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THE EFFECT OF RECENT VOLCANIC ASH FALLS
ON THE PRODUCTIVITY OF TWO BRISTOL BAY SOCKEYE SALMON LAKES

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One form of lake fertilization results from nutrients added by ash deposits from volcanic eruptions. Many of the sockeye salmon-producing lakes in southwestern Alaska are situated in a very active volcanic region and have received ash deposits from volcanic eruptions.

Studies on the biological impact of two recent ash falls on two different sockeye salmon-producing lake systems in Bristol Bay are currently being conducted by the Fisheries Research Institute. Iliamna Lake was affected by ash fallout from the 1976 January-February eruptions of Augustine Volcano and Lake Becharof received a localized but heavy deposit of ash from the eruptions that formed the Ukinrek Maars in March of 1977 (Fig. 1). Limnological parameters have been monitored in both lake systems since these ash falls occurred.

Past studies in Alaska and elsewhere concerning the biological impacts of volcanic ash falls on aquatic systems show that not all ash falls are equally beneficial and differences in chemical composition, solubility, absolute volume, and distribution of ash, which vary from eruption to eruption, will interact with the diverse limnological characters of affected lakes to produce a range of biological responses.

Results of our limnological studies in these two lake systems indicate that ash fertilization caused an immediate low level increase in primary production in Iliamna Lake and no change in production in Becharof Lake. However, this interpretation is weakened by a host of confounding environmental factors such as yearly differences in watershed runoff, lake level, incident solar radiation, and the timing of ice formation and breakup, all of which profoundly affect production levels in these lake systems. In Iliamna Lake the situation is further complicated, since the ash fall coincided with biogenic fertilization through the salmon carcasses from the peak cycle year 1975.

In light of these differences and uncertainties, controlled ^{14}C incubation experiments and ash leaching studies were performed in 1978 to evaluate the two different types of ash as fertilizing agents. Volcanic ash as a fertilizer of phytoplankton was tested on cultures of Iliamna Lake water and its accompanying flora during June and August of 1978. Ash from the Augustine Volcano and Ukinrek Maars eruptions was added separately to plankton cultures which were incubated under semi-natural conditions in Iliamna Lake near the FRI Porcupine Island field station. Primary production rates were measured by the ^{14}C method and compared to those of control cultures which received either no nutrient addition or diammonium phosphate, a fertilizer shown to be beneficial to lake plankton in the Little Togiak fertilization studies in the Wood River Lakes system. Ash leaching studies were performed using distilled-deionized water to determine the solubility of certain important nutrients.

Results of the incubation experiments in August are shown in Fig. 2. Primary production rates were stimulated appreciably by the Augustine ash, but to a lesser extent than by diammonium phosphate commercial fertilizer. The Becharof ash treatment showed little difference from the control. Hence, the Augustine ash was clearly a better fertilizer than the Becharof ash in the conditions under which they were tested in the experiments.

The explanation for this most certainly lies in the chemical make-up and solubility characteristics of the two ashes. Data from the water leaching experiments are summarized in Table 1. The results show that the Augustine ash contained approximately eight times as much water soluble nitrate and three times as much soluble phosphate as the Becharof ash, while the Becharof ash contained seventeen times as much water soluble magnesium and eight times as much soluble silica as the Augustine ash. The stimulating effect of nitrates and phosphates on primary production in Alaskan lakes has been demonstrated in the fertilization experiments at Bare Lake (1950-1956) and recently at Little Togiak Lake (1974-1978). The high carbon fixation rate of the diammonium phosphate treatment in our 1978 incubation experiments also attests to the stimulating effect of phosphates on primary production. The greater availability of silica and magnesium from the Becharof ash was of no advantage, thus indicating that these nutrients were not limiting during the time of our experiments.

The immediate effects of the inorganic nutrients added by the two different ash falls on primary production in Iliamna and Becharof Lakes have been summarized above. However, the ultimate goal of our ash falls studies is to determine if this fertilization actually increased salmon production in these two lake systems. This cannot be fully evaluated until the return as adults of year classes affected by the ash falls, but obviously no enhancing effect is anticipated at Becharof Lake. Even at Iliamna Lake the positive contribution from the Augustine Volcano ash is probably too small to be significant. It therefore evolves that although salmon production in Iliamna Lake has been enhanced at some low level by the ash fallout, this influence is not outstanding compared to the complex of other abiotic and biotic factors acting upon this ecosystem.

Table 1. Solubility in water of several important nutrients contained in the Augustine and Ukinrek Maars ashes. Values are micrograms of nutrient leached from 4 grams of ash into 1 liter of water in 48 hours. Analysis by Fisheries Research Institute water chemistry lab.

Ashfall	μg nutrient			
	NO_3	PO_4	Si	Mg
Augustine Volcano	78.4	31.2	59.2	13.2
Ukinrek Maars	9.6	11.6	485.2	224.8