Temporal Variation and Cycling of Trace Elements in the Humboldt Bay Estuary

Abstract

The distribution of metals (manganese, zinc, cobalt, nickel, copper, iron, cadmium, lead) and nutrients (nitrate, phosphate, silicate) was investigated during 2007-2008 in the waters of Humboldt Bay. Samples were collected at the Humboldt Bay entrance during the incoming tide, Indian Island at mid-tide, and Mad River Slough during the outgoing tide. The study established background levels, identified contributing members, and resolved the temporal variation of these trace elements in Humboldt Bay. The physical speciation of the metals was determined by separating the water samples into particulate, colloidal and soluble fractions. The metal data suggest that both runoff and resuspended sediments contribute to elevated levels of trace metals (except cadmium) in the water column, with runoff during the winter months contributing to the highest dissolved metal concentrations. The contaminant metals (cobalt, nickel, copper, zinc, lead) delivered to Humboldt Bay through freshwater inputs accumulate in the sediments and are resuspended during spring wind events and subsequently removed from the estuary through tidal action. Lead is primarily associated with the particulate phase and can be used as a tracer of suspended sediments. Upwelled water entering Humboldt Bay is the primary source of cadmium with the highest concentrations found at the bay entrance during late spring. The nutrient data show that the California coastal waters are the primary source of nutrients to Humboldt Bay. Although anthropogenic sources of metals and nutrients exist, levels of these trace elements are well below other well-studied estuaries in the continental United States.

Methods

Unfiltered Sample

UV-irradiation and shaking resin column purification (CRCP)

MS-ICP-MS

Aceric acid leached

Bath digested in conc. HNO₃, HNO₃ and HF

0.2 µm filter

0.2 µm PCTE filter

10 µm PCTE filter

0.03 µm (300k) 0.03 µm filter

Results

Concentrations of metals in the dissolved and soluble phases at each of the three study sites were determined every two weeks. All metal concentrations were influenced by climate conditions, tidal action and location within the bay. Manganese, zinc, cobalt, and nickel show increasing concentrations with increased distance from the bay entrance (Figures a, b, c, d). Cadmium exhibits the opposite relationship (Figure d). Likewise, all of the metals except cadmium show increasing concentrations during the winter while cadmium is highest in the spring (Figures a, b, c, d).

Comparison of Dissolved Metal Concentrations in Humboldt Bay with other Estuarine Waters

<table>
<thead>
<tr>
<th>Element</th>
<th>Humboldt Bay</th>
<th>San Francisco Bay</th>
<th>Galveston Bay</th>
<th>Narragansett Bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>2.33</td>
<td>1.5-1.6</td>
<td>0.5-0.6</td>
<td>2.00-4.8</td>
</tr>
<tr>
<td>Cd</td>
<td>0.0-0.05</td>
<td>0.1-0.5</td>
<td>0.1-0.5</td>
<td>0.1-0.5</td>
</tr>
<tr>
<td>Pb</td>
<td>0.01-0.1</td>
<td>0.05-0.2</td>
<td>0.05-0.2</td>
<td>NA</td>
</tr>
<tr>
<td>Cu</td>
<td>0.03-0.5</td>
<td>0.03-0.5</td>
<td>0.03-0.5</td>
<td>0.03-0.5</td>
</tr>
</tbody>
</table>

Conclusion

- Weather conditions (i.e., NW wind contributing to sediment resuspension, autumnal runoff) play an important role in the concentrations of contaminant trace metals observed in Humboldt Bay.
- The contaminant trace metal concentrations measured in Humboldt Bay were significantly lower than the concentrations measured within other estuaries in the United States.
- Nutrient data suggest that runoff from the Arcata Bottoms is a contributing source of nutrient species, but is significantly less due to the contributions of the Pacific Ocean when the wind flux is taken into account.

Acknowledgments

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