PCB-induced changes of a benthic community and expected ecosystem recovery following in-situ sediment treatment

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Introduction: Contaminants in sediment that cause chronic toxicity can simplify the community structure by reducing the abundance of sensitive species and increasing the abundance of tolerant species [*1*, *2*]. While the response of one species in an ecosystem may not be representative of the response of the whole system, changes in the species groups performing a common ecosystem function may represent alteration in the ecological processes. Sediment remediation strategies that target ecosystem recovery have to be evaluated based on their capability to mitigate exposure and risk in relation to reference conditions. A better understanding of the ecological benefits of the expected remedial response is crucial for sediment management.

Methods: Pollution induced changes and the recovery potential of the benthic community was evaluated at the PCB Superfund site at Hunters Point, within the San Francisco Bay, California and at 30 reference sites. The benthic community composition was analyzed by means of abundance, diversity, and functional ecology. Functional groups were defined by feeding and reproductive modes and position in the sediment. PCBs are the major risk driver and reference conditions show only ambient levels of pollution. A biodynamic model was used to predict PCB tissue concentrations for three marine invertebrates that represent different feeding strategies and interaction with the contaminated environment: a filter and surface-deposit feeder, a deposit feeder, and a filter feeder, with

$$\frac{dC_{\mathrm{org}}}{dt} = \underbrace{IR \cdot AE_s \cdot C_s}_{\text{uptake from sediment}} + \underbrace{k_w \cdot C_w}_{\text{uptake from water}} \underbrace{- k_{e+g} \cdot C_{org}}_{\text{loss and growth}}$$

Bioaccumulation for different contamination levels were compared incuding the clean-up goal for Hunters Point, the Effective Range Median and Low (ERM, ERL) suggested by the sediment quality guidlines, the reference conditions. The remedial success of an in-situ sediment treatment with activated carbon (AC) was evaluated based on its reduction of PCB availability and bioaccumulation.

Results: The benthic community at Hunters Point in comparison to reference sites lacks deposit feeders, subsurfac carnivores, egg laying species, and species with no/weak protective barrier (Figure 1). Biodynamic modeling demonstrates how varying exposure and functional feeding strategies affect PCB bioaccumulation (Figure 2). PCB tissue concentrations at Hunters Point are two orders of magnitude higher than at the reference sites and highest for deposit feeders. The expected remedial response of an AC-amendment with 85-90% redcution of PCB availability corresponds to exposure conditions of the sediment quality guidelines and the clean-up goal for Hunters Point but remains slightly higher than at the reference sites.

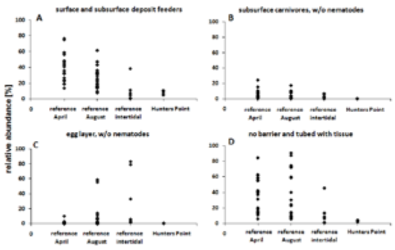

Figure 1. Normalized abundance of species groups for each sample station (N) at the reference sites in April (N = 21), August (N = 20), and at intertidal reference sites (N = 6) compared to Hunters Point (N = 3).

Discussion: Analysis on the basis of functional ecology showed that the benthic community at Hunters Point is deprived of species apparently stressed by the sediment contamination due to their functional traits and an AC-amendment would reduce PCB availablity and bioaccumulation to levels required by the clean-up goal for Hunters Point.

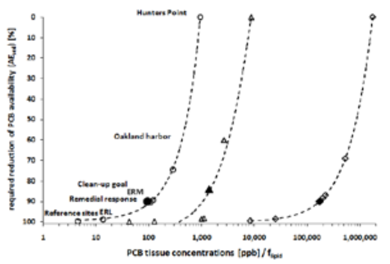

Figure 2. Required reduction of PCB availability at Hunters Point to achieve desired PCB tissue concentrations for a deposit feeder (◇), a surface deposit and filter feeder (△), and a filter feeder (○) and the expected remedial response (full symbols).

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References: Fuchsman, et al. (2006) *Environ. Tox and Chem*, **25**:2601-12; Pearson et al., (1983), *Mar ecol-prog* **12**: 237-255.