RESPONSE TO A SMELTER CLOSURE IN CASCADE MOUNTAIN LAKES

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Abstract. A statistically significant decrease in sulfate was observed in high elevation Cascade lakes during 1983 through 1988. The total decrease averaged 2.2 μeq L⁻¹ in two slow-flush lakes and 4.2 μeq L⁻¹ in three fast-flush lakes for 1983–1985 vs 1986–1988, respectively. Coincident with these changes in sulfate concentrations were a sharp decrease of SO₂ emissions from the ASARCO smelter (100 km SE of the lakes), from 87 to 70 kt yr⁻¹ during 1983–1984 to 12 in 1985, the year of its closure, and a gradual change in SO₂ emissions from Mt. St. Helens, from 39 to 27 during 1983–1984 to 5 in 1988. The sharpest decreases occurred in non-marine sulfate in fast-flush lakes from 1984 to 1985 (about 2 μeq L⁻¹) and in slow-flush lakes from 1985 to 1986 (1 μeq L⁻¹), which point to the ASARCO closure as the sole cause. However, some of the more gradual decline in non-marine sulfate observed during 1983 through the 1988 sampling periods may have been due to a slow washout of sulfate enriched ash from the 1980 Mt. St. Helens' eruption. Sulfate concentrations in precipitation also declined significantly by about 2 μeq L⁻¹, but changes in volume-weighted sulfate content were not significant. Lake alkalinity did not show a consistent increase in response to decreased sulfate. This was probably due to either watershed neutralization of acidic deposition or the greater variability in alkalinity measurements caused by small changes in acidic deposition making it difficult to detect changes.

1. Introduction

Lakes in the Cascade mountains of western Washington and Oregon are some of the most sensitive to acid precipitation in the United States. The Western Lake Survey found that nearly 20% of the 1,706 Cascade lake population had less than 50 μeq L⁻¹ alkalinity (Landers et al., 1987; Eilers et al., 1988). Several lakes in the Alpine Lakes Wilderness Area (ALWA) have been monitored since 1980 (multiple sampling since 1983) to: (1) develop background data to identify any long-term changes in acid precipitation effects and (2) to determine the response of these lakes to the ASARCO smelter closure in March, 1985. Before closure in 1985, the smelter near Tacoma contributed about 70% of the SO₂ emissions in the Puget Sound area and presumably was a principal source of acidic deposition to the ALWA lakes, which are located about 100 km generally downwind from the smelter (Figure 1). Storm patterns are dominated by south westerly winds that move storms northeast over Puget Sound towards the Cascade mountains.

The ALWA lakes were not considered to be significantly acidified due to anthropogenic acid deposition, although they are highly sensitive (alkalinity about 20 μeq L⁻¹), and the SO₄ content in some of the lakes was similar to that in precipitation (Welch et al., 1986; Logan et al., 1982). The extent to which ASARCO
emissions contributed to the SO₄ content of ALWA lakes, as well as precipitation acidity, was of interest. Vong et al. (1988) found that the ASARCO closure lowered the average sulfate content of five rainstorms by 6 μeq L⁻¹ within 25 km downwind of the smelter. However, effects on sensitive receptors, located farther away and slightly to the east of the downwind path from the smelter, were expected to be less (Figure 1). Nevertheless, within and between year variability in lake SO₄ was