Sediment | N.A. | 97 | 92 | 95 |
| Arcata Bay Reference | 3.4 - 4.0 | 80 | 88 | 88 |
| North Arcata Bay Reference | 2.6 - 3.0 | 86 | 88 | 98 |
| C-6 Composite | 7.0 | 85 | 96 | 91 |
| C-4 Composite | 12.8 - 32.16 | 91 | 96 | 89 |
| USS Composite | 13.2 | 90 | 100 | 95 |
| DSS Composite | 11.3 | 86 | 96 | 96 |
| USS-2 Composite | 4.2 - 8.7 | 89 | 96 | 96 |
| BC Composite | 9.6 | 85 | 92 | 95 |

Bioaccumulation Testing. Survival among *N. virens* exposed in 28-d bioaccumulation tests to selected sediment samples was also high (89% to 98%). The results of subsequent dioxin analysis using Method 8290 (Table 3) showed relatively low TEQ residue concentrations ranging between 0.3 and 0.7 ng TEQ/kg. It is interesting to note that residue levels in animals at test initiation (i.e., Time 0) showed TEQ_F and TEQ_{HH} values of 0.6 and 0.8, respectively, indicating that the body burdens in test organisms at day 0 of testing were higher than the body burdens measured at test termination. Test organisms provided by suppliers were collected from wild stock, and did not represent commercial farmed stock. The reduction in TEQ levels relative to time 0, suggests there was no significant uptake of PCDD/Fs in test organisms exposed to Arcata Bay or Mad River Slough sediments and that the test organisms may, in some instances, have been depurating over the course of the exposure period.

Based on these results, there do not appear to be any significant sediment-associated, contaminant effects for the selected sampling locations and metrics evaluated (e.g., benthic community response, acute toxicity and/or bioaccumulation potential).

Table 3: Average lipid normalized tissue residue TEQ concentrations (ng TEQ / kg) for *N. virens* exposed to sediments from Arcata Bay, California.

| Sample | TEQ _F | TEQ _{III} |
|----------------------------|------------------|--------------------|
| Zero Time | 0.615 | 0.800 |
| Arcata Bay Reference | 0.333 | 0.376 |
| North Arcata Bay Reference | 0.361 | 0.392 |
| C-6 Composite | 0.347 | 0.389 |
| C-4 Composite | 0.431 | 0.570 |
| USS Composite | 0.504 | 0.669 |
| DSS Composite | 0.470 | 0.624 |
| USS-2 Composite | 0.417 | 0.502 |
| BC Composite | 0.376 | 0.444 |

References

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- ² U.S. Environmental Protection Agency; 1993. Guidance Manual Bedded Sediment Bioaccumulation Test. EPA/600/R-93/183.
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