YELLOWSTONE LAKE: AN EVALUATION OF PATTERNS IN PRODUCTIVITY

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Objectives

There is evidence to suggest that the primary productivity of Yellowstone Lake may have decreased during the last 1500 years, with an accelerated decline in the last 100 years. Shero and Parker (1977) analyzed diatom frustules preserved in lake sediments and described a gradual decrease in both numbers and volume of frustules over the past 1500 years, although species composition has remained relatively constant. Varley (1974, and personal communication) compared chemical analyses of lake water made in 1884 with recent analyses and found lower concentrations of several elements in the recent samples. He also notes that early visitors at the Lake Hotel often complained about the offensive smell of rotting "seeweed" piled 3-4 feet deep on the beach, whereas only scattered macrophyte detritus can be found on the lake shore today.

Most oligotrophic lakes appear to become more eutrophic with time (Lindemann 1942), so a progressive decline in the productivity of Yellowstone Lake leads to the question of why this lake shows a different pattern. The apparent drop in productivity also has important management implications, since Yellowstone Lake supports one of the last remaining populations of the native cutthroat trout (Salmo clarkii), which once inhabited many of the mountain streams and lakes in this region. The trout in turn support a complex food web including otters, pelicans, eagles, ospreys, and bears. Yellowstone Lake is regarded as unpolluted, and most of its watershed is wilderness. Nevertheless, human activities such as fire suppression and removal of trout through sport fishing may have had subtle effects on the nutrient budget of the lake, and may have contributed to the apparent sharp drop in productivity during the last century.

Thus, our research has three objectives:

1. Assemble, summarize, and evaluate existing data and observations related to the past and present trophic status of Yellowstone Lake.

2. Identify all possible explanations for the observed patterns in lake productivity, both long-term (last 1500 years) and recent (last 100 years), and summarize and evaluate existing evidence to support or refute each

proposed explanation.

3. Collect new data to test one attractive hypothesis that has been mentioned frequently but never examined closely, namely that changes in the nutrient status and productivity of the lake are related, at least in part, to the effects of large fires in the watershed (Varley 1974, Romme and Knight 1982).

Methods

To locate and assemble all existing data on the productivity and nutrient cycling of Yellowstone Lake, we reviewed documents and records in the library at Mammoth Hot Springs and examined unpublished data and observations in files maintained by the U.S. Fish and Wildlife Service. The staff of the Fish and Wildlife Service have been making detailed water chemistry analyses in several different parts of Yellowstone Lake since 1976, maintaining the data in computer files. They have now summarized these measurements from 1976 - 1982 to provide a baseline description of the lake's present conditions and the magnitude of yearly and seasonal variations in water chemistry. This summary will be included in our final report, and we gratefully acknowledge the assistance of the Fish and Wildldife Service staff in this matter. We have also obtaianed data on the chemistry of precipitation in Yellowstone National Park from the National Atmospheric Deposition Program, to evaluate the possible impact of regional air pollution (particularly acidic deposition) on Yellowstone Lake.

To identify and evaluate possible explanations for the changes in Yellowstone Lake, we conducted a computerized bibliographic search with the assistance of the University of Wyoming library. The search uncovered several hundred references to studies of productivity and nutrient cycling in temperate lakes around the world. We also talked with limnologists and paleo-ecologists at the annual meetings of the Ecological Society of America and the American Institute of Biological Sciences in 1982 and 1983.

To test the hypothesis that documented changes in the productivity and nutrient concentrations of Yellowstone Lake are related to the effects of large forest fires, we reconstructed fire history in the watersheds of the South Arm and Flat Mountain Arm, and in a portion of the watershed of West Thumb. For this work we collected sections from fire-scarred trees and increment cores from even-aged lodgepole pine forests of fire origin (Heinselman 1973, Arno and Sneck 1977, Romme 1982). Using these data and a forest cover map prepared by Don G. Despain, Yellowstone Park Biologist, we will construct a fire history map showing the present age and successional stage of all homogeneous forest units. We will then reconstruct past vegetation mosaics in the watershed (Romme 1982). By comparing patterns in the diatoms preserved in the sediments of the South Arm (Shero and Parker 1977) and our reconstructed patterns in fire history and vegetational composition of the watershed, we expect to detect the connections, if any, between large fires and phytoplankton productivity.

We expanded the scope of our study slightly in 1983 by cooperating with Dr.

Jerry Kaster in his study of the sediments of Yellowstone Lake. Kaster collected sediment cores from several locations, and is conducting detailed analyses of the sediment chemistry. By dating the sediments at various depths with lead-210, he will obtain more precise and detailed documentation of changes in the lake during the last century than was previously available. We are sharing our fire history data for the watersheds of the Flat Mountain Arm and the South Arm in exchange for Kaster's data on sediment chemistry. This means a delay in completion of our final report, but we feel that the delay is justified because Kaster's data will allow us to greatly improve our analysis of the effects of past fires on the lake's nutrient budget.

Results

We have not yet completed our analyses, so no conclusions can be reached at this time. In 1983 we collected additional fire history data from a remote portion of the watershed of the South Arm that had been sampled inadequately the previous year. This new sampling did not reveal any major fires that had not been documented earlier, and served to substantiate the tentative conclusions about the area's fire history that we reported in our progress report for 1982 (see that report for details). We also collected more fire history data in the watershed of the Flat Mountain Arm in connection with Kaster's sediment analyses in that area.

Conclusions

Our analyses are not yet complete enough to draw conclusions at this time. We expect to finish our analyses and write our final report in 1984.

Literature Cited

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