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**KLAMATH RIVER
COMPACT COMMISSION**

**INVESTIGATION INTO
METHODS TO CONTROL ALGAE
IN THE
KLAMATH RIVER BASIN**

JUNE 1962

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KLAMATH RIVER COMPACT COMMISSION

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State Capitol
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Honorable Arthur A. Ohniraus
Chief Clerk of the Assembly
State Capitol
Sacramento, California

Honorable Robert Duncan
Speaker of the House
State Capitol
Salem, Oregon

Gentlemen:

Pursuant to Senate Joint Resolution No. 6, 1961 Session, California State Legislature, there is hereby transmitted to you a report entitled "Investigation Into Methods to Control Algae in the Klamath River Basin."

Excessive algal growth in the Klamath River Basin is a natural phenomenon that has been present for many years. The life cycle of algae is short. They have a tendency to grow rapidly during the daylight hours and die during the hours of darkness. During the period of growth algae give off oxygen to the water and as they die and start to decompose they consume oxygen from the water thereby depleting the oxygen content of the water. As a mass of dead algae decomposes, it produces obnoxious odors to the extent of creating a nuisance. Extensive studies in progress throughout the world seek methods of controlling this algal growth.

Although the algae problem in the Klamath River Basin has been present for many years, recreational use of the streams in the Klamath River Basin makes the problem increasingly more evident. With the increased use of the streams in the Klamath River Basin and more particularly the main Klamath River, more people are becoming aware of the nuisance problem.

Pursuant to Senate Joint Resolution No. 6, 1961 Session, California State Legislature, and requests from the Water Pollution Control Agencies in both the States of California and Oregon, the Klamath River Compact Commission has made a study of the problem to determine what action could be taken to expedite the development of some method of control. The report attached hereto is the result of this investigation and is submitted for your Information and consideration.

Sincerely yours,

A handwritten signature in cursive script that reads "A. E. Kuiper".

A. E. Kuiper
Executive Director

Attachment

INVESTIGATION INTO METHODS TO CONTROL
ALGAE IN THE KLAMATH RIVER BASIN

Pursuant to Senate Joint Resolution #6, relative to pollution of the Klamath River, California State Legislature, 1961 Session, which is quoted in part as follows:

"Resolved by the Senate and the Assembly of the State of California, jointly, THAT the legislature of the State of California respectfully request the United States and the State of Oregon to Join with the State of California in conducting a cooperative study of the problem existing on the Klamath River;..."

and letters from the State Water Pollution Control Board of California and the Oregon State Sanitary Authority of Oregon dated June 22, 1961, and June 28, 1961, respectively, the Klamath River Compact Commission has undertaken a cooperative study of the pollution problem in the Klamath River Basin.

The pollution problem in the Klamath River Basin, resulting from extensive growth of blue-green algae, first came to the attention of the Klamath River Compact Commission during negotiation of the compact. At that time the two state commissions supported a study of the problem from July 1, 1955, through June 30, 1956. Subsequently, from July 1, 1956, through June 30, 1958, the study was supported jointly by the Klamath County Court, the City of Klamath Falls and the Klamath County Chamber of Commerce. The study period was extended through a fourth year to June 30, 1959, at a somewhat reduced rate of support. The study was confined in a large part to Klamath Lake, although there is also an algae problem at times in Copco Lake and Klamath River, and to a lesser degree its influent waters. A brief study was also made of the reservoirs and natural lakes in the surrounding territory and the extent of the pollution in the Klamath River was determined.

The principal points that were investigated were biology of the algae bloom, distribution of the bloom in the Klamath Basin, chemistry of influent waters, effect of the algal population of the effluent waters, distribution of bloom organisms in the area, detrimental effect arising from the presence of the bloom population including the aesthetic problem and the oxygen relations and control of the bloom.

During the investigation it was learned that the physical features of the lake are ideal for production of algae. The great area of the lake provides an extensive trap for the conversion of radiant energy into plant material. The shallowness of the lake provides the possibility of nearly constant circulation of raw materials and organisms between top and bottom. This constant circulation and the uniform temperature from top to bottom of the lake combine to make nutrient released from the bottom by decomposition almost immediately available to the algal plants.

It has been concluded that the limited funds that were available for this four-year study did not permit sufficient investigation to arrive at definite conclusions that could be **submitted** with respect to control of the algal growth in the Klamath River Basin.

Senate Joint Resolution #6 by the California State Legislature was considered and discussed by the Klamath River Compact Commission at their regular meeting on June 29, 1961. Representatives from public agencies and local interests were invited to attend and participate in the discussion of the algae problem. It was at this meeting that the California State Water Pollution Control Board and the Oregon State Sanitary Authority requested the Klamath River Compact Commission to coordinate any studies that might be developed with respect to SJR 6.

The commission arranged for the convening of a meeting of interested agencies and technical people in the field of water quality to discuss the algae problem in the Klamath River Basin and to develop one or more approaches to carry out the Intent of Senate Joint Resolution #6. Subsequent meetings with interested agencies and technical people in the field of water quality participating were held to discuss the algae problem in the Klamath River Basin and available published data with respect to blue-green algae were reviewed to obtain a better understanding of the problem. This was followed by a public meeting on October 10, 1961, for a thorough discussion of what action could be taken. Technical experts were also invited to this meeting to assist the commission in obtaining information and background.

The meeting was held in Klamath Falls on October 10, 1961, and various ways of proceeding to investigate the Klamath River algae problem were discussed. It was finally concluded that with such a complex problem, the next step should be to arrange for the convening of a panel of experts to discuss the problem and submit recommendations to the commission on what action could be taken. The meeting was arranged and a panel of experts was assembled in Corvallis, Oregon, on February 19 and 20, 1962, consisting of:

Dr. W. T. Edmondson, Dept. of Zoology, Univ. of Washington, Seattle
Dr. C. G. Golueke, Dept. of Sanitary Engineering, Univ. of Calif.,
Berkeley
Dr. H. K. Phinney, Dept. of Botany, Oregon State Univ., Corvallis
Dr. C. E. Warren, Dept. of Fish and Game Management, Oregon State
Univ., Corvallis
Mr. J. H. Wales, Dept. of Fish and Game Management, Oregon State
Univ., Corvallis
Mr. J. N. Wilson, U. S. Public Health Service, Portland

A report on the discussion by the panel was submitted by Professor Harry K. Phinney, dated March 12, 1962. A copy of this report is attached hereto as Attachment A for your information.

The purpose of the meeting was to develop one or more approaches to carry out the intent of Senate Joint Resolution #6 approved by the 1961 session of the California State Legislature. The paragraphs that follow are submitted in consideration of this objective, and summarize the discussion by the panel of experts at Corvallis on February 19, 1962. The following points are called to your attention:

1. Chemical treatment to control algae in the Klamath River Basin would not be economically feasible and would be extremely dangerous. The risk of extensive damage to other resources within the basin would be very great.

2. Operations being carried on throughout the world by other agencies in an attempt to control blue-green algae are so extensive that any contribution that might be made by an investigation that could be financially supported by the commission would be relatively minute•

3. To take advantage of possible future discoveries in the field of chemical control agents, two types of information would be required: (1) an economic study to establish the benefits to be derived from control and (2) a chemical and biological characterization of the lake to determine whether future chemical discoveries permitting control of blue-green algae would be applicable to the problem in the Klamath Basin.

4. Control of algae by introduction of biological agents including daphnia is not feasible.

5. Harvesting of algae would require processing the total flow of the river if control was to be effective to any appreciable extent. Research has shown that an algae concentration equivalent to 200 or 300 parts per million of solid is required before harvesting is economically feasible. Klamath River waters have a much lower concentration than this. Also the blue-green algae in Klamath River has a potential toxic element that would be adverse to marketing the harvested product.

6. The vast area that is infested by algae in the Upper Klamath River Basin and the physiography of the area make it infeasible to control algae by elimination of the nutrient from the Klamath River Basin water.

7. The control of algal production by artificially reducing the light penetration in the Klamath Lake region was considered. It was concluded that in addition to the danger of the adverse effects such as increase in water temperature, the cost of an operation of this type would exceed those of control with chemicals.

After a thorough discussion of the above seven items, during which other methods of control were touched on briefly and dismissed as being impractical, the discussion turned to what could be done at the present time with respect to algae in the Klamath River Basin that would be constructive. The panel considered that there were two types of information that were needed. One was an economic study to determine the value that would be obtained by controlling algae growth and the other was a study of the algae condition to learn enough about it so that when control measures are discovered by other

research programs that are being carried on, it could be readily determined whether the control could be applied in the Klamath River Basin.

The Klamath River Compact Commission concluded that in general they concurred in the findings of the panel of experts. However, they felt that to make an economic study of the benefits that could be derived from controlling algae in the Klamath River Basin at this time would be premature. This type of study would be more practical when more information is available on the physical effects and extent of control of the algae.

A general limnological study to characterize the Klamath River drainage basin both chemically and biologically would be beneficial. It was noted that the Executive Board of the Water Resources Research Institute at Oregon State University has such a program under consideration at the present time. It was also indicated by the panel that to operate effectively such a study should be supported by a national Institute of Health or a National Science Foundation grant.

It was concluded by the commission that the appropriate action to be taken at this time would be to support the proposal of the Executive Board of the Water Resources Research Institute at Oregon State University to establish a cooperative study to examine the fundamental limnology of the entire Klamath drainage system. It was further concluded that if and when a method of control of algae is developed, the Klamath River Compact Commission again consider the possibility of an economic study to determine the benefits to be derived from such control of algae in the Klamath River Basin.

Attachment

School of Science

March 12, 1962

Klamath River Compact Commission
A. E. Kuiper, Executive Director
P. O. Box 388
Sacramento 2, California

Gentlemen:

Pursuant to the request of the Compact Commission, a panel of experienced aquatic biologists was convened at Corvallis on February 19th. The purpose of this meeting was to discuss possible future action that might be taken by the Commission with respect to the problem of over-abundant production of blue-green algae in the waters of the Klamath River drainage basin.

Present at the meeting on February 19th were:

Dr. W. T. Edmondson, Dept. of Zoology, Univ. of Washington, Seattle
Dr. C. G. Golueke, Dept. of Sanitary Engineering, Univ. of Calif., Berkeley
Dr. H. K. Phinney, Dept. of Botany, Oregon State Univ., Corvallis
Mr. J. H. Wales, Dept. of Fish and Game Management, Oregon State Univ., Corvallis
Dr. C. E. Warren, Dept. of Fish and Game Management, Oregon State Univ., Corvallis
Mr. J. N. Wilson, U. S. Public Health Service, Portland

Representing the Commission were:

Mr. O. L. Abbott
Mr. A. E. Kuiper
Mr. Lewis Stanley
Mr. C. L. Wheeler

The major portion of the discussion was completed on the 19th; however, further consideration of the extent and form of these recommendations occurred at a meeting of the panel of consultants on the 20th. Below in brief form, omitting the detailed discussion, is the consensus of the panel.

I. Chemical control of the production of algae.

A. Chemical treatment of Upper Klamath Lake and of the marshes draining into the Lake with any of the known chemical materials would appear to be not only uneconomic, but in the present stage of knowledge of the chemistry and biology of the basin, extremely dangerous. The probability of extensive damage to the resource arising from injury to desirable organisms living in, on, or about the Lake, or to organisms receiving water through the irrigation system, is very great.

B. It was concluded that the contribution that might be made by the Commission by supporting intensive investigations designed to discover a suitable chemical control agent is extremely problematical and would moreover be dwarfed by the extensive parallel operations already sponsored by a number of other agencies.

C. It was further concluded that it will be necessary to have two types of information in order to take immediate advantage of possible future discoveries in the rapidly developing field of chemical control agents. An economic study is needed to establish the economic necessity for, and the benefits that would be derived from, any type of control problem. In addition a chemical and biological characterization of the Lake is needed to allow intelligent selection of agents that might be available.

II. Control of algal production by the introduction of biological agents.

A. The algal problem has existed in Upper Klamath Lake for a considerable number of years without any evidence that any biological agent can make a significant reduction in the numbers of nuisance organisms.

B. The suggestion that Daphnia, introduced in large numbers, might effect a reduction in the population of Aphanizomenon is definitely contradicted by three observations.

1. Daphnia has long been present in the Lake and there is no evidence that they presently exert a control on the numbers of nuisance organisms.

2. Research elsewhere has shown that Daphnia is unable to ingest the filaments of Aphanizomenon effectively.

3. If there were an aquatic organism living in this kind of water anywhere in the world, successfully utilizing these blue-green algae for food, it is to be expected that they would be known and put into use by now.

III. Removal of the algae by harvesting.

A. It must be pointed out that harvesting the algae from the lake water would make but a very minor reduction in the quantity of algae in the Lake and in the River, and only if the total outflow were processed would the problem be alleviated to any extent in the River.

B. Research has proven that the cost of equipment and power dictate that to harvest algae for an animal feed supplement the algae must be present at a concentration equivalent to 200-300 parts per million of solids to allow their separation by centrifugation. As this concentration exceeds the maximum

occurring in Klamath Lake by several times, and since the organisms in the Lake possess a demonstrable toxic element, the product would be of necessity cost more to harvest and would not have the market value to make harvesting economic at the present time.

IV. Control of algal productivity by elimination of nutrient.

The opinion of the panel was that the diffuse nature of the nutrient sources militates against the successful application of this approach. In the cases where this method has been successfully applied the sources of enrichment have been man made, easily defined and easily intercepted. In fact, they were detected because the normal ecology of the lakes in question was being disturbed. In Klamath Lake this approach, even if otherwise feasible, promises to interfere with the natural high productivity of the basin and could result in severe economic repercussions.

V. Control of algal production by artificially reducing light penetration.

A discussion of the possibility of reducing light penetration by 1) introduction of dye materials, 2) introduction of inert suspended solids, and 3) stirring the bottom sediments, led to the conclusion that in addition to the danger of such side effects as increase in water temperature to be expected from such operations, there is a very great probability that the costs would even exceed those of control with chemicals. The consensus was against recommending a study of this type of control.

The discussions of the panel made it clear that if the Compact Commission feels compelled to embark on a program to investigate the Lake and/or the feasibility of methods of algal control it should be understood that in the present state of knowledge the studies would have to be supported for a period of a good many years at a level of approximately \$50,000 a year without any real promise that control would be forthcoming.

Following the discussion of these proposals the attention of the panel turned to consideration of recommendations for positive action that could be placed before the Compact Commission.

I. An economic study of the water resources of the Klamath drainage.

Repeatedly during the discussions of the panel the desirability of an economic study was emphasized. There is a necessity of placing in proper perspective the present and projected valuations that can be assigned to the resource in its various applications.

The knowledge to be obtained from such a study would be of great value (1) in the deliberations of the Compact Commission and other government agencies concerned with the desirability of, or economic necessity for, support of studies of methods of control; (2) in determining the economic feasibility of any control program that might become available in the future; (3) in establishing the changes in the value of the resource that would result from the institution of new plans for developing the resource.

It is the opinion of the panel that the Compact Commission could obtain this information from a study of a year or two in duration. The probable cost of the study was estimated to be \$50,000.

II. A general limnological study to characterize the Lake and associated drainage system.

As conceived by the panel, this study would consist of an examination of the fundamental limnology of the entire drainage system. It would not channel effort into looking for methods of control. In order to operate effectively this project should be free of all political pressure and therefore should be supported under an N. I. H. or H. S. F. grant. It was recognized that the magnitude of the problem would require expenditure of approximately \$50,000 a year for an indefinite period to allow satisfactory investigation of all facets of the problem.

One item is included here which, although not a matter discussed by the panel, was a direct outcome of the panel's discussions. The Executive Board of the Water Resources Research Institute at Oregon State University met a day or two later and recommended the Institute support a move to establish a cooperative project that would have as its objective the above-mentioned limnological study. A meeting of a group of potential cooperators was held on the 28th of February at which a tentative plan of action was outlined. There is every reason to believe that this group will actively prosecute the plans outlined with the result that the study outline under II above will be supported.

Respectfully submitted,

/s/ Harry K. Phinney

Harry K. Phinney
Associate Professor of Botany