Crater Lake Limnological Studies 1982

Crater Lake National Park
Oregon

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FIRST ANNUAL REPORT ON THE LIMNOLOGY AND WATER QUALITY MONITORING PROGRAM AT CRATER LAKE NATIONAL PARK, OREGON

FINAL

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prepared for:

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CONTENTS

INTRODUCTION

In 1982, the National Park Service provided funds in the amount of $30,000 for a limnological monitoring program at Crater Lake National Park. This action was prompted by a study which indicated that Crater Lake had undergone an estimated 25-30 percent reduction in epilimnetic transparency (from surface to 40 meters, approximately) in less than 15 years, as determined by Secchi disk and Kahl photometer (Table 1). The investigator (D. W. Larson, unpublished data) attributed this loss of clarity, tentatively, to an increase in phytoplankton biomass, which is often the cause of reduced Secchi transparency (Wetzel, 1975), and is regarded as a precursor of accelerated eutrophication in oligotrophic lakes (Hasler, 1969).

Initially, the monitoring program was envisioned as having three objectives:

(1) Provide the National Park Service with reliable baseline limnological data for use as a benchmark, or basis for comparison. This would allow future investigators to determine whether the lake had changed, and if so, how and to what extent. Indications that the lake had become less transparent (based primarily on Secchi disk measurements) were questionable because of a meager historical record, consisting of two Secchi readings in 1913, three in 1937, and six in 1968-1969.

(2) Gain a better understanding of the lake's physical, chemical and biological properties, and of how these elements interact to produce the unique limnological character of Crater Lake. This information would assist Crater Lake National Park interpretive staff in responding to visitors' questions about some of the lake's unusual limnological phenomena.

(3) Develop an applied research capability so that cause-effect relationships, with regard to the impacts of park use and management practices on lake quality, might be ascertained. A long-term monitoring record would prove if there was indeed a trend toward lake degradation. This would establish whether a special study, aimed at identifying the cause of degradation, would be needed. This would hasten the time that corrective action might be taken, before the lake was irreversibly damaged.

PROGRAM DEVELOPMENT

In response to documented evidence suggesting optical deterioration of Crater Lake, the National Park Service sponsored a workshop at Oregon State University in January 1982 to examine this information, choose an appropriate course of action to deal with the problem, and generally familiarize the workshop participants with the history of limnological research at the Park. Workshop attendees included NPS personnel from the Pacific Northwest regional office and Crater Lake, limnological and oceanographic specialists from academic institutions and the U.S. Government, and private individuals with Crater Lake research experience.

Following two days of presentations, information exchange, strategy sessions, and debate, the participants concluded that some type of limnological or water quality monitoring was needed at Crater Lake. But there was no agreement on what should be monitored and how often. Nor was there a consensus about the validity of the limnological evidence, particularly the Secchi disk data, which had led some workshop participants to believe that lake quality had diminished since the 1960's. Nevertheless, participants drafted a list of broad water quality objectives and a preliminary monitoring plan to be implemented by summer 1982.

D. W. Larson, a limnologist with the U.S. Army Corps of Engineers and former VIP (Volunteer-in-the-Park) limnological researcher at Crater Lake National Park, was retained on a part-time basis to advise NPS on the development, implementation and conduct of a limnological/water quality monitoring program.

A second meeting was held at Portland in April 1982 to discuss details of the monitoring program, including personnel and equipment needs, and how the program should be funded, administered, and executed in the field. Agreement was reached on a provisional monitoring schedule, including an estimate of start-up time and a list of essential water quality determinations. D. W. Larson was assigned the additional task of compiling all literature pertaining to limnological and other kinds of aquatic research at Crater Lake. This material was assembled and delivered to the Pacific Northwest Region, NPS during the fall and early winter of 1982.

Mr. Mike Gilmore was subsequently hired by NPS to perform the field and laboratory tasks. As Biological Technician (GS-5), it was his specific responsibility to (1) collect lakewater samples for chemical determinations, (2) obtain temperature and optical measurements in the field, (3) conduct water analyses and filtrations in the laboratory, and (4) maintain the boat and limnological gear. During June and early July, Mr. Gilmore received basic training in the fundamentals of limnology and water analyses from D. W. Larson. Assistance in the field and laboratory was provided by either VIP personnel or seasonal park employees who were untrained and inexperienced in limnological techniques. Consequently, they required special attention from Mr. Gilmore to insure that their work met procedural standards. Mr. Gilmore's salary was about $4200 which covered his four-month period of employment (June-September). Roughly the same amount was used to pay salary, per diem and travel costs for D. W. Larson.

The procurement of equipment and supplies got started in May 1982 and continued throughout the summer. The cost of these purchases totalled $19,053.22 (Appendix I). Approximately 35 percent of this amount ($7000) was spent on a pontoon boat and a 35 hp outboard motor (Appendix I).

MONITORING PROCEDURES

During June 1982, D. W. Larson met with regional and park personnel at Crater Lake to finalize plans for activating the water quality program. Larson provided a map showing lake sampling stations (Figure 1), and recommended the following set of monitoring procedures:

(1) Chemistry

(a) Collect water samples once every seven days and analyze for dissolved oxygen (DO), total alkalinity (TA), specific conductance (SC) and pH. Collect a total of 14 samples from seven depths: (surface, 50m, 100m, 150m, 200m, 250m, 300m) at stations 13 and 23 (Figure 1).

(b) Return samples to the lab as soon as possible and refrigerate. At the lab, determine pH without delay. Do determinations for DO, TA, and SC on the same day of sampling (if time permits), or on the following day. Complete all analyses within 24-36 hours following sample collections.

(2) Biological - chlorophyll

(a) Collect water samples once every seven days and filter for chlorophyll determinations. Collect a total of 24 two-liter volume samples from 12 depths: (surface, 10m, 20m, 40m, 60m, 80m, 100m, 120m, 140m, 160m, 180m, 200m) at stations 13 and 23 (Figure 1).

(b) Immediately fix samples with $MgCO_3$ and return to the lab for Millipore-filtration (HA-types, 0.45 micrometer pore diam.). Complete filtering within 24-36 hours following sample collections. Freeze filters for later analyses.

(3) Biological - phytoplankton (ID and counts)

(a) Collect water samples once every 14 days and store for eventual phytoplankton species identification and enumeration. Collect a total of 24 one-liter volume samples from 12 depths: (surface, 10m, 20m, 40m, 60m, 80m, 100m, 120m, 140m, 160m, 180m, 200m) at stations 13 and 23 (Figure 1).

(b) Fix samples immediately with Lugol's solution and store in a dark, cool place. Prepare Lugol's solution in accordance with Standard Methods, 14th ed., 1975, pp. 1016. Add ten milliliters of Lugol's solution to 1 liter of sample water.

(4) Physical - thermal and optical measurements

(a) Record thermal profiles on three separate days over a period of seven days. Record profiles at stations 13 and 23 (Figure 1). Extend profiles from lake surface to a depth of 100m.

(b) Determine Secchi disk depths on three separate days over a period of seven days. Lower disks (both 8-inch and 40-inch types) at stations 11, 13, 23, 16, 25 (Figure 1) on each of the three recording days.

(5) Possible Routine

Monday - Collect 14 water samples for chemistry at each station.
Temperature profiling
Secchi disk readings

Tuesday - Chemical analyses in lab
Data processing and transfer
Preparations for next sampling run

Wednesday - Collect 24 water samples for chlorophyll
Collect 24 water samples for phytoplankton
Temperature profiling
Secchi disk readings

Thursday - Chlorophyll filtration in lab
Label and store chlorophyll filters
Label and store phytoplankton

Friday - Temperature profiling
Secchi disk readings
Preparations for next sampling run

MONITORING ACTIVITIES DURING SUMMER 1982

Monitoring was initiated on 12 July 1982. This late start resulted from an unusually heavy snowpack, which prevented access to the lake, and delays in the arrival of essential instrumentation and field sampling equipment. The water lab was completely operational on 13 July with the exception of a suitable conductivity meter.

Water samples were collected with 2-1/2 and 4 liter volume Van Dorn PVC messenger-activated bottles (Scott manufacture, Seattle). Bottles were arranged in a vertical profile at discrete depths along a cable, and were closed simultaneously by messengers.

Thermal profiles were measured with a YSI tele-thermistor, Model 43TD. The temperature probe was limited to a maximum deployment depth of 100 meters.

Analyses for DO, TA and pH were performed as follows:

(1) DO - Winkler Method, Azide Modification, PAO titrant (Hach chemicals); procedures described in Standard Methods, (APHA, 1975).

(2) pH - pH meter, Altex (Beckman) Expand - Mate instrument. Instrument calibrated frequently with pH 7.0 and pH 10.0 buffer solutions.

(3) TA - Total alkalinity determined colorimetrically using 0.018N H_2SO_4 as titrant and brom-cresol green - methyl red as indicator solution; procedures described in Standard Methods, (APHA, 1975).

(4) SC - Specific conductance measurements were not done during summer 1982 because of the late arrival of instrumentation (YSI conductivity bridge, Model 31). The meter arrived about mid-July, but the probe was not received until late August.

Between 12 July and 7 September 1982, a total of 28 days were spent on the lake collecting, or attempting to collect, water samples and taking temperature and optical measurements. Approximately one-half of these days featured conditions suitable for field activities (i.e., smooth lake surface,clear sky). Poor weather (i.e., overcast, rough lake surface) prevented sample collections and measurements on the remaining 13-14 days. Table 2 provides general information on daily weather conditions.

A Kahl submarine photometer, on loan from the Corps of Engineers, was used by D. W. Larson to measure light transmission and spectral selectivity through the vertical water column (surface to 90 meters). These measurements were made on 16 and 29 July. The vertical attenuation of unfiltered light was similar to attenuation rates measured in 1980 and 1981 (Figure 2).

MONITORING RESULTS FOR 1982

A total of 25 temperature profiles were recorded at stations 13 and 23 (tables 3 and 4, respectively). Highest recorded temperatures occurred in the 0-10 meter stratum on 1 August. Later, this column of warmer water had extended to about 15 meters because of increased solar heating and the downwelling of upper layer water by wind action. Temperatures below 40 meters remained nearly constant throughout the summer (tables 3 and 4). Thermal gradients during 1982 were similar to those recorded during four previous years (Figure 3).

Dissolved oxygen, pH, and total alkalinity profiles were measured on five separate occasions at Station 13, and on two separate occasions at Station 23. This amounted to 49 separate determinations for each parameter (Table 5). 1982 values for DO, pH, and alkalinity were nearly identical to values reported for the same parameters in 1968 and 1969 (Table 6).

A total of 93 one-liter volume water samples were collected and preserved with Lugol's solution (Table 7). These samples were eventually examined by inverted microscope for phytoplankton identifications and enumerations (Appendix III). An additional 126 one-liter volume water samples were collected

(Table 7) and Millipore-filtered for chlorophyll determinations (Appendix IV). No attempt was made here to interpret phytoplankton or chlorophyll data. They are intended to serve as reference information for later investigations and interpretations.

The Secchi disk (8-inch diameter) was employed on 38 separate occasions at five locations on the lake. Readings ranged from 21.9 to 30.7 meters (Table 8). Some readings were the lowest ever recorded at Crater Lake under optimal conditions (Figure 4). Only one reading was taken with the 40-inch diameter disk (Station 13 on 12 July).

DISCUSSION AND RECOMMENDATIONS

Historically, the National Park Service has lacked the in-house capability to independently conduct limnological research at Crater Lake, or to routinely collect basic limnological data, which could indicate trends in lakewater quality that have resulted, possibly, from management and use of the park. Until 1982, this information was provided by academic institutions, other governmental agencies, and individual scientists whose work at Crater Lake consisted typically of short-term research projects directed toward one or perhaps a few specific components of a large, complex freshwater ecosystem. None of this work, however, ever amounted to a program of long-term, systematic limnological monitoring despite the facts that the lake is the focus of attention in the park, and is a unique, pristine, still largely unspoiled environment exposed to man-caused sources of air and water pollution.

In 1982, Congressional legislation was passed (Senate Bill S.1119) which directed the Secretary of the Interior to develop and maintain a functional water quality monitoring program at Crater Lake over the next 10 years. Such a program, described earlier in this report, was put into operation during summer 1982 at a cost of about $30,000. Yearly funding for program maintenance and material procurement is expected to continue at this level for the duration of the monitoring.

The water quality program at Crater Lake is a modest effort, and is currently in a rudimentary stage of development. Considerable improvements are needed if the National Park Service expects to achieve its lake management objectives. The following recommendations are aimed at correcting some major deficiencies in the program:

(1) The need exists for a computer-based water quality data management system. Eventually, both the monitoring program and special research projects will generate substantial quantities of raw data. This information should not be allowed to simply accumulate on endless pages of tables filed haphazardly in loose-leaf notebooks. Rather, before the data base becomes increasingly less manageable and less accessible to users, the incoming data should be promptly loaded into a computerized system for retrieval, analytical and reporting purposes (see Appendix II for an example of such a system). Additionally, the system should also accommodate other pertinent information about Crater Lake, including the bibliography of earlier limnological research and water quality surveys.

(2) An initial research project, limited in scope, should be launched by summer 1983 to try to identify the cause or source of reported deterioration of Crater Lake's optical transparency. Rather than wait several years for indisputable optical data to conclusively demonstrate that lakewater transparency is decreasing, perhaps it would be judicious to assume that the existing data suggesting a transparency reduction are correct, and that, therefore, timely action to counter this deterioration is called for. If lake degradation is in fact occurring, a delay in counteracting the problem may allow it to intensify and become more difficult to control. Although routine water quality monitoring is well underway at Crater Lake, acquiring a large data base is a necessary, but not sufficient prerequisite for pollution assessment, or for a basic understanding of limnological processes of those external environmental phenomena which cause the quality of the lake to deteriorate. Monitoring per se is not research, but rather is a mechanical process by which data are collected for interpretation and, possibly, a determination of cause-effect relationships.

(3) Research on the optical properties of Crater Lake should include the use of remote sensing techniques to study and interpret available LANDSAT imagery and U-2 photographs. LANDSAT imagery of the lake extends back to the early 1970's, and U-2 photos were taken as early as 1964. These materials could be examined chronologically for variations in surface (or epilimnetic) optical properties, which could result from an increase in algal biomass or the concentration of inorganic particulates. Information from remote sensing might also reveal horizontal variation in spectral quality, which could be caused by algal patchiness, thermal plumes, shoreline erosion, or groundwater intrusions.

Portland District, Corps of Engineers will acquire a multispectral analysis system for remote sensing purposes by spring 1983. This equipment is available for research applications at Crater Lake. The system will provide visual enhancement of U-2 photos or LANDSAT imagery through the use of several "false" color pattern overlays which can readily distinguish areas of fine differences as well as prominent or "hidden" features of interest.

(4) The assistant to Mr. Gilmore should be trained and experienced in limnology, oceanography, fisheries or some other field in aquatic science. The position should be occupied by a professional individual who will share the responsibility of maintaining the water quality program, and whose special expertise (e.g., algal taxonomy, aquatic chemistry) could contribute substantially to the program's success. Field personnel who are either technically unqualified, unmotivated or are incapable of doing the work could detract from the efficiency, effectiveness, and credibility of the program.

The National Park Service should begin to consider the need for a permanent limnologist or aquatic scientist at Crater Lake. This person would eventually assume the duties currently handled by Mr. Gilmore, and would be assisted by a qualified seasonal employee. Conceivably, this person would be hired at the GS-5 or GS-7 level, and would be versatile enough to participate and assist in other natural resource activities in the park. The work schedule for this individual should not be restricted to a standard 40-hour week or an 8-hour day. Instead, the person should be free to engage in research or monitoring tasks which may require unusual working conditions such as 12 to 14-hour days, nighttime field work, and weekends.

(5) The limnology of Crater Lake during the "winter" season (typically September through May) is virtually unknown. The reasons for this, as expressed by D.W. Larson in 1972, are understandable: "Sampling Crater Lake during winter would pose a difficult and hazardous task. The steep caldera walls ascend from 150-610 meters above the lake surface. In places, the walls rise vertically to the crater rim. Access to the lakeshore is along a single precipitous trail that switchbacks for 2 km down the caldera wall and is closed by the Park Service in September. Snowfall (September-June) averages about 14 meters annually. Avalanches are common." In addition, lake surface temperatures during winter are probably near 0°C (total ice cover is rare; the average occurrence is about once every 50 years), and wind action can quickly and unpredictably generate whitecap waves capable of swamping rafts or other small sampling craft positioned in open water perhaps a mile or more from shore. Nevertheless, it is reasonable to expect a limnological monitoring program to operate year-round so that seasonal, or monthly, variations in physical, chemical, and biological properties can be recorded. It would be particularly important at Crater Lake to determine the effects of winter conditions on (a) Secchi transparency readings, (b) thermal and light attenuation gradients, (c) the composition, vertical distribution, and relative abundance of phytoplankton species, and (d) vertical distribution of nutrient compounds. This effort would not only help attain program objectives, but could produce information which might qualify as new discoveries in the field of limnology.

Crater Lake should be visited about once every six weeks during winter. To reach the lake, it may be necessary to lower equipment and personnel down a snow chute which descends the caldera wall. This approach would be hazardous, of course, and considerable time and effort could be spent safely negotiating the extremely steep incline between the caldera rim and the lake, where towering snowbanks form the shoreline. The preferred means of reaching the lake would be via helicopter or floatplane. There is a strong possibility that a U.S. Army Reserve (aviation unit) helicopter will be available during winter to transport equipment and personnel to Wizard Island. There, a rubber raft could be launched for day-long limnological explorations. If the Army Reserve agrees to participate, and favorable weather occurs, winter airborne sampling trips into the caldera could begin as early as February 1983.

(6) The room now used for a water laboratory at Crater Lake will need to be upgraded to meet minimal laboratory standards. The room is too small, does not have a sink or tapwater, is poorly lighted and improperly ventilated, has only one electrical outlet to accommodate several instrument plug-ins, and lacks safety equipment such as an eye washer or decontamination shower. Furthermore, storage space is limited and the lab bench is actually a table overcrowded with instruments and filtration equipment. A portion of the room also serves as an office for the Park's sanitarian. His laboratory is in an adjoining room, and is used exclusively to test drinking water samples for coliform bacteria MPN (membrane filter technique). That lab space is properly equipped and illuminated, and has facilities and amenities which are not available in the water lab (e.g., eye washer, sink, storage cabinets, and extensive bench-top areas).

The two laboratory rooms should be combined into a single water-testing facility used jointly by water quality personnel and the sanitarian. All water analyses (chemical and bacteriological), biological examinations, bioassays, and sample preparations would be performed in the existing bacteriological lab. Both parties could have their offices and space for equipment and supply storage in the adjoining room which now serves as the water lab.

(7) The need exists for in situ monitoring equipment to improve the efficiency of data collection on the lake, and to generally enhance the limnological capability of the program. If funds are available, NPS should procure the following instruments:

(a) A transmissometer (in situ turbidity meter) to determine concentrations of suspended particulate matter through the vertical water column. This instrument can be obtained from Montedoro-Whitney under GSA contract. The preferred instrument is the M-W model TMU1B which costs about $6,200. Cable length is 250 meters.

(b) A fluorometer, with constant flow and recording capability, to measure chlorophyll continuously through the vertical water column. The present method for chlorophyll determinations at Crater Lake (i.e., grab sampling, filtration, extraction, and spectrophotometric analyses) is tedious and inefficient, and is likely to produce an inaccurate vertical profile of chlorophyll concentrations.

Turner Design is one of several fluorometer manufacturers. Their model 10-005 R is priced at $7,000. An additional $2,000 would be needed to purchase a recorder ($1,200) and other accessories (cuvettes, cuvette adapter kit, submersible pump, combined chlorophyll and rhodamine accessory kit).

(c) A Kahl photometer (model 268WA 350) should be procured by NPS to replace the Kahl instrument (also a model 268WA 350) now on loan from the Corps of Engineers. A replacement, with digital recording capability, would cost approximately $6,800.

(8) Sample filtrations and some analyses (pH, conductivity) could be done in a temporary field lab on Wizard Island. This would greatly reduce the number of sample containers, and the volume of water, which is normally hauled out of the caldera by NPS trail crews. Because this hauling must be done before 3:00 PM, to avoid overtime costs and other inconveniences, sample collections are completed by 2:00 PM so that sufficient time remains to deliver the samples to the trail crew waiting at Cleetwood Cove. If much of the sample water could be processed and tested on Wizard Island, fewer samples would have to go up the trail. These few samples could be collected first and taken leisurely to Cleetwood Cove well before the 3:00 PM deadline. Work to obtain the remaining set of samples could then continue without fear of missing the deadline since those samples would be handled on Wizard Island. This could ease any pressure the monitoring team might feel in completing the required tasks for the day.

Prompt analyses of fresh samples would also minimize or avoid data inaccuracies resulting from chemical changes in samples stored for lengthy periods of time, or subjected to agitation during the trip up the trail. pH, in particular, can be affected by these conditions.

(9) Some means of securing the boat in a fixed position during sampling and gear deployment at each of the lake stations should be provided. Because no

anchoring devices are available, the boat now tends to drift even when a slight breeze produces surface ripples. Stronger winds, which generate waves, cause the boat to drift away from a station more quickly. Consequently, sampling locations are scattered in the vicinity of a station, and drifting causes Van Dorn bottles and instruments to deploy obliquely rather than vertically. Thus, work on the lake is limited to fair-weather, calm, smooth-surface days, only 14 of which occurred during summer 1982 (Table 2). This limitation could tend to bias the data.

There should also be some means of determining precise station locations. Buoys could be used to mark these points, but flotation devices would probably be prohibited by NPS since each would have to be large enough to be seen by monitoring personnel. Without marker buoys, however, it is difficult if not impossible to arrive precisely at the same sampling point each time the stations are visited. Triangulation is an alternative method of fixing station locations, but the method may be imprecise and hence little better than merely "eyeballing" or estimating the location.

(10) Perhaps the most important monitoring task at Crater Lake is the phytoplankton study. There are at least 150 species of phytoplankton in the lake, 20 of which are predominant (D.W. Larson, unpublished data for the period 1978-1981). Changes within this community, with regard to species composition, the relative abundance of individual species, species distribution in the vertical water column, and the total number of phytoplankton, or biomass, could indicate subtle shifts in the limnological quality of the lake. Thus, it is imperative that this work be continued, and that the analyses be conducted by an algologist or phytoplankton taxonomist,

preferably one who is familiar with phytoplankton assemblages in Crater Lake and in other high Cascade lakes in Oregon. Ideally, for the sake of continuity, this individual should be retained for duration of the study. This data is needed to help design the research project under recommendation 2.

(11) Nutrient analyses for ammonia, nitrate, phosphate, and silicate need to be initiated. One possible cause for the decreased water clarity is enhanced phytoplankton production made possible by increased nutrient availability. Almost no nutrient analyses have been performed to date on Crater Lake water. Monitoring of nutrient concentrations in 1983 needs to be initiated.

PEER REVIEW

We have established a peer review committee consisting of prominent limnologists and oceanographers from the Pacific Northwest and California. The purpose of this committee is to evaluate the limnological and water quality monitoring program at Crater Lake National Park. The peer review committee will provide recommendations to insure that this program is adequately staffed and equipped, and that correct, state-of-the-art field and laboratory procedures are employed. The committee will also assess the accuracy and the precision of collected data, and the scientific validity and thoroughness of data interpretations.

The peer review committee met for the first time, in February 1983, at Oregon State University, Corvallis. Members received copies of this 1982 Annual Report and were asked to comment on it (Appendix V). The qualifications and expertise of peer review committee members are given for reference in Appendix VI.

REFERENCES CITED

American Public Health Association. 1975. Standard methods for the examination of water and wastewater. 14th Ed. New York, APHA. 1193p.

Hasler, A.D. 1969. Cultural eutrophication is reversible. Bioscience 19:425-431.

Larson, D.W. 1972. Temperature, transparency, and phytoplankton productivity in Crater Lake, Oregon. Limnol. Oceanog. 17 (3):410-417.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Co., Philadelphia. 743p.

FIGURES

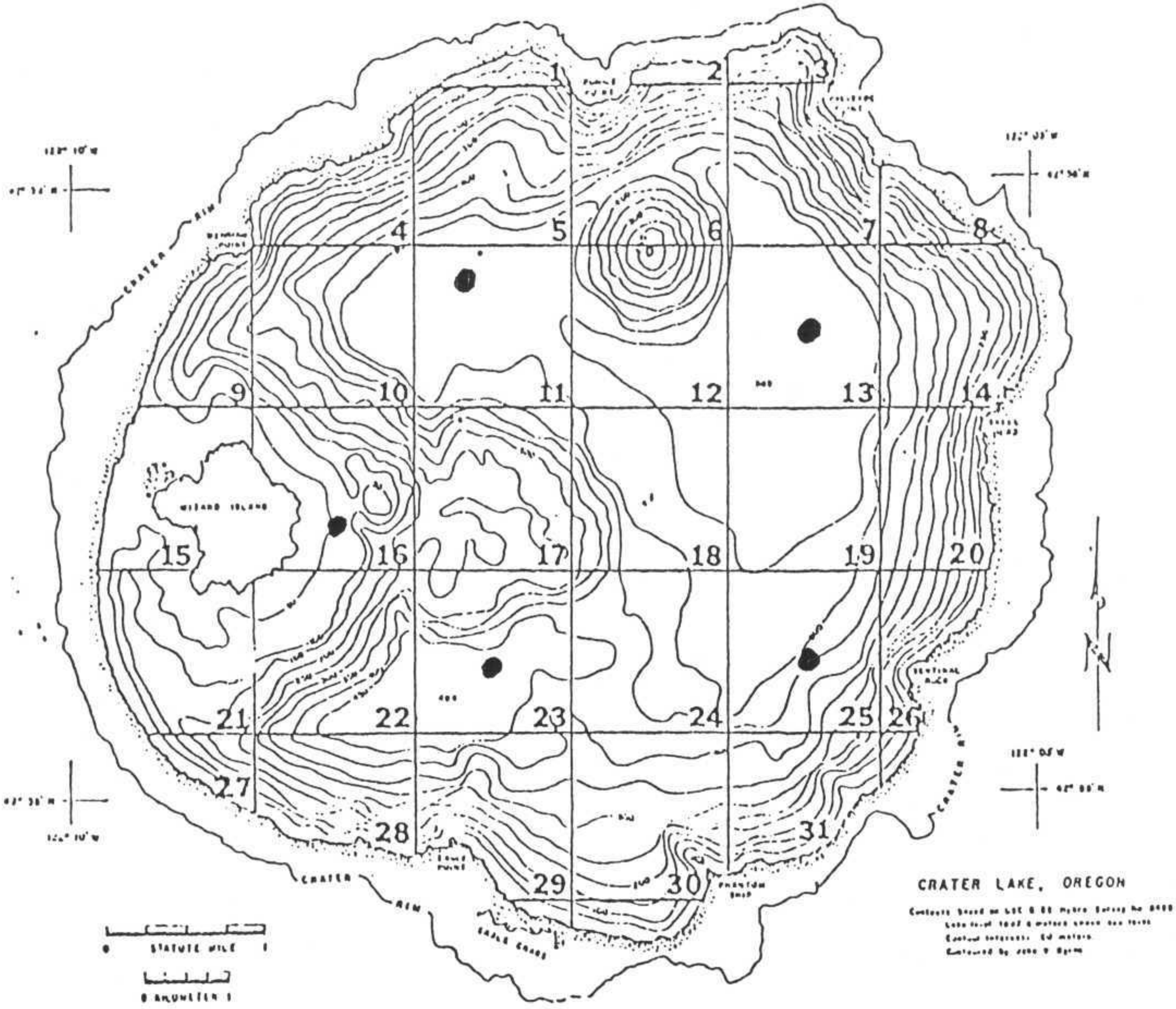

Figure 1. Lakewater sampling locations at stations 11,13,16,23,and 25.

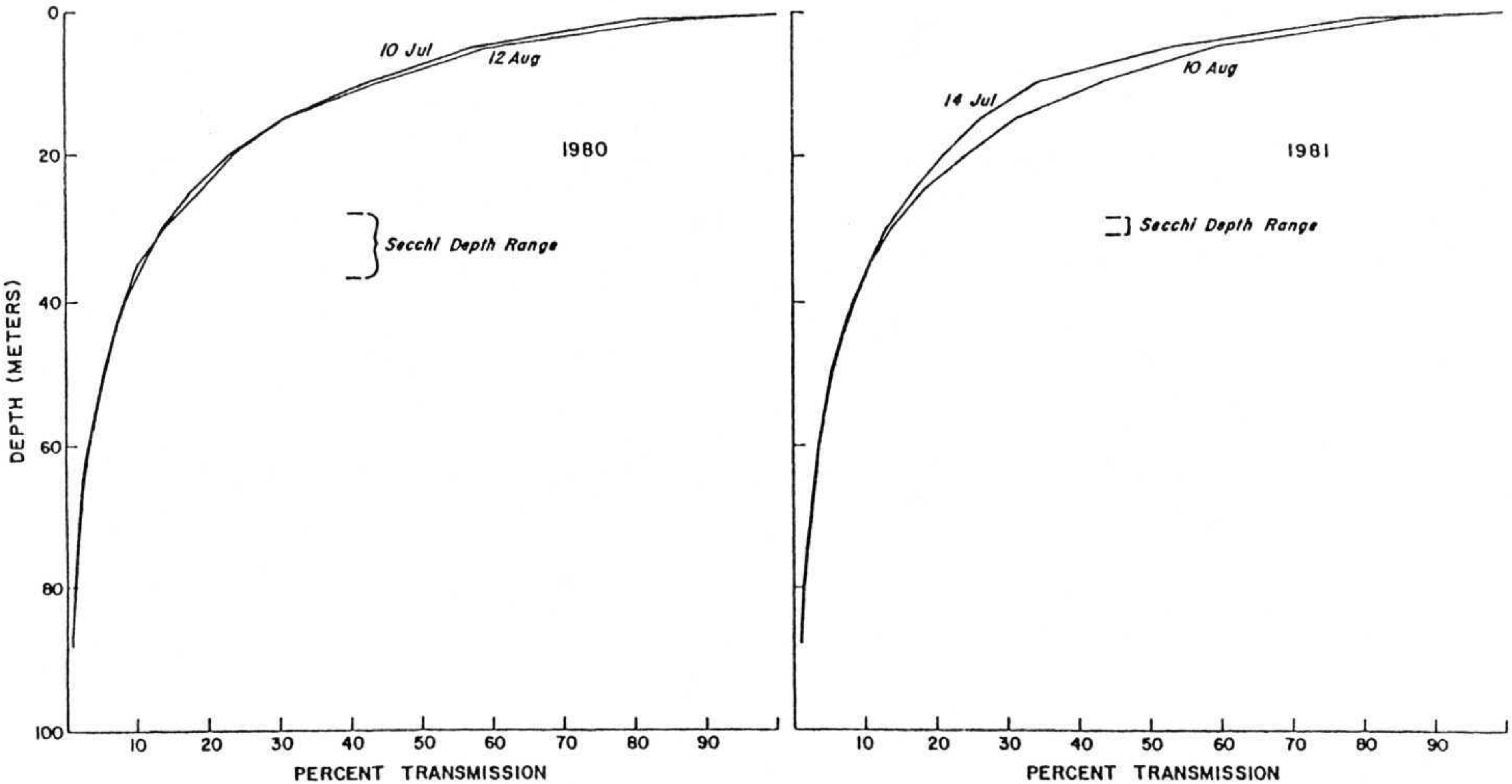

Figure 2. Photometer and Secchi disk readings for 1980 and 1981, Crater lake. Profiles show the attenuation of unfiltered light with depth.

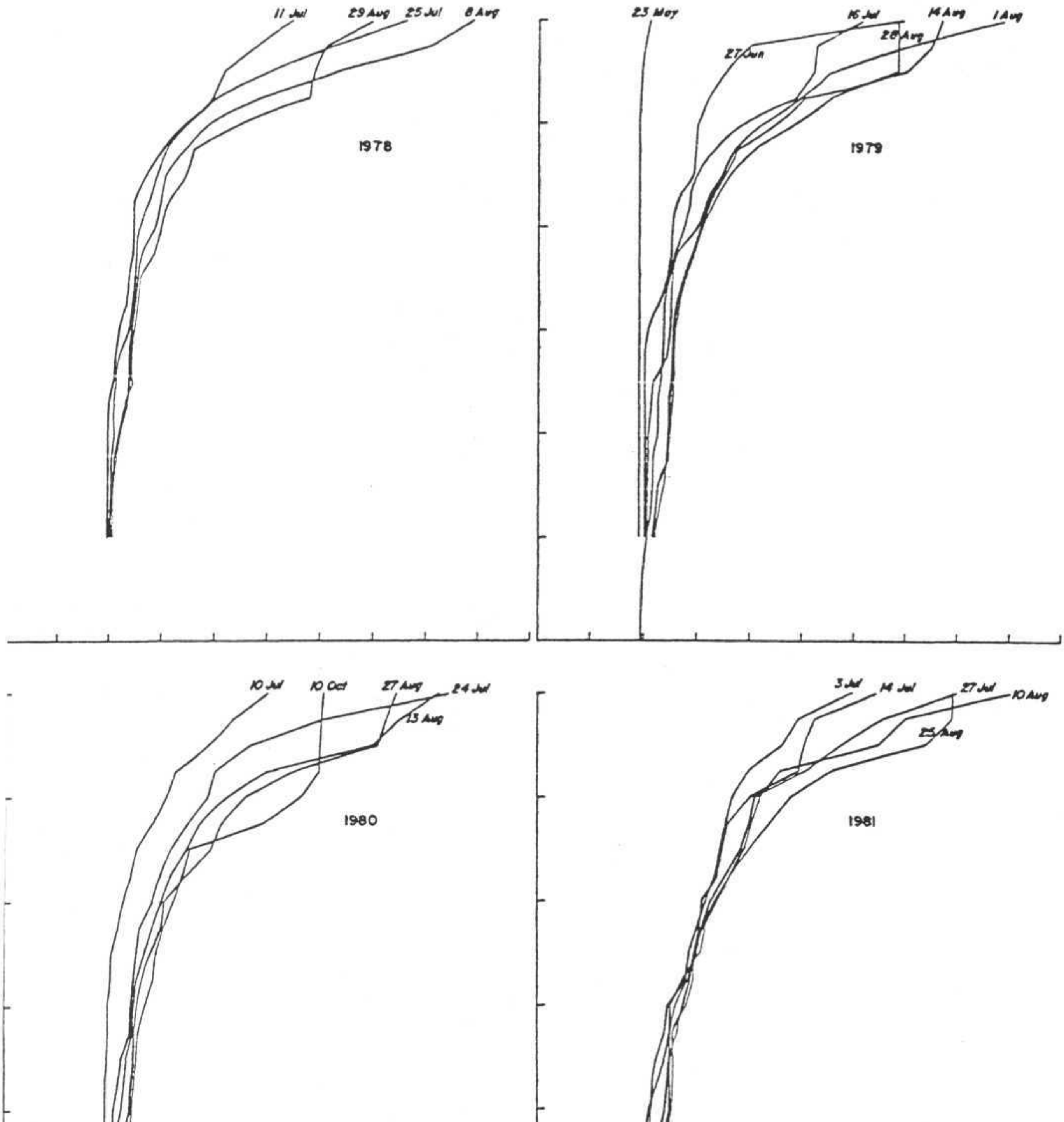

Figure 3. Thermal profiles for Crater Lake, 1978-1981.

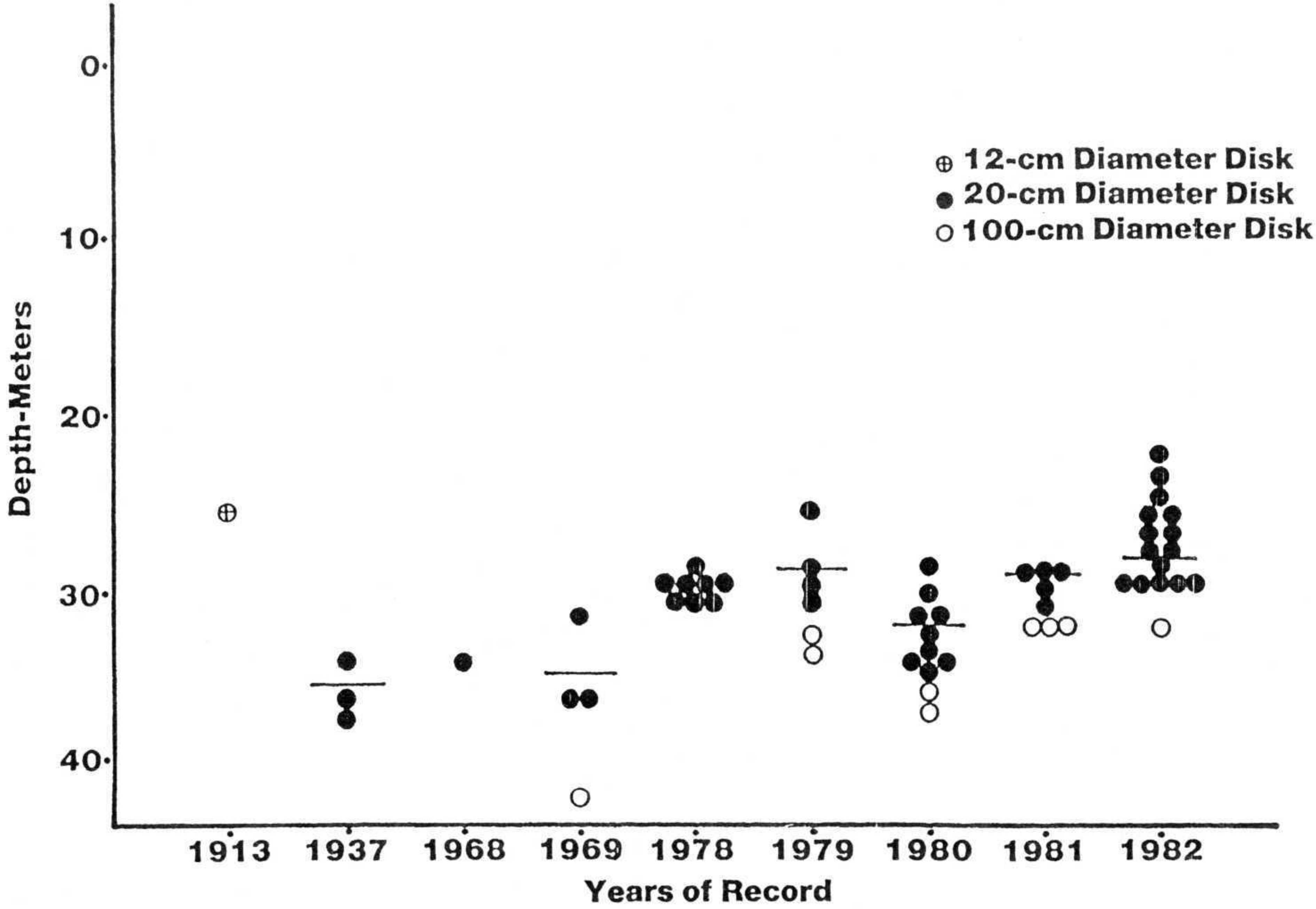

Figure 4. Secchi disk readings for Crater Lake,1913-1982. Horizontal bars represent mean values. 1982 readings were taken at Station 13.

TABLES

TABLE 1

SECCHI DISK RECORDS 1913-1981

1913		Meters		Disk Diam.(inches)	Remarks
1 August		25		4.75	
5 September		26		4.75	
		$\bar{X} = 26$			
1937					
10 August		36		8.0	
19 August		39		8.0	
27 August		40		8.0	
		$\bar{X} = 38$			
1967					
August		18		8.0	Slightly windy and cloudy.
1968					
14 June		31		8.0	
23 July		36		8.0	
27 August		18		8.0	Reading taken during storm.
		$\bar{X} = 28$ $\bar{X}$ (31 + 36) = 34			
1969					
16 July		39		8.0	
16 July		44		40.0	
5 August		39		8.0	
31 August		32		8.0	
		$\bar{X}$ (39 + 39 + 32) = 36.7			
1978 [1.]					
12 July		28	clear, windy	8.0	Jerry Stachiw, PhD
25 July	(1100 hrs)	30	clear, windy	8.0	Naval Ocean Systems Center
7 August	(1249 hrs)	29	clear, calm	8.0	Code 5204
8 August	(1000 hrs)	29	clear, calm	8.0	San Diego, CA 92152
28 August	(1115 hrs)	30	clear, calm	8.0	Secchi reading on 24-25
28 August	(1345 hrs)	30	clear, calm	8.0	July off wineglass
29 August	(1145 hrs)	29	clear, calm	8.0	(several hundred yards): 95 ft. (28.96 m)
		$\bar{X} = 29$			

TABLE 1 (cont.)

1979[1]		Meters	Disk Diam. (inches)	Remarks
27 June		28.3	8.0	1345 - 1450
27 June		28.8	4.75	1345 - 1450
16 July		31.0	8.0	1308 - 1338
16 July		35.0	40.0	1308 - 1338
1 August		29.0	8.0	1145 - 1215
1 August		34.2	40.0	1145 - 1215
1 August		28.3	4.75	1145 - 1215
14 August		22.9	8.0	1055 - 1110
14 August		28.5	40.0	1055 - 1110
1980[1]				
10 July	Station 3	30.2	8.0	1130 hrs.
10 July	Station 3	33.8	40.0	1500 hrs.
24 July	Station 1	31.9	8.0	1040 hrs.
24 July	Station 2	34.0	8.0	1110 hrs.
24 July	Station 2	36.5	40.0	1120 hrs.
24 July	Station 3	36.3	8.0	1230 hrs.
24 July	Station 3	39.4	40.0	1250 hrs.
24 July	Station 3	36.3	8.0	1350 hrs.
24 July	Station 4	35.2	8.0	1420 hrs.
25 July	Station 3	36.5	8.0	1240 hrs.
25 July	Station 3	39.6	40.0	1250 hrs.
12 August	Station 3	31.9	8.0	1222 hrs.
12 August	Station 3	35.5	40.0	1208 hrs.
1981[1]				
3 July		29.7	8.0	@0930
3 July		33.3	40.0	@0930
13 July		28.7	8.0	
13 July		31.7	40.0	
27 July		29.3	8.0	@1125
27 July		33.2	40.0	@1125
10 August	Station 2	29.1	8.0	
10 August	Station 2	32.5	40.0	
11 August	Station 3	31.1	8.0	
11 August	Station 1	30.4	40.0	

1. Unpublished data courtesy of D.W.Larson.

TABLE 2

WEATHER CONDITIONS, SUMMER 1982

July 12	Clear skies and calm lake
July 15	Clear skies and calm lake
July 16	Clear skies and calm lake
July 19	Sunny; slight breeze, slight ripples
July 21	Partly cloudy, slight ripples, wind came up and forced stop to sampling
July 23	Partly cloudy, slight wind, slight ripple
July 26	Hazy, partly cloudy, lake calm
July 27	Partly cloudy to cloudy, slight haze over lake, slight ripples
July 28	Clear skies, slight cloud puffs, calm lake
July 29	Clear skies, calm lake
August 1	Total cloud cover, choppy lake
August 3	Lake too choppy for sampling, moderate to strong winds, total cloud cover
August 4	Choppy lake, moderate winds, partly cloudy skies
August 5	Calm lake, clear skies, choppy lake in afternoon
August 6	Calm lake, clear skies
August 9	Bad weather - no sampling
August 10	Lake surface too rough for sampling; cloudy, cold, choppy
August 11	Lake surface too rough - no sampling; attached new winch system to boat deck
August 12	Clear skies, lake calm
August 13	Lake surface too rough for sampling
August 16	Lake surface too rough for sampling
August 17	Clear skies, calm lake 1040 hrs; clear skies, mild to choppy 1137 hrs; too choppy for sampling in afternoon

TABLE 2 (cont.)

August 21	Clear skies, calm lake
August 23	Lake conditions too choppy for sampling afternoon; therefore, no temperature or Secchi data. Clear skies, calm lake before noon.
September 1	Sunny but hazy, calm lake
September 2	Partly cloudy, lake calm
September 3	Lake conditions too choppy for sampling
September 7	Hazy skies, lake calm (final sampling day)

TABLE 3

1982
TEMPERATURE PROFILES (°C)
STATION 13

DEPTH (METERS)	JULY 12	JULY 21	JULY 23	JULY 26	JULY 27	JULY 29	AUGUST 1	AUGUST 5	AUGUST 6	AUGUST 12	AUGUST 17	AUGUST 21	SEPTEMBER 1	SEPTEMBER 2	SEPTEMBER 7
Surface	17.5	14.0	12.8	15.0	15.9	19.0	15.0	14.6	15.8	15.0	14.6	19.2	16.1	16.4	15.0
1	12.0	13.0	12.0	14.5	14.9	16.0	15.0	14.1	14.8	14.0	14.2	14.6	14.8	15.4	14.9
2	11.5	12.5	12.0	13.2	14.7	15.5	15.0	14.0	14.5	13.8	14.0	14.3	14.5	15.0	14.6
3	11.0	12.3	12.0	12.0	12.8	14.0	14.8	13.9	13.9	13.8	14.0	14.3	14.5	14.9	14.5
4	11.0	12.1	12.0	11.5	11.8	12.5	14.6	13.7	13.2	13.8	14.0	14.2	14.5	14.8	14.5
5	11.0	12.0	11.9	11.2	11.7	12.0	14.5	13.4	13.1	13.8	13.9	14.2	14.2	14.7	14.4
6	11.0	12.0	11.5	11.0	11.0	11.9	14.5	13.1	13.1	13.8	13.9	14.1	14.2	14.5	14.4
7	10.8	12.0	11.0	10.2	10.5	11.6	14.1	13.0	13.0	13.6	13.9	14.0	14.2	14.5	14.4
8	10.8	11.0	10.0	10.0	9.9	11.1	13.8	12.9	12.2	13.6	13.8	14.0	14.1	14.5	14.2
9	10.2	10.9	9.5	9.5	9.0	10.9	11.9	12.1	11.2	13.2	13.6	14.0	14.1	14.5	14.2
10	10.0	10.2	9.0	9.0	9.0	10.1	11.0	10.1	10.8	13.2	13.5	13.9	14.0	14.5	14.2
11	9.3	9.8	8.8	9.0	8.8	10.0	10.0	9.2	9.9	13.0	13.0	13.4	13.9	14.5	14.0
12	9.0	9.0	8.5	8.5	8.2	9.9	9.0	9.0	9.3	12.0	11.9	13.4	12.9	14.2	13.9
13	8.9	8.5	8.2	8.0	8.1	9.3	8.8	8.9	9.0	10.2	11.8	11.2	11.9	13.9	13.0
14	8.2	8.1	8.1	7.9	8.0	8.9	8.0	8.2	9.0	9.0	9.4	10.0	10.0	12.8	11.8
15	8.0	8.0	8.0	7.9	7.7	8.5	7.8	8.0	8.5	8.8	9.0	9.0	9.5	10.5	10.5
16	7.5	7.2	7.9	7.5	7.3	8.0	7.5	7.8	8.5	8.2	8.8	8.9	9.0	9.3	10.0
17	7.2	7.0	7.6	7.0	7.2	7.9	7.1	7.2	8.2	8.0	8.0	8.7	8.9	8.8	9.5
18	7.0	6.8	7.5	7.0	7.2	7.2	7.0	6.9	7.9	7.9	7.8	8.5	8.5	8.3	9.0
19	6.8	6.5	7.1	6.9	7.1	6.9	7.0	6.6	7.5	7.9	7.2	8.1	8.5	8.0	8.0
20	6.5	6.2	7.0	6.2	7.0	6.5	6.8	6.2	7.2	7.0	7.0	7.7	8.0	7.8	7.9
25	5.0	5.8	6.1	6.0	6.0	5.9	6.0	5.9	6.2	6.2	6.2	6.8	6.8	6.9	7.0
30	4.9	5.2	5.9	5.5	5.2	5.6	5.5	5.3	6.0	5.8	5.8	6.1	6.1	6.2	6.4
35	4.8	5.0	5.6	5.0	5.0	5.1	5.2	5.0	5.5	5.2	5.2	5.9	5.9	5.9	5.9
40	4.2	4.9	5.2	4.9	4.9	5.0	5.0	5.0	5.1	5.2	5.0	5.4	5.4	5.5	5.2
45	4.0	4.6	5.0	4.8	4.8	4.9	4.9	4.9	5.0	5.0	5.0	5.1	5.1	5.1	5.0
50	4.0	4.5	4.9	4.5	4.2	4.7	4.8	4.7	4.9	4.9	4.8	5.0	5.0	5.0	5.0
55	4.0	4.2	4.8	4.2	4.1	4.5	4.5	4.5	4.9	4.6	4.5	4.9	4.9	4.9	4.9
60	4.0	4.0	4.5	4.1	4.0	4.2	4.2	4.3	4.5	4.5	4.2	4.7	4.8	4.9	4.6
65	4.0	4.0	4.5	4.0	4.0	4.2	4.2	4.1	4.5	4.2	4.1	4.4	4.4	4.5	4.2
70	4.0	4.0	4.5	4.0	4.0	4.1	4.1	4.1	4.2	4.0	4.0	4.2	4.2	4.2	4.0
75	4.0	4.0	4.5	4.0	4.0	4.0	4.1	4.0	4.2	4.0	4.0	4.1	4.0	4.2	4.0
80	3.9	4.0	4.4	3.9	3.9	4.0	4.0	4.0	4.1	4.0	4.0	4.0	4.0	4.1	4.0
85	3.9	3.9	4.2	3.9	3.9	4.0	4.0	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
90	3.9	3.9	4.2	3.9	3.8	4.0	4.0	3.9	4.0	4.0	4.0	4.0	3.9	4.0	3.9
95	3.9	3.9	4.2	3.8	3.8	4.0	4.0	3.9	4.0	3.9	4.0	4.0	3.9	4.0	3.9
100	3.8	3.9	4.1	3.8	3.8	3.9	4.0	3.9	4.0	3.9	3.9	3.9	3.9	4.0	3.9
TIME	1415	1205	1015	0930	1035	1405	1040	1040	1045	1025	1040	1230	NONE	1135	NONE

TABLE 4

1982
TEMPERATURE PROFILES (°C)
STATION 23

DEPTH (METERS)	JULY 23	JULY 26	JULY 27	JULY 29	AUGUST 1	AUGUST 5	AUGUST 6	AUGUST 12	AUGUST 17	SEPTEMBER 1	SEPTEMBER 7
Surface	13.5	15.0	17.9	16.0	15.9	15.0	15.8	15.8	14.5	15.5	14.9
1	13.0	14.8	14.8	15.2	15.9	14.1	14.8	14.2	14.0	15.0	14.5
2	12.8	14.5	14.5	15.0	15.6	13.9	14.2	14.0	13.8	14.9	14.4
3	12.8	14.2	14.1	14.4	15.2	13.9	14.0	13.8	13.8	14.8	14.4
4	12.8	13.6	13.4	13.8	14.8	13.9	13.9	13.8	13.8	14.5	14.3
5	12.8	13.2	13.2	13.2	13.5	13.9	13.8	13.8	13.8	14.5	14.3
6	12.8	13.0	13.0	13.0	13.5	13.8	13.8	13.5	13.8	14.5	14.3
7	12.8	12.8	12.9	12.9	13.2	13.4	13.8	13.5	13.8	14.5	14.3
8	12.7	12.0	12.6	12.4	13.2	13.1	13.5	13.2	13.8	14.5	14.3
9	12.0	11.2	11.8	12.0	13.1	13.1	13.0	13.2	13.8	14.5	14.2
10	11.0	10.8	10.3	11.3	12.5	12.8	12.9	12.5	13.5	14.2	14.2
11	10.0	10.0	9.9	10.7	12.0	11.7	11.8	11.2	13.0	13.9	14.2
12	9.8	9.9	9.1	10.0	11.8	10.7	10.6	10.2	12.2	12.9	13.8
13	9.2	9.2	8.9	9.4	10.8	9.9	10.2	10.0	12.0	11.5	12.9
14	9.0	9.0	8.4	8.9	10.1	9.4	9.6	9.1	10.9	10.9	12.0
15	9.0	8.5	7.9	8.0	9.8	9.3	9.1	8.9	9.9	10.2	11.0
16	8.2	8.2	7.3	7.9	9.0	9.0	8.9	8.1	9.9	9.5	10.0
17	8.1	8.0	7.1	7.4	8.8	8.7	8.2	7.9	9.0	9.0	9.5
18	8.0	7.5	7.0	7.0	8.1	8.6	8.2	7.8	9.0	9.0	9.2
19	7.9	7.0	6.6	6.8	8.0	8.2	8.1	7.5	8.5	8.9	8.9
20	7.5	6.9	6.2	6.4	7.0		8.0	7.2	8.0	8.1	8.2
25	7.0	6.0	5.7	5.9	6.2		6.2	6.0	7.2	7.0	7.5
30	6.1	5.8	5.2	5.3	6.0		5.5	5.9	6.0	6.2	6.2
35	5.9	5.2	5.0	5.1	5.5		5.2	5.2	5.5	5.9	5.9
40	5.5	5.0	4.9	5.0	5.1		5.0	5.0	5.0	5.2	5.5
45	5.2	5.0	4.7	4.7	5.0		5.0	4.9	4.9	4.9	5.0
50	5.0	4.8	4.5	4.4	4.9		4.8	4.8	4.6	4.2	4.9
55	5.0	4.5	4.2	4.2	4.5		4.5	4.5	4.2	4.1	4.8
60	5.0	4.2	4.1	4.1	4.3		4.2	4.2	4.2	4.1	4.3
65	5.0	4.1	4.0	4.0	4.2		4.1	4.2	4.1	4.0	4.1
70	4.9	4.1	4.0	4.0	4.1		4.0	4.2	4.0	4.0	4.0
75	4.9	4.0	4.0	4.0	4.0		4.0	4.0	4.0	3.9	4.0
80	4.8	4.0	3.9	3.9	4.0		4.0	4.0	4.0	3.9	4.0
85	4.5	4.0	3.9	3.9	4.0		4.0	4.0	4.0	3.8	3.9
90	4.5	4.0	3.9	3.9	4.0		3.9	3.9	3.9	3.8	3.9
95	4.2	4.0	3.9	3.9	4.0		3.9	3.9	3.9	3.6	3.9
100	4.2	3.9	3.8	3.9	4.0		3.9	3.9	3.9	3.5	3.8
TIME	1135	1100	1210	0945	1115	1208	1150	1210	1137	NONE	1125

TABLE 5

1982
pH - ALKALINITY - DISSOLVED OXYGEN
STATION 13

Depth (m)	15 July pH[1]	15 July Alk.[2]	15 July DO[3]	21 July pH	21 July Alk.	21 July DO
Surface	7.90	29.7	12.1	7.90	28.8	10.9
50	7.80	29.7	14.7	7.80	28.8	13.2
100	7.70	29.3	14.4	7.80	28.8	13.5
150	7.65	29.7	14.2	7.70	29.3	12.6
200	7.65	31.1	14.2	7.60	29.3	12.6
250	7.60	29.7	13.8	7.60	29.7	12.6
300	7.50	28.8	13.6	7.50	29.7	12.6

Depth (m)	27 July pH	27 July Alk.	27 July DO	23 August pH	23 August Alk.	23 August DO
Surface	7.85	29.7	9.6	7.80	28.8	9.3
50	7.75	29.7	12.9	7.78	28.8	11.2
100	7.70	30.6	12.5	7.70	29.3	12.5
150	7.63	29.7	12.2	7.65	29.3	11.7
200	7.50	28.8	11.8	7.60	29.7	10.8
250	7.50	28.8	11.9	7.50	29.7	12.2
300	7.50	29.7	12.9	7.50	30.0	10.7

Depth (m)	7 September pH	7 September Alk.	7 September DO
Surface	7.80	29.1	9.8
50	7.80	29.1	12.3
100	7.73	28.8	11.8
150	7.69	29.3	10.4
200	7.62	29.4	10.9
250	7.59	29.7	12.2
300	7.50	30.2	11.9

STATION 23

Depth (m)	27 July pH	27 July Alk.	27 July DO	7 September pH	7 September Alk.	7 September DO
Surface	7.80	29.3	9.6	7.85	29.3	10.2
50	7.70	28.8	12.3	7.78	29.5	13.0
100	7.62	29.7	12.6	7.69	29.7	11.6
150	7.60	29.7	11.8	7.65	29.9	12.3
200	7.63	29.7	11.5	7.60	30.2	12.0
250	7.50	28.8	11.2	7.60	30.2	14.0
300	7.50	29.7	11.3	7.55	30.2	12.2

1 - pH in pH units
2 - alkalinity in mg/liter as $CaCO_3$
3 - dissolved oxygen in mg/liter

TABLE 6. Representative profiles of dissolved oxygen (mg/liter), pH, and total alkalinity (mg/liter CaCO) for Crater Lake[1]

Depth (m)	23 Jul 68			16 Jul 69		
	DO	pH	Total alk.	DO	pH	Total alk.
0	8.76	7.2	29.1	9.44	7.4	29.2
20	10.10	7.2	29.1	10.20	7.5	29.0
40	10.60	7.2	29.0	10.82	7.5	29.0
60	10.60	7.2	29.1			
70				10.48	7.5	29.5
80	10.60	7.4	29.0			
100	10.44	7.4	28.7			
110				10.50	7.6	29.3
130	10.24	7.4	28.9			
200				10.54	7.5	29.2
300	10.16	7.4	28.8			
400	10.00	7.4	28.8			
500	9.90	7.3	29.0			

[1] D.W. Larson. 1972. Temperature, Transparency, and Phytoplankton Productivity in Crater Lake, Oregon. Limnol. Oceanog. 17(3): 410-417.

TABLE 7

1982
CHLOROPHYLL - PHYTOPLANKTON
COLLECTIONS
STATION 13

Depth (m)	15 July		21 July		29 July	
	CHL[2]	PHYTO[1]	CHL	PHYTO	CHL	PHYTO
Surface	X	96	X	-	X	25
10	-	-	X	-	X	24
20	X	95	X	-	X	26
40	X	94	X	-	X	21
60	X	93	X	-	X	22
80	X	92	X	-	X	23
100	X	91	X	-	X	18
120	X	90	X	-	X	19
140	X	89	X	-	X	20
160	X	88	X	-	X	15
180	X	87	X	-	X	16
200	X	86	X	-	X	17

Depth (m)	5 August		23 August		1 September		2 September	
	CHL	PHYTO	CHL	PHYTO	CHL	PHYTO	CHL	PHYTO
Surface	X	-	X	55	X	P-12	X	8
10	X	-	X	57	X	P-11	-	-
20	X	-	X	58	X	P-10	-	-
40	X	-	X	59	X	P-9	X	9
60	X	-	X	67	X	P-8	-	-
80	X	-	X	49	X	P-7	X	10
100	X	-	X	50	X	P-1	X	11
120	X	-	X	51	X	P-2	X	12
140	X	-	X	52	X	P-3	-	-
160	X	-	X	53	X	P-4	X	13
180	X	-	X	54	X	P-5	-	-
200	X	-	X	56	X	P-6	X	14

STATION 23

Depth (m)	29 July		1 September	
	CHL	PHYTO	CHL	PHYTO
Surface	X	32	X	P-63
10	X	65	X	P-64
20	X	64	X	P-65
40	X	63	X	P-66
60	X	62	X	P-67
80	X	53	X	P-68
100	X	44	X	P-69
120	X	50	X	P-70
140	X	47	X	P-71
160	X	35	X	P-72
180	X	38	X	P-73
200	X	41	X	P-74

1.- bottle numbers given
2.- data recorded on filter wraps

TABLE 8

1982
SECCHI DISK READINGS
(8" Diameter Disk)

	Station	Time	Depth (m)
12 July	13	12:30	29.30
12 July	13	12:40	33.00 (40" Disk)
16 July	13	None	28.50
21 July	13	11:50	28.48
23 July	13	10:30	29.01
	25	11:05	30.16
	23	11:30	29.70
	16	12:00	28.30
	11	12:30	30.60
26 July	13	10:00	28.40
	25	11:00	29.30
	23	11:25	26.27
	16	12:00	28.80
	11	12:15	29.04
28 July	13	11:00	28.70
	25	11:25	29.20
	16	12:05	26.90
	11	12:45	30.70
5 August	13	11:30	25.30
6 August	13	11:10	26.70
	25	11:30	25.20
	23	11:50	25.10
	16	12:45	25.00
	11	13:00	28.00
12 August	13	10:45	24.10
	25	11:40	24.10
	23	12:05	24.80
	16	12:35	24.60
	11	12:45	23.30
17 August	13	11:05	22.90
	25	11:20	23.70
	11	12:30	22.60
21 August	13	12:15	21.90
26 August	13	12:19	25.00
1 September	13	11:30	26.00
	23	None	26.20
2 Sept.	13	11:15	25.80
7 Sept.	23	12:30	27.00

APPENDIX I

EQUIPMENT AND SUPPLIES OBTAINED FOR WATER QUALITY PROGRAM IN 1982

APPENDIX I
EQUIPMENT AND SUPPLIES OBTAINED FOR WATER QUALITY PROGRAM IN 1982

	Description	Quantity	Total Cost
1.	Pontoon Boat, Model DC-26, with 8' x 24' deck	1	$ 5,532.00
2.	Johnson 35hp Outboard Motor, Model J35 ELCN	1	$ 1,315.44
3.	Snatch Block Meter Wheel, w/dials, Reading in Meters #252WA220	1	$ 709.00
4.	Heavy Duty Hand Winch, #317WA102, Hednaw	1	$ 599.00
5.	Belfort Pyrheliograph (solar radiation recorder) Cat. #5-3850A	1	$ 736.00
6.	Charts for pyrheliograph 192 hour 100 charts in the package	1 pkg.	$ 12.50
7.	Thermistor (Thermograph) Model TC-5, with 250 Meters of Cable, Montedoro-Whitney	1	$ 2,763.00
8.	pH Meter, Beckman Altex Expand-Mate Cat.No.34101-213	1	$ 495.00
9.	Van Dorn Bottles, 4 liter volume, PVC, Vertical	5	$ 1,050.00
10.	Brass Van Dorn Bottle Messengers	2	$ 70.00
11.	Wire Rope for Winch, 1/8 inch Diameter	1,000 ft.	$ 290.00
12.	Conductivity Bridge, YSI Model #23200-009	1	$ 729.00
13.	Conductivity Cell, Pyrex, Yellowsprings Model 3402 Cat. No. 23201-045	1	$ 148.00
14.	KCL conductance solution, 0.01 M, 32 oz., Cat. No. AL51340-4	1 bottle	$ 13.00
15.	pH Meter, Model 5, Corning 47500 #34103-300	1	$ 495.00

Description	Quantity	Total Cost
16. Combination pH Meter Electrode, Glass, 12mm, Altex by Beckman, Cat. No. 34105-101	1	$ 86.00
17. Buffer Solution, pH 7, Cat. No. 34180-286	8 pints	$ 40.16
18. Buffer Solution, pH 4, Cat. No. 34180-253	2 pints	$ 10.04
19. Buffer Solution, pH 10, Cat. No. 34180-300	2 pints	$ 10.04
20. Filter Holder, PVC Manifold, 3 Place, #XX26-047-35, Millipore Corp.	1	$ 314.00
21. Filters, HAWP, 047-00, Autoclave Packed w/absorbent Pads, Pore Size 0.45 micrometers-47mm, White, Plain, Millipore Corp.	3 pkgs	$ 122.70
22. All Glass Filter Apparatus, 47mm Diameter, #XX15-047-00, Millipore Corp.	3	$ 468.00
23. Vacuum Pressure Pump, 115 v, 60 HZ, #XX55-000-00 Millipore Corp.	1	$ 377.00
24. Glass Funnels, Cat. #XX10-047-04, Millipore Corp.	3	$ 117.30
25. Glass Base, Cat. #XX10-047-02 Millipore Corp.	3	$ 152.10
26. Clamps, Cat. #XX10-047-03 Millipore Corp.	3	$ 81.30
27. Stoppers, Cat #XX10-047-08 Millipore Corp.	1 set	$ 32.40
28. Magnetic Stirrer (GS-005-45063), #58935-250	1	$ 93.00
29. Thermometers, Celsius, #61066-046	3	$ 14.58
30. Stand, Buret Support, 329-00	1	$ 31.90
31. Stand, Buret, Double, 328-00	1	$ 15.15
32. Air Horn, Hand-held, with Extra Can	1	$ 11.95
33. Carboy, Nalgene, with Spigot (50 liters) #16334-264	1	$ 62.89

Description	Quantity	Total Cost
34. Burets, Kimax, 50 ml Cap. #17454-443	2	$ 33.30
35. Burets, Accu-red, 100 ml Cap., Pyrex (Corning 2122A), #17452-164	2	$ 84.10
36. Burets, Accu-red, Pyrex (Corning 2122A), 10ml capacity, Cat. No. 17452-109	2	$ 66.60
37. Flasks, 250 ml, Erlenmeyer (Kimble 26650) #29140-544	2 pkgs	$ 47.08
38. Flasks, Volumetric, 1000 ml, (Kimble 28014 Series) #29619-653	1 case	$ 112.08
39. Flasks, Volumetric, 2000 ml, (Kimble 28014 Series) #29619-664	2	$ 68.50
40. Flasks, Filter, Kimax, 1000 ml #29415-121	2	$ 41.56
41. Beakers, Pyrex, 100 ml, #13912-160	1 pkg	$ 17.55
42. Beakers, Pyrex, 400 ml, #13912-229	1 pkg	$ 19.54
43. Beakers, Pyrex, 1000 ml, #13912-284	1 pkg	$ 23.32
44. Pipettes, Volumetric, 100 ml, #52966-239	1 pkg	$ 72.70
45. Pipettes, Volumetric, 5 ml, #52961-111	1 pkg	$ 27.11
46. Pipettes, Volumetric, 10 ml, #52961-133	1 pkg	$ 30.98
47. Washbottles, 250 ml, #16651-165	1 pkg	$ 8.75
48. Washbottles, 1000 ml #16651-223	1 pkg	$ 9.00
49. Reagent Bottles, 1000 ml, #16267-101	6	$ 111.90
50. Bottles, Wide Mouth, Amber, 1000 ml, #16127-226	4 pkgs	$ 67.64
51. Bottles, Wide Mouth, Amber, 500 ml, #16127-204	4 pkgs	$ 77.24
52. Bottles, Dropper, Safety, 250 ml, 20861-46	1 case	$ 20.20

	Description	Quantity	Total Cost
53.	Bottle, Dropping Assembly, 250 ml, Nalgene, #16353-101	2 pkgs	$ 32.20
54.	BOD Bottles, 300 ml capacity #16285	2 cases (48 bottles)	$ 205.20
55.	Cylinders, Graduated, 1000 ml #24774-127	2	$ 22.94
56.	Cylinders, Graduated, 50 ml #24707-061	2	$ 26.64
57.	Cylinders, Graduated, 100 ml #24707-083	2	$ 31.04
58.	Cylinders, Graduated, 250 ml #24707-108	2	$ 41.66
59.	Funnels, Short Stem, Kimax (Kimble 28950), 90mm ID Top	6	$ 26.68
60.	Vacuum Pressure Tubing, 1/4" I.D. #62994-183	1	$ 19.50
61.	PAO Titrant 0.025N, 3.78 L, 1070-17	2	$ 49.56
62.	Phenolphthalein Indicator Solution, 473 ml, 1897-11	2	$ 16.00
63.	Bromcresol Green-Methyl Red Indicator Solution, 473 ml, 451-11	2	$ 10.00
64.	Starch Indicator Solution, 946 ml, 349-16	1	$ 6.75
65.	Kimwipes, Cleaning Tissues #21905-047	1 case	$ 61.25
66.	Stopcock Grease, Dow Corning #59344-055	2	$ 13.98
67.	Johnson Outboard Motor Oil	2 cases	$ 70.00
		SUB-TOTAL	$18,570.00

ADDITIONAL PURCHASES (OSU Chemistry Stores)

	Description	Quantity	Total Cost
1.	Poly Tube Connecting "Y", 1/4"	12	$ 5.28
2.	Poly Tube Connecting "Y", 3/8"	12	$ 7.44
3.	Tubing, Black, Pressure, 3/8 x 5/16 - 1	4 ft.	$ 12.68
4.	Tubing, Black, Pressure, 1/4 x 3/16 - 1	4 ft.	$ 5.32
5.	Scoopulas, Lab	4	$ 1.92
6.	Clamp Pinchcock	10	$ 5.50
7.	Lab-Bench Paper Kimpack, 20" x 0.4"	300 ft.	$ 25.42
8.	Paper Filters, Whatman #1 12.5 cm Diameter	3 pkgs	$ 6.36
9.	Acid Bottle Safety Carrier, 2-1/2 Liter	1	$ 19.38
10.	Poly Bottle, Narrow Mouth, Screw-Cap, 1 Liter Volume	216	$233.28
11.	Poly Bottle, Narrow Mouth, Screw-Cap, 500 ml Volume	24	$ 21.36
12.	pH Buffer, pH7	10 capsules	$ 3.00
13.	Iodine, Resublimed	1/4 pound	$ 21.96
14.	Magnesium Carbonate	1/4 pound	$ 8.33
15.	Potassium Iodide	500 grams	$ 18.45
16.	Sulfuric Acid	5 pints	$ 9.27
17.	Sodium Hydroxide Pellets	2 pounds	$ 7.94
18.	Sodium Iodide	1/4 Pound	$ 11.15
19.	Sodium Azide	100 grams	$ 9.94

ADDITIONAL PURCHASES (OSU Chemistry Stores)

	Description	Quantity	Total Cost
20.	Manganese Sulfate Monohydrate	2 pounds	$ 16.68
21.	Drierite, Indicating	5 pounds	$ 16.10
22.	Formaldehyde	1 gallon	$ 16.46
		SUB-TOTAL	$483.22
		GRAND-TOTAL	$19,053.22

APPENDIX II

COMPUTERIZED DATA MANAGEMENT SYSTEM

JOURNAL OF
THE WATER RESOURCES
PLANNING AND
MANAGEMENT DIVISION

Conversational Water Quality Data Retrieval System

By Douglas W. Larson[1] and Thomas Bingham[2]

Introduction

Water resource management often requires the use of a computer to store and manipulate large quantities of data. But data retrieval may present a problem for the investigator or program manager who is inexperienced with computers, terminal communications and commands, and syntax language, or who accesses the stored data so infrequently that each new retrieval session requires, essentially, a costly and perhaps time-consuming "re-learning" of procedures and language. Ideally, the most efficient, useful retrieval system would probably be one requiring the fewest commands in the simplest language. Here we describe a data management system which can be activated and used quickly, with minimal training, jargon, and incentive, while still employing the latest data retrieval software available.

System Description

Since 1974, we have collected much physical, chemical, and biological data for reservoirs and rivers in western Oregon. This information is handled through use of the data-base management system SIR (scientific information retrieval) (3), and a FORTRAN program which interfaces SIR with the user. SIR was chosen for several reasons:

[1]Limnologist, Hydr. Section, United States Army Corps of Engrs. Dist., Portland, Ore. 97208.

[2]Statistician, Boeing Computer Service, Energy-Tech.-Application Div., Tukwila, Wash. 98188.

Note.—Discussion open until August 1, 1981. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. Manuscript was submitted for review for possible publication on February 19, 1980. This paper is part of the Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. WR1, March, 1981. ISSN 0145-0743/81/0001-0239/$01.00.

1. SIR is a hierarchical system with the capability to pinpoint sub-populations of data, and then process only those portions of the data base at a relatively low cost.

2. SIR has a versatile reporting capability which can produce reports under any format of the user's choice.

3. SIR has a built-in direct link with two major statistical packages designated as the statistical package for social sciences (SPSS) (2) and the biomedical computer programs P-Series (1) via system file creation, which facilitates easy, yet powerful statistical analyses.

The FORTRAN interface program was designed to prompt the user with questions, the answers to which describe the exact nature of the retrieval. SIR

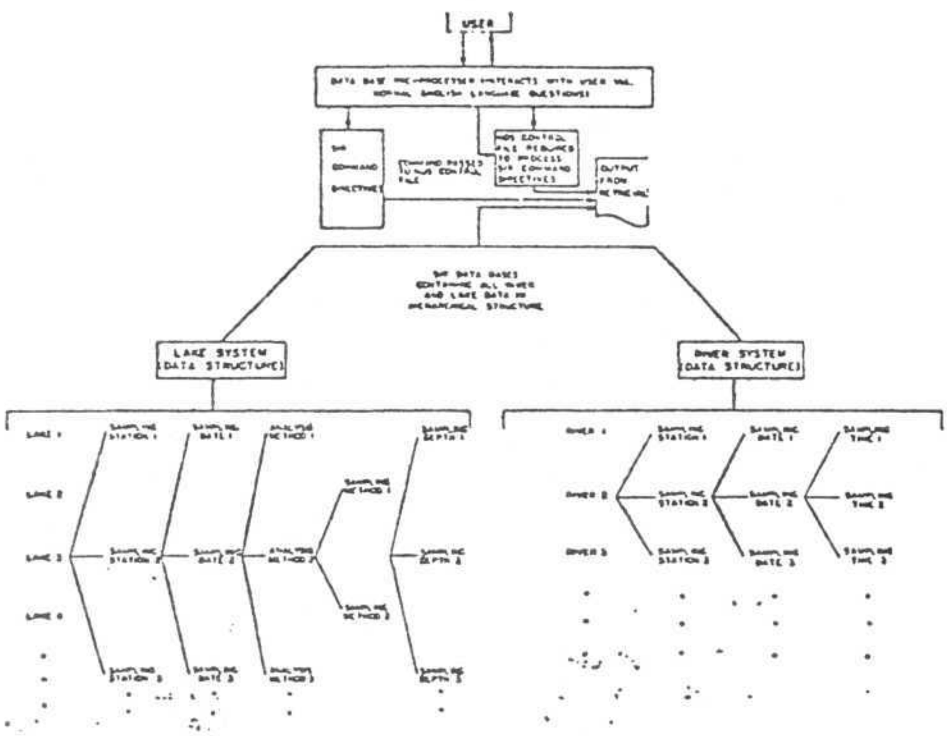

FIG. 1.—Schematic of Water Quality Data Retrieval System (NOS = Network Operating System)

directives, corresponding to the answers as created by the FORTRAN program, are then executed. The results of the retrieval are displayed to the user in the form of the user's choice (see Fig. 1).

For users who might be unfamiliar with the interface program, a self-documenting capability was built into the program so that it could be operated successfully with no user's manual. Essentially, this documentation consists of several "menus" which are displayed individually upon request, thereby giving all available responses to questions about a particular category of information.

Overall, the system combines a tutorial interactive capability with batch

TABLE 1.—Example of Typical Data Retrieval Session Using Conversational Water Quality Data Management System

C >	CALL, RETRIEV
	please enter your name:
I >	SMITH
	enter subject category (0 = menu):
I >	0
	enter one of the following numeric codes:[a]
	1. river data
	2. lake data
	3. groundwater
I >	2
	enter any assortment of record types desired[a] (0 = menu
I >	0
	1. nutrients
	2. pesticides
	3. biological
I >	1 3
	enter the numeric codes representing the desired parameters to be retrieved from record type 1[a] (0 = menu):
I >	0
	1. nitrate-nitrogen
	2. orthophosphate
	3. silica
I >	1 2
	enter the numeric codes representing the desired parameters to be retrieved from record type 3[a] (0 = menu):
I >	0
	1. phytoplankton primary production
	2. phytoplankton chlorophyll concentrations
	3. phytoplankton species composition
I >	2 3
	enter the river/lake basin number[a] (0 = menu):
I >	0
	1. Columbia
	2. Willamette
	3. Rogue
I >	2
	enter the numeric codes representing the desired lakes to be retrieved from record type 2[a] (0 = menu):
I >	0
	1. Lookout Point
	2. Hills Creek
	3. Cougar
I >	2
	enter the desired station numbers[a] (0 = menu):
I >	0
	1. HC5
	2. HC12
	3. HC26
I >	HC5 HC26

TABLE 1.—*Continued*

	enter the date from which the retrieval is to begin. The required format is DD MM YY:
I >	15 5 75
	enter the date on which the retrieval is to end. The required format is DD MM YY:
I >	30 8 78
	enter output options[a] (0 = menu):
I >	0
	1. create easy-graph files for plotting
	2. re-sort data records by one or more parameters
	3. create SIR line printer plots of any number of parameter pairs
	4. create an SPSS system file for statistical analyses
	5. print-out requested data
I >	5
	enter your desired job priority[a] (0 = menu):
I >	0
	1. standby
	2. four hours turn around
	3. one hour turn around
I >	3
	successful completion of water quality information system

[a] An unlimited number of numeric codes, record types, or options can be listed; examples are given.

[b] The system is not restricted to water quality data; application is intended for other types of data bases.

processing which may contribute to greater flexibility, responsiveness, and ease in data retrieval, and yet be relatively inexpensive and require shorter periods of time at the terminal because of the batch job feature. This differs from systems which exclusively use batch processing to retrieve data—e.g., STORET (4) or WATSTORE (5)—or are purely interactive.

System Operation

To operate our system, the user first logs on by dialing, in our case, Boeing EKS (Enhanced Kronos System) and providing a user identification code. Completion of log-on is signified by a "C" prompt, i.e., C >. The user then executes system by entering the command "CALL, RETRIEV." From this point on, the system questions the user in "everyday" conversational language concerning information needed to perform the retrieval. If the user is unsure as to how to initiate a response (e.g., to answer a specific question posed by the system), a "menu" of available responses may be activated by entering a "key" number (usually zero) which is also indicated by the system (see Table 1).

If the user enters an invalid response, a "diagnostic" is printed by the program with the request to try again. Thus, "bug-free" SIR directives are always written, thereby freeing the user of the problem of using the "debugging" code. At any point during execution, the entire run may be aborted by entering "STOP."

Re-execution is done by reentering "CALL, RETRIEV." After completing all desired retrievals in a given session, the user can log off by entering "BYE" and then hanging up the phone.

Because all operating commands are built into the system, little or no experience with any form of computing is required to operate the system other than the procedure given in Table 1. Any files that are to be saved by the system for subsequent statistical analyses (e.g., by SPSS) can be stored under the names chosen by the user during the execution of the system. The use of these files, however, will require some knowledge of SPSS and computer operating language. Requested data can be printed automatically on a local line printer.

Our system is currently limited to Boeing EKS (i.e., the system is not designed to interface with other data management systems), although the data base could be transferred en masse to STORET (4) or WATSTORE (5), for example.

Summary and Conclusions

A system is described which simplifies the process of retrieving data from computer storage. "Everyday" conversational language forms the basis of communication between data retriever and computer, thereby minimizing the need for specialized training and knowledge in computer operations.

The system allows for relatively easy access to stored data of any kind, and can rapidly generate data tabulations, graphics, and statistical plots and analyses for prompt assessment of water quality or for use in continued aquatic research.

Appendix.—References

1. Dixon, W. J., and Brown, M. B., *BMDP Biomedical Computer Programs P-Series*, University of California Press, Berkeley, Calif., 1979.
2. Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., and Bent, D. H., *SPSS: Statistical Package for the Social Sciences*, McGraw-Hill Book Co., Inc., New York, N.Y., 1975.
3. Robinson, B. N., Anderson, G. D., Cohen, E., and Gazdzik, W. F., *SIR (Scientific Information Retrieval) User's Manual*, Northwestern University, Evanston, Ill., 1979.
4. *STORET User Handbook*, 1st ed., Office of Water and Hazardous Materials, United States Environmental Protection Agency, Washington, D.C., 1975.
5. "WATSTORE User's Guide," *Open-File Report 75-426*, United States Geological Survey, Reston, Va., 1975.

APPENDIX III

PHYTOPLANKTON METHODOLOGY AND SPECIES COMPOSITION - 1982*

* Phytoplankton enumerations are not included in this report.
Original sample counts are on file with Mr.Stan Geiger,Scientific Resources, Incorporated and D.W.Larson,Corps of Engineers,Portland.

Inverted microscope method
(B–1520–77)

Parameter and code: Phytoplankton, total (cells/ml) 60050

1. Application

The method is suitable for all waters.

2. Summary of method

Taxonomic and numerical assessment of natural populations of phytoplankton require direct microscopic examination. The inverted microscope method permits the observation of the phytoplankton in an aliquot of water at high-power magnification without disrupting or crushing the delicate organisms.

The phytoplankton are concentrated by settling to the bottom of a sample container or a vertical-tube sedimentation apparatus (Utermohl, 1931, 1936, 1958; Lovegrove, 1960). Lund, Kipling, and LeCren (1958) reported that all known algae can be settled.

An aliquot of a phytoplankton sample is poured into a plankton chamber or a sedimentation apparatus. The algae settle onto a microscope cover glass which forms the bottom of the chamber or apparatus, and the settled algae are observed from beneath using an inverted microscope. Because this method permits use of the high dry and oil-immersion objectives on the microscope, very small forms can be identified and enumerated.

3. Interferences

The method is generally free of interferences. Suspended sediment may obscure microorganisms in a sample. Previously used sample bottles and parts of the sedimentation apparatus must be scrubbed thoroughly to remove adherent diatoms and other material, especially from the bottom surfaces. Convection currents and air bubbles in the apparatus can interfere with sedimentation.

4. Apparatus

4.1 *Inverted microscope*, Zeiss Invertoscope D, Nikon (MS-76560), Tiyoda (2020), or equivalent.

4.2 *Ocular micrometer*, Whipple grid, Bausch & Lomb (31-16-13) or equivalent.

4.3 *Plankton chamber*, 26×76 mm glass slide with 12-mm circular hole covered by cementing no. 1½ cover slip to slide.

4.4 *Sedimentation apparatus* of the type described by Lovegrove (1960) (fig. 14), 8-cm high, 25-ml capacity, Scott Instruments, Seattle, Wash., or equivalent. Other sizes may be needed for some types of samples (see 7.3 below).

4.5 *Coverglass*, 22-mm diameter, No. 1 and No. 1½.

4.6 *Rubber cement* for attaching cover glass to the counting chamber.

4.7 *Sample containers*, plastic bottles, 1,000-ml capacity.

4.8 *Water-sampling bottle*, Wildlife Supply Co. (1510 or 1920) (figs. 11 and 12); Scott Instruments, Seattle, Wash., Foerst Mechanical Specialties Co., Improved Water Sampler, Kemmerer-type; or equivalent. Depth-integrated samplers are discussed by Guy and Norman (1970).

4.9 *Cotton swabs*.

4.10 *Vacuum grease*.

4.11 *Pipet*, serological, 1 ml.

4.12 *Balance*, with automatic tare, Sartorius or equivalent.

5. Reagents

5.1 *Cupric sulfate solution*, saturated, dissolve 21 g $CuSO_4$ in 100 ml distilled water.

5.2 *Formaldehyde*-cupric sulfate solution, mix 1 liter of 40 percent aqueous formaldehyde containing 10–15 percent methanol, Fisher Scientific No. F-78, or equivalent, with 1 ml of solution 5.1.

5.3 *Detergent solution*, 20 percent, dilute 20 ml liquid detergent (Liqui-Nox, Catalog C6308–2, phos-

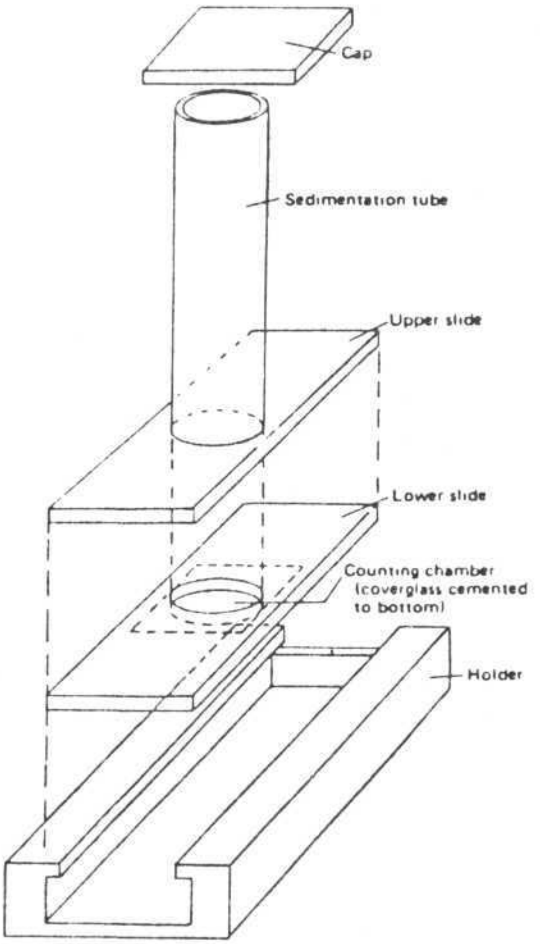

Figure 14.—Sedimentation apparatus. (Modified from Lovegrove, 1960).

phate free, or equivalent) to 100 ml with distilled water.

5.4 *Lugol's solution:* Dissolve 10 g iodine crystals and 20 g potassium iodide in 200 ml distilled water.

6. Collection

A phytoplankton sample consists of a volume of water, usually 1 liter. To insure maximum correlation of results, the sample sites and methods used for phytoplankton should correspond as closely as possible to those selected for chemical and bacteriological sampling.

The sample collection method will be determined by the study objectives. In lakes, reservoirs, deep rivers, and estuaries, phytoplankton abundance may vary transversely, with depth, and with time of day. To collect a sample representative of the phytoplankton density at a particular depth, use a water-sampling bottle. To collect a sample representative of the entire flow of a stream, use a depth-integrated sampler (Guy and Norman, 1970; Goerlitz and Brown, 1972). For small streams, a depth-integrated sample or a point sample at a single transverse position located at the centroid of flow may be adequate. Study design, collection, and statistics for streams, rivers, and lakes are described in Federal Working Group on Pest Management (1974).

Preserve sample as follows: To each 1,000 ml of sample add 40 ml of 37–40 percent aqueous formaldehyde solution (100 percent Formalin), 5 ml of 20 percent detergent solution, and 1 ml of cupric sulfate solution. This preservative maintains cell coloration and is effective indefinitely.

Many biologists consider Lugol's solution to be the best plankton preservative. It has been effective for at least 1 year (Weber, 1968); it facilitates sedimentation of cells and maintains fragile cell structures, such as flagella. If Lugol's solution is preferred as a preservative, add 1 ml Lugol's solution to each 100 ml of sample. Store the preserved samples in the dark.

7. Analysis

7.1 If using the sedimentation apparatus (fig. 14), proceed to 7.5. If using the plankton chamber, proceed as follows: If concentration is necessary, allow the sample to settle undisturbed in the sample container for 4 hours per centimeter of depth to be settled. After settling, tare the sample container on an automatic balance.

7.2 Carefully siphon the supernatant to avoid disturbance of the settled material. Place sample container with remaining sample on balance and weigh. The reduction in weight (in grams) is equivalent to the number of milliliters of supernatant removed. The same method can be used to obtain the volume of concentrate.

7.3 Mix the concentrated sample well (but not vigorously) and pipet an appropriate volume into each of two plankton chambers. Slide cover slip into place.

7.4 Place the plankton chamber on the mechanical stage of a calibrated microscope. Proceed to 7.10.

7.5 To prepare the sedimentation apparatus, cement a No. 1 glass cover glass to the bottom of the lower slide to form the bottom of the counting chamber (fig. 14). When dry, remove the excess rubber cement from the inside of the counting chamber with a knife.

7.6 Test for leaks: Coat the underside of the upper slide (fig. 14) with vacuum grease, and press onto the lower slide to form a watertight seal. Assemble the apparatus and fill with distilled water so that the meniscus bulges slightly above the top of the sedimentation tube. Slide the cap over the top to seal the tube. Let stand overnight and check for water loss in the morning.

7.7 If no leaks are detected, thoroughly mix a sample by inverting it at least 40 times, and then fill the sedimentation apparatus and apply the cap as described in 7.2. Allow 4 hours settling time per 1 cm of sedimentation tube length. The volume of sample is dependent on the density of algae. In plankton-poor waters, 100 ml of sample may be required; in more fertile waters, 25 ml or less of sample may be sufficient. The 25 ml volume is most commonly used. The samples may be diluted, if necessary.

Note: Air bubbles on the sides of the chamber tube can be prevented if the water sample and the sedimentation apparatus are at the same temperature when the sample is introduced. The apparatus should be maintained at a constant temperature to avoid convection currents which can interfere with settling.

7.8 After settling, isolate the algae in the counting chamber from the remainder of the apparatus. To separate the sedimentation tube and upper slide from the lower slide and counting chamber (fig. 14), move the sedimentation tube to one side splitting the water column. Remove the tube cap and siphon or pipet off the supernatant. Remove the empty sedimentation tube.

7.9 Remove the lower slide with the counting chamber from the holder (fig. 14). Place the cap over the top of the counting chamber to form a closed cell. If an air bubble remains under the cap, tease it to one side of the chamber and carefully add distilled water to fill the void. Replace the tube cap and put the slide on the inverted microscope.

7.10 Count and identify the total number of algal cells (at × 200–300 magnification) in randomly chosen fields. In making the counts, enumerate all forms that intersect two of the borders of the grid, but do not count those that intersect the opposite borders. If a large number of colonies appear within the field, determine the average number of cells in an average size colony and multiply by the number of colonies present. Similarly, tabulate the numbers and lengths of trichomes of blue-green algae in each grid and determine the average number of cells per unit length of trichome. Count all algae containing any part of a protoplast as having been living at the time of collection. Count a minimum of 100 units (unit - one filament, one colony, or one unicellular algae) or 250 fields (at × 200–300) whichever is obtained first. For concentrated samples count a minimum of 10 fields.

8. Calculations

$$\frac{(\text{chamber area, mm}^2) \times (\text{number of fields})}{(0.96)^* \times (\text{field area, mm}^2)} \times \frac{(\text{total count})}{(\text{initial volume, ml})} \times \frac{(\text{volume of concentrate, ml})}{(\text{chamber volume, ml})}$$

*Compensates for addition of formaldehyde-detergent preservative.

9. Report

Report phytoplankton concentrations to two significant figures. Report values for each of the three groups: diatoms, green algae, and blue-green algae.

10. Precision

No precision data are available.

References

Federal Working Group on Pest Management, 1974, Guidelines on sampling and statistical methodologies for ambient pesticide monitoring: Washington, D.C., Federal Working Group on Pest Management, 59 p.

Goerlitz, D. F., and Brown, Eugene, 1972, Methods for analysis of organic substances in water: U.S. Geol. Survey Techniques Water-Resources Inv., book 5, chap. A3, 40 p.

Guy, H. P., and Norman, V. W., 1970, Field methods for the measurement of fluvial sediments: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. C2, 59 p.

Lovegrove, T., 1960, An improved form of sedimentation apparatus for use with an inverted microscope: Conseil Permanent Internat. Explor. Mer. Jour., v. 25, no. 3, p. 279–284.

Lund, J. W. G., Kipling, C., and LeCren, E. D., 1958, The inverted microscope method of estimating algal numbers and the statistical basis of estimations by counting: Hydrobiologia, v. 11, p. 144–170.

Utermöhl, H., 1931, Über das umgekehrte Mikroskop: Archiv Hydrobiologie Planktonkunde, v. 22, p. 643–645.

——— 1936, Quantitative Methoden zur Untersuchung des Nannoplankton: Abderhalden Handb. biol. ArbMeth., Abt. 2, v. 2, p. 1879–1937.

——— 1958, Zur Vervollkommnung der quantitativen Phytoplankton-Methodik: Internat. Verein. Limnologie Mitt., no. 9, 38 p.

Weber, C. I., 1968, The preservation of phytoplankton grab samples: Am. Microscop. Soc. Trans., v. 87, p. 70–81.

ADDENDUM TO NPS RQ9000-3-0001

TECHNICAL SPECIFICATIONS

Chlorophyll *a* and pheophytin *a* analyses will be performed on frozen MF-Millipore filters according to the USEPA-approved procedures in the 15th edition of Standards Methods (APHA-AWWA-WPCF 1981; Section 1002G). To insure adequate recovery of the low chlorophyll *a* levels previously reported for Crater Lake (Geiger and Larson, 1980) absorbances will be determined using a Gilford model 300N spectrophotometer with a spectral slit width of 8.0 nm. Chlorophyll *a* reference samples from the USEPA Environmental Monitoring and Support Laboratory at Cincinnati, Ohio will be used to estimate the levels of analytical precision and confidence limits for the analyses. Data from the analyses will be entered on a standard form (Appendix A) and concentrations of chlorophyll *a* and pheophytin *a* will be provided in mg/m^3 (or $\mu g/m^3$).

Phytoplankton samples preserved with Lugol's solution will be analyzed following USEPA-approved procedures for enumeration using an inverted microscope (APHA AWWA WPCF 1981; Section 1002F and Weber 1973, EPA-670/4-73-001, p. 10). A total of 100 individual "units" or particles per sample will be counted. Total unit densities per sample as well as the relative abundance of each species will be calculated. Only "units" with apparent, "healthy" chloroplasts will be counted.

The previous analyses of Crater Lake phytoplankton sampled in a manner similar to the samples to be analyzed showed a predominance of diatoms with occasional chlorophytes and flagellated chrysophytes (Larson and Geiger 1979, Geiger and Larson 1980, and Geiger 1981). A personal taxonomic libary comprising references for identifying these species has already been assembled (see selected list of references appended to this addendum). Both phase and SEM photographs have been made of various species for precise identification (see copy of appended 1981 article by Geiger for examples). Documented taxonomic consultation on the identification of unique species has been prepared to assure accurate identifications. Comparisons of individuals with species identified in previous studies of the phytoplankton will be made to insure continuity with earlier identifications. Reference slides from all previous sampling are maintained by the analyst. The rationale for identifications made, in addition to references used, will be provided with the results.

A Wild M-40 inverted microscope will be used for the analyses. Supplemental identification, primarily of diatoms will be made using an AO H20 Phasestar microscope. Sample bottles and remaining phtoplankton samples will be returned following the analyses, to the National Park Service.

TAXA CODE LIST FOR ALGAE SPECIES IDENTIFIED

PROJECT D2921 COFFEY LABORATORIES INCORPORATED
PREPARED BY BEAK CONSULTANTS INCORPORATED / ANALYSES PERFORMED BY N. STAN GEIGER (identified as NSG on the Lab Data Forms)
Samples analyzed from 1981 and 1982 sampling of Crater Lake, Oregon

TAXA CODE	TAXA NAME	AUTHORITY	REFERENCE
A1670	TRIBONEMA AFFINE	G.S.WEST	Prescott, 1962
A3171	STEPHANODISCUS HANTZSCHII	GRUN.	Huber-Pestalozzi and Hustedt, 1942
A3850	FRAGILARIA CONSTRUENS	(EHR.) GRUN.	Patrick and Reimer, 1966
A3879	FRAGILARIA VAUCHERIAE V. CAPITELLATA	(GRUN.) PATR.	Patrick and Reimer, 1966
A3880	FRAGILARIA VAUCHERIAE	(KUETZ.) PETERS	Patrick and Reimer, 1966
A4100	SYNEDRA ACUS	KUETZ.	Patrick and Reimer, 1966
A4101	SYNEDRA DELICATISSIMA	W. SMITH	Patrick and Reimer, 1966
A4109	SYNEDRA RUMPENS V. FAMILIARIS	(KUETZ.) HUST.	Patrick and Reimer, 1966
A4140	SYNEDRA MAZAMAENSIS	SOV.	Patrick and Reimer, 1966
A4380	ACHNANTHES MINUTISSIMA	KUETZ.	Patrick and Reimer, 1966
A5081	NAVICULA CRYPTOCEPHALA V. VENETA	(K.) RABH.	Patrick and Reimer, 1966
A5973	GOMPHONEMA OLIVACEUM V. CALCAREA	CLEVE	Patrick and Reimer, 1975
A6501	NITZSCHIA SILICA	ARCH.	Archibald, 1972
A6510	NITZSCHIA PALEA	(KUETZ.) W.SMITH	Archibald, 1972
A6531	NITZSCHIA PERMINUTA	GRUN	Archibald, 1972
A6540	NITZSCHIA FRUSTULUM	KUETZ.	Archibald, 1972
A6550	NITZSCHIA LINEARIS	W. SMITH	Archibald, 1972
A6623	NITZSCHIA BACATA F. LIN.	HUST.	Archibald, 1972
A6690	NITZSCHIA VERMICULARIS	(KUETZ.) GRUN.	Archibald, 1972
A6760	NITZSCHIA GRACILIS	HANTZSCH.	Archibald, 1972
A7960	KEPHYRION SPIRALE	(LACK.) CONRAD	Bourrelly, 1968
A7961	KEPHYRION ASPER	(LACK.) BOURR.	Bourrelly, 1968
A7987	CALYCOMONAS SP.		Bourrelly, 1968
A8002	CHROMULINA-LIKE SP.		
A8301	OCHROMONAS CL1		
A8304	OCHROMONAS CL2		
A8305	OCHROMONAS CL3		
A8400	DINOBRYON SERTULARIA	EHR.	Prescott, 1962
A8431	PSEUDOKEPHYRION ENTZII	CONR.	Bourrelly, 1968
A9969	CHRYSOPHYTE STATOSPORE CL2		
A9977	CHRYSOPHYTE STATOSPORE CL1		
C0000*	CHLOROPHYTA UNIDENTIFIABLE		
C1600	OOCYSTIS PUSILLA	HANSGIRG	Prescott, 1962
C1801	ANKISTRODESMUS FALCATUS V. ACICULARIS	(A.BRAUN) G.S. WEST	Prescott, 1962
C1801	ANKISTRODESMUS FALCATUS V. SPIRALIS	(TURNER) LEMM.	Prescott, 1962
C2550	PLANKTOSPHAERIA GLATINOSA	G.M. SMITH	Prescott, 1962
C3000	SELANASTRUM MINUTUM	(NAEG.) COLL.	Prescott, 1962
C9422	MOUGEOTIA SP.		
E0000	CYANOPHYTA UNIDENTIFIABLE		
G0000	PYRROPHYTA UNIDENTIFIABLE		
G1200	CRYPTOCHRYSIS POLYCHRYSIS	PASCHER	Huber-Pestalozzi, 1968
G1400	RHODOMONAS MINUTA	SKUJA	Huber-Pestalozzi, 1968
G1401	RHODOMONAS LACUSTRIS	PASCH. E. RUTT.	Huber-Pestalozzi, 1968

*See end of Taxa Code List for more information on C0000

TAXA CODE	TAXA NAME	AUTHORITY	REFERENCE
G1690	AMPHIDINIUM LUTEUM	SKUJA	Huber-Pestalozzi, 1968
G1704	GYMNODINIUM FUSCUM	(E.) STEIN	Huber-Pestalozzi, 1968
G1705	GYMNODINIUM INVERSUM	NYGAARD	Huber-Pestalozzi, 1968
G2014	PERIDINIUM INCONSPICUUM	LEMM.	Huber-Pestalozzi, 1968
G2015	PERIDINIUM ACICULIFERUM	(LEMM.) LEMM.	Huber-Pestalozzi, 1968

1981 -1982

NOTE ON C0000:

The following forms of unidentifiable unicellular green algae were observed. Descriptions of the forms and drawings are found on the data sheets.

- C0000: a non-flagellated, spherical cell that stains with IKI around 3 micrometers in diameter.
- *C0000: a non-flagellated, spherical cell that does not stain with IKI with IKI; around 2-3 micrometers in diameter.
- oC0000: elliptical, rod-shaped cells, probably NANNOCHLORIS SP., 2 micrometers wide by 3 long.

CALCULATION OF UNIT DENSITIES:

The low densities of algae in all samples collected necessitated the concentration of the algae prior to preparing settling chambers for the analysis. The following formula is to be used in calculating unit densities using the Beak settling chambers:

$$\text{Algae units/liter} = \text{Organisms counted}\# \times \frac{\dfrac{2.54\ \text{cm}^2 *}{(0.0133\ \text{cm}¢ \times \text{length of transects-cm})}}{\dfrac{1\ \text{liter} \times 5\ \text{ml}+}{1000\ \text{ml}}} \times \frac{\text{Volume concentrate}}{\text{Volume original sample}}$$

* = the area of the settling chamber bottom

\+ = the volume used in the settling chamber (generally 5 ml but occasionally 4 ml.

\# = 100 for all samples counted with the exception of very sparse samples (less than 3 or 4)

¢ = width of field at x1500

APPENDIX IV

CHLOROPHYLL METHODS AND DETERMINATIONS
1982

COFFEY LABORATORIES, INC.
4914 N.E. 122nd Ave.
Portland, OR 97230
Phone: (503) 254-1794

June 17, 1983

ACCURACY AND PRECISION DATA

The values obtained using a Bausch and Lomb 700 Spectrophotometer with a 0.2 nm band width. In an Analytical Quality Control Newsletter, October 1976, a computer simulation demonstrated the effect of Spectrophotometer resolution (nm) on the results of chlorophyll analyses. According to the article, the apparent recovery with a 0.2 nm resolution is approximately 100%. A copy of the newsletter title page along with a plot taken from the computer simulation is included.

EPA reference samples were analyzed at the onset of the Crater Lake National Park samples. The method used for the quality control samples was provided by the EPA. Method, data sheets and final results with true values are included.

Accuracy of the analyses can be determined by examining the correlation of laboratory values and the known EPA quality control samples.

Chlorophyll (mg/l) uncorrected for pheophytin Trichromatic method.

	Lab Values (5/10/83)	EPA Value (12/16/82)	Δ %
Chl-a	7.29	7.40	1.51
Chl-b	0.58	0.78	34.5
Chl-c	1.31	1.25	4.8

This report continued . .

Precision is demonstrated with ten replicate readings of a practice sample at the wavelengths dictated by the method.

Wavelength (nm)	750	663	645	630
Mean	3.8	11	7.9	5.6
Standard Deviation	0.42	0.88	0.57	0.97
Variance	0.16	0.69	0.29	0.84

(The mean S.D. and variance based on V readings average are 10^3 times the actual readings.)

Sincerely,

Susan M. Coffey

Susan M Coffey

SMC:hs

QUALITY CONTROL DATA

Dilutions were made of EPA concentrate quality control samples to match more closely the values of the chlorophyll samples from Crater Lake. Results are listed below:

Conc. 1 True Value in Concentrated Form = 7.76

	Lab Values	True Value
1/10 dilution	0.758	0.776
1/25 silution	0.305	0.310
	0.294	

Conc. 2 True Value in Concentrated Form = 7.40

	Lab Values	True Value
1/10 dilution	0.682	0.740
	0.747	
1/25 dilution	0.297	0.296
	0.253	

CALCULATIONS

The following pages show the computer program used in the HP-55 calculator, and the corrected absorbances used to store in the program for each sample.

The equation which all these calculations is based on is listed below:

Corrected O.D. Equations:

(O.D. 663) - (O.D. 750)	= corrected O.D. 663
(O.D. 645) - (O.D. 750)	= corrected O.D. 645
(O.D. 630) - (O.D. 750)	= corrected O.D. 630

$$11.64\,(\text{O.D. }663)_{\text{corrected}} - 2.16\,(\text{O.D. }645)_{\text{corrected}} +).10\,(\text{O.D. }630)_{\text{corrected}}$$

$$= \text{Chlorophyll a}$$

$$\frac{\text{Chlorophyll a (extract volume, ml)}}{\dfrac{\text{Sample Volume Filtered, liters}}{1000}} = \text{Chlorophyll a}/m^3$$

1982 (CORRECTED)

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m³)
7-15-82	13	Surface	0.16
"	13	20 meters	0.00
"	13	40 "	0.20
"	13	60 "	0.27
"	13	80 "	0.24
"	13	100 "	0.72
"	13	120 "	1.2
"	13	140 "	0.96
"	13	160 "	0.40
"	13	180 "	0.53
"	13	200 "	0.41
7-29-82	13	Surface	0.00
"	13	Surface	0.10
"	13	10 meters	0.04
"	13	10 "	0.11
"	13	20 "	0.10
"	13	20 "	0.17
"	13	40 "	0.04
"	13	40 "	0.10
"	13	60 "	0.49
"	13	60 "	0.24
"	13	80 "	0.45
"	13	80 "	0.25
"	13	100 "	0.57
"	13	100 "	0.67
"	13	120 "	0.75
"	13	120 "	0.65

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m^3)
7-29-82	13	140 meters	0.15
"	13	160 "	0.00
"	13	180 "	0.24
"	13	180 "	0.00
"	13	200 "	0.10
"	13	200 "	0.43
7-21-82	13	Surface	0.00
"	13	"	0.33
"	13	10 meters	0.31
"	13	10 "	0.33
"	13	20 "	0.36
"	13	20 "	0.43
"	13	40 "	0.28
"	13	40 "	0.23
"	13	60 "	0.38
"	13	60 "	0.29
"	13	80 "	0.06
"	13	80 "	0.40
"	13	100 "	0.55
"	13	100 "	0.55
"	13	120 "	0.55
"	13	120 "	0.48
"	13	140 "	0.06
"	13	140 "	0.05
"	13	160 "	0.42
"	13	180 "	0.42
"	13	180 "	0.38

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m³)
7-21-82	13	200 meters	0.00
"	13	200 "	0.06
7-24-82	23	Surface	0.38
"	23	Surface	0.14
"	23	10 meters	0.37
"	23	10 "	0.44
"	23	20 "	-0.02
"	23	20 "	0.00
"	23	40 "	0.05
"	23	40 "	0.00
"	23	60 "	0.00
"	23	60 "	0.15
"	23	80 "	0.34
"	23	80 "	0.25
"	23	100 "	0.93
"	23	100 "	1.00
"	23	120 "	0.99
"	23	120 "	1.00
"	23	140 "	0.53
"	23	140 "	0.48
"	23	160 "	0.48
"	23	160 "	0.47
"	23	180 "	0.43
"	23	180 "	0.48
"	23	200 "	0.24
"	23	200 "	0.24
8-5-82	13	Surface	0.49

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m^3)
8-5-82	13	Surface	0.43
"	13	10 meters	0.18
"	13	10 "	-0.00972
"	13	20 "	0.05
"	13	20 "	0.05
"	13	40 "	0.25
"	13	40 "	0.50
"	13	60 "	0.46
"	13	60 "	0.31
"	13	80 "	0.25
"	13	80 "	0.21
"	13	100 "	0.47
"	13	100 "	0.50
"	13	120 "	0.41
"	13	120 "	0.45
"	13	140 "	0.28
"	13	140 "	0.39
"	13	160 "	0.25
"	13	160 "	0.26
"	13	180 "	0.06
"	13	180 "	0.00
"	13	200 "	0.00
"	13	200 "	0.06
8-23-82	13	Surface	0.00
"	13	"	0.00
"	13	10 meters	0.10
"	13	10 "	0.00

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m^3)
8-23-82	13	20 meters	0.00
"	13	20 "	0.00
"	13	40 "	0.17
"	13	40 "	0.05
"	13	60 "	0.05
"	13	60 "	0.13
"	13	80 "	0.05
"	13	80 "	0.45
"	13	100 "	0.69
"	13	100 "	0.53
"	13	120 "	0.87
"	13	120 "	0.69
"	13	140 "	0.46
"	13	140 "	0.35
"	13	160 "	0.27
"	13	160 "	0.37
"	13	180 "	0.38
"	13	180 "	0.11
"	13	200 "	0.12
"	13	200 "	0.06
9-1-82	13	Surface	0.17
"	13	"	0.45
"	13	10 meter	0.30
"	13	10 "	0.25
"	13	20 "	0.20
"	13	20 "	0.14
"	13	40 "	0.18

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m^3)
9-1-82	13	40 meters	0.21
"	13	60 "	0.26
"	13	60 "	0.27
"	13	80 "	0.27
"	13	80 "	0.38
"	13	100 "	0.65
"	13	100 "	0.69
"	13	120 "	0.58
"	13	120 "	0.78
"	13	140 "	1.00
"	13	140 "	0.48
"	13	160 "	0.20
"	13	160 "	0.19
"	13	180 "	0.36
"	13	180 "	0.34
"	13	200 "	0.42
"	13	200"	0.42
9-1-82	23	Surface	0.31
"	23	Surface	0.31
"	23	10 meters	0.30
"	23	10 "	0.21
"	23	20 "	0.16
"	23	20 "	0.09
"	23	40 "	0.15
"	23	40 "	0.21
"	23	60 "	0.45

CRATR 12/83

Crater Lake National Park

Chlorophyll a Analyses

Sample Date	Station Sampled	Depth Sampled	Chlorophyll a (mg/m^3)
9-1-82	23	60 meters	0.33
"	23	80 "	0.81
"	23	80 "	0.67
"	23	100 "	0.89
"	23	100 "	0.82
"	23	120 "	0.24
"	23	120 "	0.51
"	23	140 "	0.23
"	23	140 "	0.32
"	23	160 "	0.20
"	23	160 "	0.41
"	23	180 "	0.27
"	23	180 "	0.24
"	23	200 "	0.14
"	23	200 "	0.15
9-2-82	13	Surface	0.11
"	13	40 meters	0.27
"	13	80 "	0.44
"	13	100 "	0.64
"	13	120 "	0.62
"	13	160 "	0.37
"	13	200 "	0.20

CRATR 12/83

APPENDIX V

COMMENTS BY THE PEER REVIEW COMMITTEE ON THE 1982 ANNUAL REPORT, LIMNOLOGICAL AND WATER QUALITY MONITORING PROGRAM AT CRATER LAKE NATIONAL PARK

(ARRANGED ALPHABETICALLY)

NIVERSITY OF CALIFORNIA, DAVIS

RKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO — SANTA BARBARA • SANTA CRUZ

VISION OF ENVIRONMENTAL STUDIES — DAVIS, CALIFORNIA 95616

28 February 1983

Dr. Doug Larson
Army Corps of Engineers
Hydrology
P.O. Box 2946
Portland, Oregon 97208

Dear Doug,

Enclosed are our specific comments and recommendations for the Crater Lake Monitoring Program. We all felt that the meeting in Corvallis on 16 Feb. was very constructive and enjoyed seeing you again. It is regrettable that you did not have the opportunity to utilize the experience of the Tahoe Research Group sooner- but we are all happy to see you finally getting some financial support and systematically collected data.

We also strongly encourage you to consider allocating a modest amount of money to help support a nutrient enrichment study of Crater Lake phytoplankton during the coming summer (item #10). This time frame is particularly relevant because of the expertise, interest, and availability of Judith Lane. She conducted a preliminary experiment on Crater Lake phytoplankton in 1981 and has recently completed her Master's degree dissertation on similar types of experiments at Lake Tahoe and Castle Lake. Costs can be greatly reduced by incorporating these studies with some additional experiments she is planning to do at Castle this summer. We'll send a more detailed proposal under separate cover.

We've also enclosed some Tahoe/Castle reprints and reports which you might find useful.

Sincerely,

Rich

Richard Axler

Stan

Stanford Loeb

John Reuter
John

Tahoe/Castle Research Groups

Encls.

TO: Dr. Doug Larson

FROM: R.P.Axler, S.L.Loeb, J.E.Reuter
Tahoe/Castle Research Groups

DAVIS: DIVISION OF ENVIRONMENTAL STUDIE

25 February 1983

Recommended Sampling Program for Crater Lake

1) The biological, physical and chemical monitoring of Crater Lake should be conducted at a single "index" station. Concentrating the majority of the sampling at one station would reduce the amount of time required to be out on the lake, enable collection of a more complete and correlative data set, and facilitate a stronger interpretive analysis of the collected information. Synoptic collection at two or three other locations ~~once every month~~ periodically would provide information concerning the spatial heterogeneity of a few specific parameters (e.g. nutrient concentrations, chlorophyll a depth distribution, and Secchi depth.

2) Secchi depth readings should be continued throughout this ten year program. Measurements should be made at least once every week and, if possible, two people should make independent readings. Time of day, lake water surface conditions, and cloud cover should be standardized and recorded.

3) Water temperature depth profiles should be continued as during the summer 1982 at the one index station. Weekly profiles should be sufficient.

4) Dissolved oxygen, total alkalinity, specific conductance and pH analyses should be conducted twice during the summer (June-September), once during June or July and once during late August or early September (& once during winter)

5) Chlorophyll a (µg/liter) depth profiles should be conducted once a week or every two weeks. Filtration for this analysis should be done on the same day as collection. Fluorometry is recommended as an alternative to the more time consuming and costly acetone extraction method. The Turner Design flow-through instrument coupled with a pumping system would be an excellent choice, however, it is also quite costly. A Turner III Fluorometer would be adequate to characterize the depth-distribution profile of chlorophyll a using Van Dorn collected water samples for considerably less money. Calibration of the fluorometry with standards made from pure chlorophyll a extract is considered a necessity, together with period lake water acetone-extract cros comparisons.

6) Nutrient analysis of the entire water column is essential. Analyses should include: nitrate-nitrogen, ammonium-nitrogen, soluble phosphorus, total phosphorus and total iron. Analytical methods for these elements should have detection limits of 1 - 5 micrograms per liter (1-5 parts per billion).

Ammonium-nitrogen and soluble phosphorus are likely to be below these levels of detection in Crater Lake waters throughout the year, therefore, routine analyses for these forms should be reevaluated when more information becomes available. Sampling once a week or every two weeks for nutrient chemistry should be adequate. If a winter sampling trip is to be conducted, analysis of nutrient chemistry for the entire water column is strongly suggested since nitrate profile changes may provide an estimate of depth of mixing.

7. Trace element concentrations of water samples from a few depths in the lake should be conducted once a year. A single composite sample should be sufficient to characterize these elements, however, an initial comparison of a discrete-depth profile with a composite sample is recommended. Trace elements may be useful for characterizing suspected inflow of geothermal waters at the bottom of Crater Lake.

8. Phytoplankton species enumeration should be made on a composite water column sample (0-200 m). Discrete depth samples should be taken and stored for possible future needs which might require a more detailed analysis of the depth distribution of the phytoplankton community structure or an analysis of the community at a specific depth corresponding to a chlorophyll a (or fluorescence) maximum. Samples should be collected every two weeks or once a month. Our recommendation to use a composite sample and to reduce the frequency of this analysis is based on our experience that species enumeration is a very time consuming and costly procedure. Since discrete depth samples will be collected, this detailed information will not be lost. It might also be possible to reduce the sample volume if settling chambers are used for concentrating samples (125 ml is adequate for Lake Tahoe).

9. Attached algae (periphyton) is a very useful site-specific indicator of nutrient inputs from the watershed. At Crater Lake, Cladophora sp. (a green filamentous algae) has been observed growing attached to rock surfaces in the splash zone, for example, near Cleetwood Cove. A reconnaissance of the shoreline of Crater Lake to map the spatial distribution of this algae is recommended to identify locations where nutrient inflow may be occurring. This survey should be conducted once during the summer, the month of August being the most appropriate time. A time series colonization of algae on artificial substrates (e.g. glass microscope slides) can be used to quantify differences in water fertility (nutrient richness) and help identify sites where external nutrient inputs occur. Glass slides

should be positioned vertically in wooden racks at a depth of 1.0 m, removed monthly and analyzed for biomass accrual (e.g. ash-free dry weight per slide).

10. The decrease in transparency of the waters of Crater Lake, whether it has already occurred or will occur in the future, would most likely be the result of increased availability of nutrients. A series of biological nutrient assays designed to identify which nutrients (e.g. nitrogen, phosphorus, iron, etc.) the lake phytoplankton are most sensitive to (i.e. growth stimulated by) is strongly recommended, if not essential, in the beginning phase of this monitoring program. Two assay periods are suggested per summer; one in June and one in September. Nutrient stimulation biological assays should be repeated every year if possible or at least every 2 to 3 years over the ten year duration of this program.

    The research group of Professor Charles R. Goldman at the University of California, Davis, is uniquely qualified to perform this type of assay based on more than twenty years of experience at Lake Tahoe and Castle Lake.

11. External inputs of nutrients to Crater Lake via precipitation should be examined. Optimally, analysis of the nutrient chemistry for each storm is suggested. Snow cores can be collected and melted from "snow board", the boards placed back on the snow surface after each storm. If this procedure is not practical a core of the entire snow pack at the end of the snow fall season (prior to runoff) could be analyzed for nutrient concentrations. These nutrient concentrations data could be adjusted using the total precipitation gauge already in the park to estimate total inputs. Dry atmospheric deposition is likely to be equally important but until better sampling techniques are developed, we would not recommend devoting monies to measure it. Dr. Wissmar's comments regarding consideration of the potential impacts of atmospheric acid and nutrient inputs were well taken. Collection of snow cores and analysis for plant nutrients will require minimum cost and effort and will be extremely valuable in future analyses of the Crater Lake ecosystem.

NIVERSITY OF CALIFORNIA, DAVIS

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INSTITUTE OF ECOLOGY - R.P.Axler   DAVIS, CALIFORNIA 95616

Dr. Doug Larson
Army Corps of Engineers
Portland, Oregon

4 March 1983

Dear Doug,

I've worked up the cost for a nutrient enrichment study of Crater Lake phytoplankton. The basic experimental design would include 8 triplicated treatments- probably split up as 4 in the epilimnion and 4 in the hypolimnion (perhaps N, P, NP, trace elements as the 4 treatments). Assays would run for 6 days with every-other-day sampling. C-14 PPr and fluorescence would be the basic parameters measured along with initial and final nutrient levels, chlorophyll-a, and cell density. A final report with data and interpretation would also be prepared for inclusion in your annual report. It's a lot of information which relates directly to the "cause-effect" aspect of the Crater Lake Monitoring Program. We all realize that your budget is tight. However, Judy Lane will probably be doing some similar work at Castle and Tahoe (on a part-time basis) and so we can keep costs low by including only full sampling days during the bioassays, even though she would undoubtedly be spending much more of her own time than has been budgeted. Basically, we are all interested in the Crater Lake ecosystem and these types of experiments can be fit into the overall framework of the current Castle/Tahoe nitrogen cycling program (C.R.Goldman, P.I.).

I think there are probably quite a few limnologists, oceanographers, and geochemists in the region who would be very interested in doing some work at Crater. Some encouragement might in turn be very helpful towards your goal of understanding this ecosystem and the changes which may be occuring.

BUDGET:	Time:	travel (Davis-Crater RT)	2 d
		field work (Crater)	1 d
		bioassay set-up (Castle Lake)	1 d
		bioassay (days 2, 4, 6)	3 d
		nutrient/chlorophyll analyses	2 d
		C-14 analysis	1 d
		data reduction	2 d
		Summary Report preparation	3 d
			15 days

Personnel cost...... 15 days (6% of annual) $1350*

* based on University of California PGR III plus 29% fringe benefits

Travel: Davis-Crater Lake RT (ca 1000mi@ 18.5¢)....$185

Supplies (filters, ^{14}C, sample bottles, misc.)......$150

TOTAL COST : ca.$ 1685

. Lane
. lock

Rich

United States Department of the Interior

NATIONAL PARK SERVICE

Pacific Northwest Region
Westin Building, Room 1920
2001 Sixth Avenue
Seattle, Washington 98121

IN REPLY REFER TO:

N3617(PNR-RS)

March 8, 1983

Dr. Douglas W. Larson
Hydraulics and Hydrology Branch,
U.S. Army Corps of Engineers
P.O. Box 2946
Portland, Oregon 97208

Dear Dr. Larson:

We are enclosing a draft copy of the notes from the Peer Review Meeting for the Crater Lake Water Quality Monitoring Program. Would you please review them and call me by March 25 with any needed corrections (206) 442-4235 or FTS 399-4235.

Thank you for your assistance.

Sincerely,

Shirley M. Clark

Shirley M. Clark
Air and Water Quality Coordinator

Enclosure

DRAFT

1. ADDITIONAL RESEARCH

--NPS funding is competitive process

--park can provide some logistic support for private researchers

--Stan Loeb volunteered weighed filters for "quick and dirty" idea of biological vs. nonbiological ratio

--Cliff Dahm volunteered nutrient analysis of 200 samples from one station

--Ron Zaneveld volunteered to make some optical measurements

--Ron Zaneveld and/or Cliff Dahm volunteered determination of inorganic component

--Cliff Dahm will analyze some snow samples from the park

--Rich Axler will do enrichment studies on water from Crater Lake

2. ATMOSPHERIC DEPOSITION

--atmospheric deposition can be very important to lake nutrient budget and can be a source of trace metals

--dry deposition may be more important for nitrate in the western United States than wet deposition

--lake too alkaline to have pH affected by acid precipitation

--should monitor atmospheric deposition

--more meteorological data may also be needed

--little acid precipitation data available on alpine lakes, more work needed

--workshop on acid precipitation in northwest lakes would be helpful

3. BUOY

--installation of permanent buoy at sample site appeared to be preferred method for finding and holding position

--small buoy with radiotransmitter

--triangulate technology and small float

--major buoy under lake surface and "beer can" size float on surface

--may be difficult to stabilize buoy in such a deep lake

--Doug Larson, Ed Starkey, and Mark Forbes will work on buoy project

4. CHLOROPHYLL and PHYTOPLANKTON

--should explore possibility of doing chlorophyll at park

--important to stay with same analyzer

--local person should do samples

--phytoplankton samples fixed in Lugol's lasts for years, last summer's samples should definitely be analyzed

--discrete phytoplankton samples may be needed for research but perhaps composites are adequate for monitoring

--composite phytoplankton samples from Secchi level to surface would provide more information for less money

--analysis of discrete phytoplankton samples is labor intensive and Crater Lake may not have dramatic species shifts, composite samples would allow detection of long-term shift of phytoplankton species.

--phaeophytin probably not worth doing

--variation in Secchi disc readings demonstrates that lake is not necessarily decreasing in clarity

--should sample phytoplankton less frequently and chlorophyll more often

--phytoplankton and optics are two most important parameters

5. DATA STORAGE

--data presented in annual reports and will be stored in computer at Oregon State University

--possibility of linking park to OSU computer so data can be routinely stored

6. EQUIPMENT

--transmissiometer, photometer, and fluorometer data also needed

--Ron Zaneveld has 80 lb. instrument with both transmissometer and fluorometer

--Ray Smith has remote control equipment for optic measurements but may be hard to get on boat because of weight

--Ron Zaneveld has small portable transmissometer which might be made available for use in Crater Lake

--Ron Zaneveld has portable Coulter counter which could be taken to the lake, data correlates well with suspended mass and organic component can be distinguished from inorganic

--park does not have technical person to operate fluorometer, so chlorophyll sampling may be necessary

--earlier photometer data taken with different instrument so data not comparable, Cliff Dahm will look for old photometer at OSU

7. NUTRIENTS

--trace metals might be more important than nitrogen

--nutrient work in Crater Lake would require lots of sampling

--small algae in oligotrophic lakes have large surface area and are thus very efficient in absorbing nutrients

--phosphate usually abundant in volcanic areas

--only inorganics, nitrate, phosphate and silicate, are needed

--nutrient analysis needed

--nutrient concentrations low so samples must be analyzed soon after collection

--nutrient data very important

--though Crater Lake is large and deep, it appears to be uniform enough to sample only one area for nutrients

--baseline data on nitrogen at a number of depths is needed

--water from Crater Lake was taken to Castle Lake; phosphate, nitrate, iron and trace metals were added to different bottles; most sensitive to nitrogen

--may be lots of nitrogen in hypolimnion but if mixing is inadequate, it can still be limiting factor

--EPA can run samples, usually for a modest charge

8. ORGANIC/INORGANIC MATERIAL

--suspended material in upper layer is phytoplankton and that causes Secchi to decrease

--gradual decrease in Secchi reading with peak in August supports phytoplankton being the causative agent

--determination of suspended mass is needed because it determines extinction

--suspended mass plus chlorophyll and phytoplankton needed to determine percent inorganic material

--ash-free dry weight perhaps easier method to get at inorganic component though diatom frustules may cause problems

--management needs to know if it is a biological or nonbiological problem

9. PERIPHYTON

--good indicator of point sources of nutrients

--examine shoreline of whole lake once a year in August for attached algae, may be associated with human activities

--should try to get earlier information on *Cladophora* near Wizard Island, for example, ask other investigators

--*Anabaena*, a blue-green, earlier reported in Crater Lake - probably *Nostoc* which looks similar

--blue greens not in open water in low nitrogen lakes, but may be in periphyton

--should suspend glass slides to study periphyton growth

10. SAMPLING PROCEDURES

--should alkalinity be done potentiometrically rather than colorimetrically?

--should sample at one station only

--perhaps sample phytoplankton at only one site

--perhaps alkalinity once a month and DO once or twice a summer

--pH taken at boat dock rather than in lab

--2 liters filtered for chlorophyll

11. SEWAGE

--liquid in and out of lagoons should be measured

--dynamics of lagoons important to public relations

--measure temperatures and calculate losses by evaporation to indicate amount of leakage

--use of tracers to track direction of flow could be expensive and present technical difficulties

--nitrogen will stay in solution while phosphate and iron will attach to soil particles

--ground water can move very slowly

--soils in Crater Lake are young and ground water may move faster

--can use tracer and dig pits to determine direction of flow to overcome slow movement of ground water

--any natural tracers like trace elements in effluent?

--use sodium chloride as tracer and measure conductivity

--model movement of lagoon nutrients into Crater Lake

12. TAHOE PROJECT

--uptake of C-14 is more dramatic but correlates well with Secchi, decrease in clarity due to algal growth and not abiotic particles (see attachment)

--limiting factor narrowed down to nutrient, specifically nitrogen which appears to be the most limiting in western United States

--due to recent influx of nitrogen, limiting factor seems to be switching from nitrogen to phosphorus

--low percentage phaeophytin in Tahoe samples

--DO done only once a year because data not interesting

--amount of rainfall affects phytoplankton - less primary production during dry year - surface runoff is primary source of nitrogen

--data not available for distribution but most has been published

13. WINTER SAMPLING

--logistics for winter sampling are complicated

--need to get winter data early and then will know if it is necessary to go through the effort again

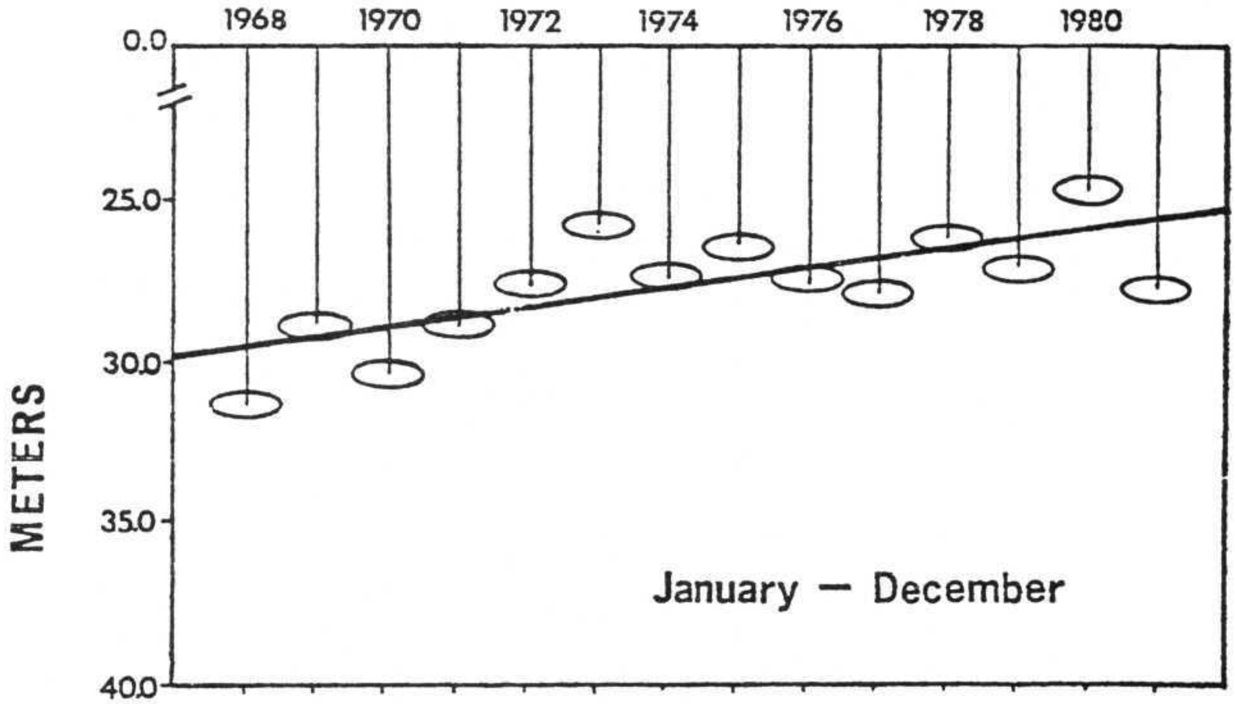
--winter sampling will allow characterization of nutrient basis

--will sample every six weeks starting next winter

--blooms from February on can strip nutrient supply

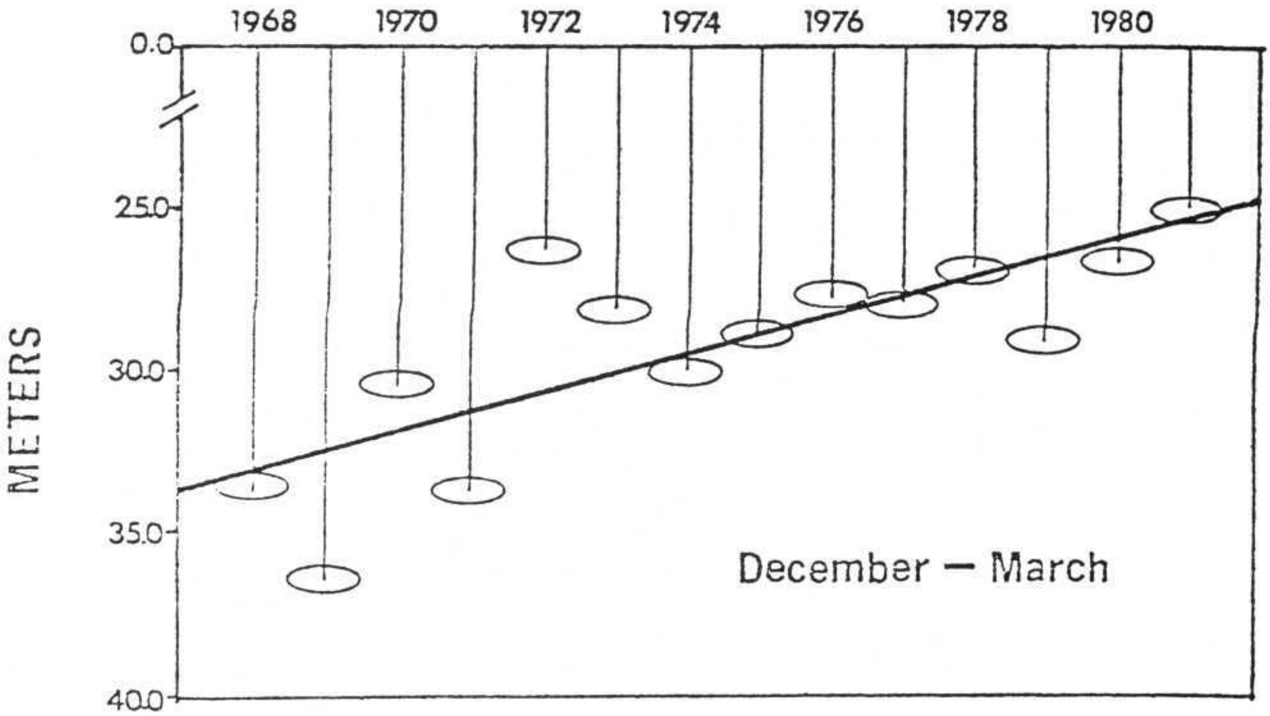
LAKE TAHOE

ANNUAL SECCHI DEPTHS



LAKE TAHOE

WINTER SECCHI DEPTHS



Department of
Fisheries and Wildlife

Oregon State University

Corvallis, Oregon 97331-3803 (503) 754-4336

February 28, 1983

Dr. Doug Larson
Portland District Office
Corps of Engineers
P.O. Box 2946
Portland, OR 97208

Dear Doug:

I am sending you the two old articles on Crater Lake that I had xeroxed, your report with my comments, and a one page curriculum vitae. I also put together a graph and data set you might consider for inclusion in the report. It attempts to show the relationship between near surface temperatures and Secchi disk measurements.

I am glad to serve on the Crater Lake review committee and applaud your efforts to date to initiate a rigorous limnological survey of Crater Lake. The early results are encouraging and hopefully will provide the foundation for further, more intensive studies.

Sincerely,

Cliff Dahm

Dr. Cliff Dahm
Research Associate

cja

Encl. (5)

COMMENTS BY DR.CLIFF DAHM,DEPARTMENT OF FISHERIES AND WILDLIFE,OREGON STATE UNIVERSITY,CORVALLIS.

(1) Section titled "Monitoring results for 1982",paragraph 1: "It looks as if September 1 and 2 had the highest temperature from 1-10meters".

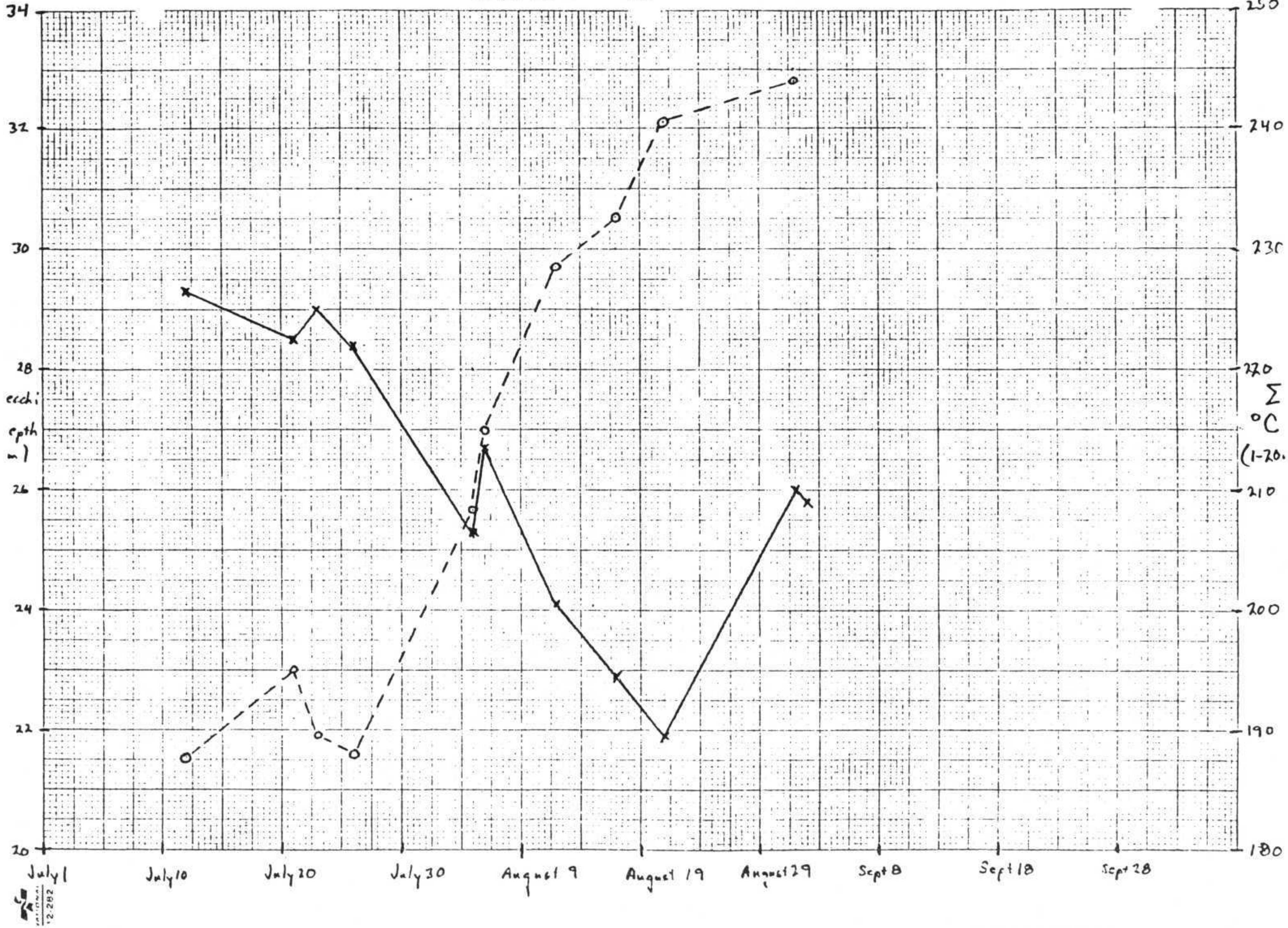
(2) Table 3,Temperature profiles at Station 13: "Are the values at the surface on July 12 and 29,and on 21 August correct?"

(3) Section titled "Discussion and Recommendations",paragraph 5,article 2: "Any recommendations as to the type of research project?"

(4) Section titled "Discussion and Recommendations",paragraph 10,article 5: "You may want to initially limit yourself to one winter sampling by helicopter,then reevaluate the need for further winter work".

(5) Section titled "Discussion and Recommendations",paragraph 11,article 5: "It would be nice to get one sample before June,1983".

Station 13



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Sept 28

1982 Data - Station 13

DATE	Temp Σ 1- 20m (°C)	Secchi Depth (m)
July 12	187.7	29.3
July 16	---	28.5
July 21	195.1	28.5
July 23	189.6	29.0
July 26	188.0	28.4
July 28	---	28.7
August 5	208.3	25.3
August 6	214.8	26.7
August 12	228.6	24.1
August 17	232.7	22.9
August 21	240.5	21.9
August 26	---	25.0
Sept 1	244.2	26.0
Sept 2	255.4	25.8

United States Department of the Interior

NATIONAL PARK SERVICE
WATER RESOURCES LABORATORY
COLORADO STATE UNIVERSITY
FORT COLLINS, CO. 80523
(303) 491-7573

IN REPLY REFER TO:
L54 (499)

Memorandum

To: Mark Forbes, Resource Management, CRLA

From: Raymond Herrmann, Chief, WRFSL

Subject: Annual Report on the Limnology and Water Quality Monitoring Program at Crater Lake National Park, 1982

As requested, enclosed are some questions and comments from our staff on the Annual Report on the Limnology and Water Quality Monitoring Program at Crater Lake National Park, 1982. We hope they will be useful to your review.

Enclosure

P.S. I again apologize for not being able to make the peer review meeting. I hope the enclosed comments will help.

R

1. The sample sites should include the coves around Wizard Island. They should be at least looked at for productivity.

2. We are wondering about the effect of altitudinal changes from field to Lab on DO and pH measurements.

3. Regarding the plankton samples and ID, is it possible for them to make replicate samples. (Are they taking replicate samples?)

4. They should report secchi data according to sample status by date and time rather than just date.

5. The assistant to Mr. Gilmore as described may not be realistic.

6. The fluorometer sounds like a good idea. (page 36B).

7. Based only on the information presented in the report an analysis of comparable secchi disc data (i.e., 8" disc readings on clear calm days only, within one or two days of the same date between years) indicates that a decrease of approximately 25% transparency has occurred for the months of July and August since 1969 to the present (1982). No major secchi depth transparency changes are indicated prior to 1969.

   These secchi depth readings also indicate a general pattern of minimum transparency during the last two weeks of August. This general pattern exists for both Station 13 and Station 23 for 1982.

   An estimation of the "thermocline" (1°C/m decrease in temperature) for Stations 13 and 23 from data on Tables 3 and 4 indicates that the greatest depth of the thermocline is also around the last two weeks of August. This condition provides the greatest volumn of water in the epilimnetic zone, thus the greatest volumn of Crater Lake's optimal conditions of light, temperature, and available nutrients for increased algal biomass. Since the secchi depth transparency is decreased during the same approximate period, it strongly indicates, as Doug Larson suggests, that an increase in overall phytoplankton biomass is responsible for reduced transparency.

   In order to gain more information between relationships of phytoplankton and transparency, two additions to the set of designed samples in the monitoring program would be valuable:

   1) Dissolved oxygen values taken from the surface to 50 m in similar depth intervals as phytoplankton samples (i.e., add 10 m, 20 m, and 40 m DO samples). This would allow analysis of % DO saturation at levels above the thermocline. Presently, if % DO saturation is used as a tool for indications of phytoplankton activity, any increase or decrease at the surface could be attributed to temperature change, and as the secchi depth values show 50 m is presumably below the compensation point. Intermediate readings would provide a means of assessing possible photosynthetic estimations, activity of phytoplankton, mixing phenomenon, and temperature interactions.

2) An analysis of suspended particulate matter would be constructive. It seems this question is addressed with the proposed purchase of a transmissometer (page 30). It is valuable to determine if decreased secchi disc values are due to increased particulate load into the water column in combination with phytoplankton activity. Is it not possible that increased Park use, particularly late in August when a lot of people take vacations, and it usually is dry (?) could provide a source of increased particulate matter? This seems to be a potentially important management concern regarding input sources to Crater Lake, and visitor use.

8. Some confusion exists regarding the measurement of dissolved oxygen as presented in the report. On page 9 the "possible routine" schedule indicates collection of samples for chemical analysis, to be done on Tuesday (within 24-36 hours of sampling). It is not clear if DO measurements are completed in the field; fixed in the field with Hach chemicals then titrated with PAO later; or simply carried out for determinations later as raw water (invalid!). If at all possible, the DO determinations should be completed in the field as soon as possible after sample collection. If Hach chemicals are to be used, then why carry out many small bottles of fixed sample (<u>must</u> be at least "fixed" immediately after collection) that may leak, break, etc.

   I would strongly suggest the purchase of an oxygen (DO) meter to measure the DO in mg/l immediately from collection. Not only would this save space in carrying several B.O.D. bottles, but the man-hours involved in titration methods could be put to better use. The approximate cost would be around $400.00 which would include spare probe, probe membranes, and 50 ft probe cable. Calibration in the Lab would provide accuracy beyond titration methods since it is not an iodometric method based on the visual interpretation of the operator.

9. The numbered topics in the Discussion and Recommendations sections (pages 25-33) are all appropriate for the proposed objectives of the study and seem necessary.

   The computer-based management system as outlined in the Appendix appears to be sound and usable.

   The use of Landsat imagery may be valuable for sensing of the listed conditions on this topic (page 26) and should be attempted, but <u>might</u> not be a priority item in regards to information gained, due to the oligotrophic nature of Crater Lake. Winter limnology on Crater Lake would be ideal, not only specifically for this study and the outlined objectives, but for temperature zone limnology in general.

   All aspects of the phytoplankton community listed on page 32 should indeed be recorded, including common statistical measures.

Ideally, one algologist should analyze all the samples, but if this is not possible it would be very important that the original algologist be a taxonomist with regionally relevant knowledge and possibly able to conduct culture studies if taxonomic variations due to temperature or nutrient conditions seem to appear.

The Crater Lake monitoring program appears to meet the designated objectives, provide basic essential limnological data which can be used as a tool to assess the conditions and changes within the Lake. The comments provided are suggestions designed to strengthen the study with minimal economic effects.

17 May 1983

Douglas W. Larson
Hydrology Section
U.S. Army Corp. of Engineers
Portland, OR 97208

PORTLAND STATE UNIVERSITY
p.o. box 751
ortland, oregon 97207
503/229-3851

department of biology

Dear Doug:

I have read your January 10, 1983 report and added a few comments. In general, I support the approach adopted and believe you are carrying it out efficiently.

I have also read through the summary of comments made at the February 16, 1983 meeting in Corvallis. The summary seems complete and accurate; it is clear you will not be able to include all the suggestions offered given your very limited budget. Some specific suggestions I would like to offer are:

1. In general, measurements should be duplicated. The replication of Secchi readings shows the value of repeated measures. Repeated measures of plankton and chemical constituents would also be valuable.

2. In contradiction to several comments in the summary of our February meeting, I believe the phytoplankton work should be continued, or even increased. As you know, shifts in the species of phytoplankton are sometimes especially clear indicators of changing ecological conditions. There is every reason to believe that any ecological changes in Crater Lake would be evident in changes in phytoplankton species long before there were any changes in chlorophyll concentration. In the hands of a skilled planktonologist, the analysis of plankton samples is very inexpensive when considered in light of the information received in return.

3. More attention should be given to the hydrography of the lake. The recent article by Williams and Herzen (1983) indicates that much of the limnological character of the lake is determined by the advection of water and heat into the bottom of the lake. In particular, the physical mixing and chemical composition of the lake water are very unusual. To understand the limnology of the lake, more good data on the influence of geothermal heat and water will be required. It would seem advisable that more attention be given to the temperature structure in the lake. Very precise temperature profiles at precise locations would be useful. (It is understandable that park managers are concerned about buoys on the lake. Perhaps the buoys would actually be an asset to public opinion if they serve to bring this study to public attention!)

Keep up the good work.

Sincerely,

Richard

Richard S. Petersen
Associate Professor of Biology

RP:mj

UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

26 April 83

Fisheries Research Institute, WH-10

Dear Doug:

I reviewed your report to the NPS and found it concise and more than adequate for its intended purpose. I have only two suggestions. (1) On page 14 you might talk in terms of layers within the water column ie., the layer extended or increased in thickness. (2) You might consider sampling some additional dissolved inorganic constituents several times a year (ie., Sept. during low runoff; early winter before winter phyto-blooms; spring before ice-out; and summer during and immediately after ice-out and during initial "phyto-bloom".) Inorganic constituents might include SO_4, Cl, and HCO_3, other select anions, major and minor cation (see enclosed St. Helens paper). Reason for SO_4 and Cl would be link to or to have background data if soil and atmosphere studies are conducted. For example, chang

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Fisheries Research Institute, WH–10

in these dissolved constituents might be used as follows:

SO_4 – might reflect Δ in atmospheric inputs;

Cl – as a conservative constituent may link to potential soil tracer studies.

Also, changes in above plus other constituents very useful in assessing changes in natural weathering processes (ie, carbonation & oxidation) and man's influences (erosion to atmospheric pollution) that may enhance weathering. You might also include some measures of CO_2.

Doug, I think your report will be of great use to the NPS. If you need more feedback, please let me know.

Cheers;
Bob.

260 Fisheries Center / Telephone: (206) 543-4650

APPENDIX VI

RÉSUMÉS: PEER REVIEW COMMITTEE

(ARRANGED ALPHABETICALLY)

RICHARD P. AXLER

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Born: November 9, 1948

EDUCATION

B.A., 1970. Physics. Temple University. Philadelphia, Pennsylvania.
Ph.D., 1979. Ecology. University of California, Davis, California.

EMPLOYMENT RECORD

Research Technician, Department of Physics, Temple University and Penn-Princeton Accelerator Facility, 1970-1974.

Fish-Checker, Institute of Ecology, Univ. of California, Davis (Castle Lake), 1975.

Research Assistant, Institute of Ecology, Univ. of California, Davis, 1976-1979. Castle Lake Limnology Program.

Teaching Assistant, Division of Environmental Studies, University of California, Davis, 1977. Introductory Limnology.

Teaching Fellow, Division of Environmental Studies, University of California, Davis, 1979. Instructor for Field and Laboratory Course in Limnology.

Post-Doctoral Research Limnologist, Institute of Ecology, University of California, Davis, 1980-present. Castle Lake Limnology Program.

Consulting Limnologist, Ecological Research Associates, 1978-present.

Co-Director, Lake Tahoe Interagency Monitoring Program, Institute of Ecology, U.C. Davis, April 1982-present.

PUBLISHED ARTICLES

Fote, A., R.P. Axler, H.K. Schurmann and T. Mihalisin. 1973. Thermo-electric power of chromium below the Neel temperature. Phys. Rev. B. 8:2099-2105.

Kimmel, B.L., R.P. Axler and C.R. Goldman. 1977. A closing replicate sample sediment trap. Limnol. Oceanogr. 22:789-793.

Kimmel, B.L., R.M. Gersberg, L.J. Paulson, R.P. Axler and C.R. Goldman. 1978. Recent changes in the meromictic status of Big Soda Lake, Nevada. Limnol. Oceanogr. 23:1021-1025.

Axler, R.P., R.M. Gersberg and L.J. Paulson. 1978. Primary productivity in Big Soda Lake, Nevada. Great Basin Nat. 38:187-192.

Gersberg, R.M., R.P. Axler, K. Krohn, N. Peek and C.R. Goldman. 1978. Nitrate uptake by phytoplankton: Measurements utilizng the radioisotope ^{13}N. Verh. Internat. Verein. Limnol. 20:388-392.

Axler, R.P. 1979. Inorganic nitrogen uptake by phytoplankton in Castle Lake, California. Ph.D. thesis, University of California, Davis. 150 p.

Gersberg, R.M., R.P. Axler and C.R. Goldman. 1980. Isotope tracer studies of nitrogen transformations in Castle Lake, California. Proc. FAO/IAEA Symposium, Vienna, Austria, August 1978.

Axler, R.P., R.M. Gersberg and C.R. Goldman. 1980. Stimulation of nitrate uptake and photosynthesis by molybdenum in Castle Lake, California. Can. J. Fish. Aquat. Sci. 37:707-712.

Axler, R.P., G.W. Redfield and C.R. Goldman. 1981. The importance of regenerated nitrogen to phytoplankton productivity in a subalpine lake. Ecology 62:345-354.

Axler, R.P. and C.R. Goldman. 1981. Isotope tracer methods for investigations of of nitrogen deficiency in Castle Lake, California. Water Research 15:627-632.

Axler, R.P. and R.M. Gersberg. 1981. Vertical patterns of inorganic carbon and nitrogen uptake in a subalpine lake. Verh. Internat. Verein. Limnol. 21:294-300.

Axler, R.P., R.M. Gersberg and C.R. Goldman. 1982. Inorganic nitrogen assimilation in a subalpine lake. Limnol. Oceanogr. 27:53-65.

Axler, R.P., C.R. Goldman, J.E. Reuter, S.L. Loeb, J.C. Priscu, and R.G. Carlton. In press. Comparative studies of the nitrogen metabolism of phytoplankton and periphyton in oligotrophic lakes. In: Proc. Combined FAO/IAGA Symp. on the Fate of Agrochemical Residues in Food and the Environment. Rome, Italy, June, 1982.

Goldman, C.R., R. Leonard, R. Axler, J.E. Reuter, and S. Loeb. 1982. Interagency Tahoe Monitoring Program: Second Annual Report, Water Year 1981. Tahoe Research Group, Institute of Ecology, Univ. Calif., Davis. 193 p.

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Education

B.S. Boise State College, Boise, ID Chemistry 1972
M.A. Oregon State University, Corvallis, OR Chemical Oceanography 1974
Ph.D. Oregon State University, Corvallis, OR Chemical Oceanography 1980

Professional Organizations

American Society of Limnology and Oceanography
Societas Internationalis Limnologiae
Ecological Society of America
American Society for Microbiology
American Goephysical Union
American Association for the Advancement of Science

Recent Publications

Dahm, C.N., J.A. Baross, A.K. Ward, M.D. Lilley and J.R. Sedell. 1983. Initial effects of the eruption of Mt. St. Helens on nitrogen cycle and related chemical processes in Ryan Lake. Applied and Environmental Microbiology (in press).

Ward, A.K., J.A. Baross, C.N. Dahm, M.D. Lilley and J.R. Sedell. 1983. Qualitative and quantitative observations on aquatic algal communities and recolonization within the blast zone of Mt. St. Helens: 1980 and 1981. Journal of Phycology (In press).

Dahm, C.N., J.A. Baross, M.D. Lilley, A.K. Ward and J.R. Sedell. 1982. Lakes in the blast zone of Mt. St. Helens: Chemical and microbial responses following the May 18, 1980 eruption. In: Conference on Mt. St. Helens: Effects on Water Resources. Portland, Oregon, October 7-8, 1981. pp. 98-137.

Baross, J.A., C.N. Dahm, A.K. Ward, M.D. Lilley and J.R. Sedell. 1982. Initial microbiological responses of lakes on Mt. St. Helens following the May 18, 1980 eruption. Nature 296:49-52.

Dahm, C.N., S.V. Gregory and P.K. Park. 1981. Organic carbon transport in the Columbia River. Estuarine, Coastal and Shelf Science 13:645-658.

Dahm, C.N. 1981. Pathways and mechanisms for removal of dissolved organic carbon from leachate in streams. Canad. J. Fish. Aquati. Sci. 38:68-76.

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EDUCATION

B.A., 1969, Zoology, University of California, Santa Barbara
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EMPLOYMENT RECORD

Staff Research Associate, Lake Tahoe Research Group, Institute of Ecology, University of California, Davis. 1973-1976.
Research Assistant, Institute of Ecology, University of California, Davis. 1976-1980
Postdoctoral Research Limnologist, Institute of Ecology, University of California, Davis, Lake Tahoe Research Program. 1980-1981.
Assistant Research Ecologist, Institute of Ecology, U.C. Davis. 1981-present.
Director, Littoral Zone Investigations, Lake Tahoe. Institute of Ecology, U.C. Davis. 1981-present.

PUBLISHED ARTICLES

Loeb, S.L. 1972. Fine structure of the adrenal gland of *Anas platyrhynchos* under normal and experimental conditions. M.A. thesis, Univ. of Ca., Santa Barbara.
Cronshaw, J., W.N. Holmes and S.L. Loeb. 1974. Fine structure of the adrenal gland in the duck (*Anas platyrhynchos*). Anat. Rec. 180:385-406.
Coats, R.W., R.L. Leonard and S.L. Loeb. 1975. Removal of nitrogen from snowmelt water by the soil-vegetation system, Lake Tahoe basin, California. Proc. West. Snow Conf., San Diego, Calif., April 22-25, 1975.
Loeb, S.L. and C.R.Goldman. 1979. Water and nutrient transport via ground water from Ward Valley into Lake Tahoe. Limnol. Oceanogr. 24:1146-1154.
Loeb, S.L. 1980. The production of the epilithic periphyton community in Lake Tahoe, California-Nevada. Ph.D. thesis, Univ. of Ca., Davis.
Loeb, S.L. 1981. An *in situ* method for measuring the primary productivity and standing crop of the epilithic periphyton community in lentic systems. Limnol. Oceanogr. 26:394-399.
Loeb, S.L. and J.E. Reuter. 1981. The epilithic periphyton community: A five-lake comparative study of community productivity, nitrogen metabolism and depth-distribution of standing crop. Verh. Internat. Verein. Limnol. 21:346-352.
Goldman, C.R., R.L. Leonard, A.P. Axler, J.E. Reuter and S.L. Loeb. 1982. Inter-agency Tahoe Monitoring Program: 2nd Annual Report, Water Year 1981. Tahoe Research Group, Institute of Ecology, Univ. of Ca., Davis. 193 p.
Loeb, S.L. 1983. Near-shore (littoral zone) Monitoring Program, July 1981 - July 1982. Institute of Ecology, Univ. of Ca., Davis. 193 p.
Loeb, S.L., J.E. Reuter and C.R. Goldman. In Press. Littoral zone production: The contributions of phytoplankton and periphyton. *In*: R.G. Wetzel (ed.), Periphyton in Freshwater Ecosystems.
Reuter, J.E., S.L. Loeb and C.R. Goldman. In Press. Nitrogen fixation in oligotrophic Lake Tahoe. *In*: R.G. Wetzel (ed.), Periphyton in Freshwater Ecosystems

HONORS, AWARDS AND MEMBERSHIPS

NDEA Title IV Fellowship (1970)
Jastro-Shields graduate research award, College of Agricultural and Environmental Sciences, University of California, Davis (1977)
Member--American Association for the Advancement of Science
Member--American Society of Limnology and Oceanography
Member--Sigma Xi
Member--International Association of Theoretical and Applied Limnology
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RICHARD R. PETERSEN

Professional Experience

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1965-1966	Research Biologist, Rayonier, Inc. Shelton, Washington

Education

1970 Duke University, Ph.D.

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American Association for the Advancement of Science

Sigma Xi

Community Service

City of Portland (Bureau of Water Works) Watershed Advisory Committee 1978-1981

President, Portland State Chapter, Sigma Xi 1981-82

Publications

Petersen, R.R., 1975. Am. Naturalist, 109:35-99. "The paradox of the plankton: An equilibrium hypothesis"

_____, 1975. Verh. Internat. Verein Limnol., 19:2274-2283. "A paleolimnological study of the eutrophication of Lake Erie"

Rickert, D.A., R.R. Petersen, S.W. McKenzie, W.A. Hines, and S.A. Wille, 1978. Geol. Survey Circ. 315-G 24pp. "Algal conditions and the potential for future algal problems in the Willamette River, Oregon"

Petersen, R.R., 1978. In River Quality Assessments, Am. Wat. Res. Assoc. "Algal growth potential--lower Willamette River, Oregon"

_____, 1982. Env. Sci. Technol., 16:443-447. "Influence of copper and zinc on the growth of a freshwater alga, Scenedesmus quadricauda: The significance of chemical speciation"

Jayaweera, R., R.R. Petersen, P. Smejtek, 1982. Pesticide Biochem. and Physiol., 18:197-204. "Induced hydrogen ion transport in lipid membranes as origin of toxin effect of pentachlorophenol in an alga"

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Published Articles:

Reuter,J.E.,1977. Seasonal distribution of phytoplankton biomass in a near-shore area of the Central Basin of Lake Erie in the vicinity of Ashtabula, Ohio. M.A. Thesis, State University College of New York, Buffalo. 73p.

Reuter,J.E., 1979. Seasonal distribution of phytoplankton biomass in a near-shore area of the Central Basin of Lake Erie, 1975-1976. Ohio J. Sci. 79(5):218-226.

Loeb,S.L. and J.E. Reuter. 1981. The epilithic periphyton community: A five-lake comparative study of community productivity, nitrogen metabolism and depth-distribution of standing crop. Verh. Internat. Verein. Limnol.21:346-352.

Goldman,C.R., R.L.Leonard, R.P.Axler, J.E. Reuter, and S.L. Loeb. 1982. Inter-agency Tahoe Monitoring Program: Second Annual Report, Water Year 1982. Tahoe Research Group, Institute of Ecology, Univ. of California, Davis. 193p.

Priscu,J.C.,R.P. Axler, R.G. Carlton, J.E. Reuter, P.A. Arneson, and C.R. Goldman. 1982. Vertical profiles of primary production, biomass and physico-chemical properties in meromictic Big Soda Lake Nevada, USA. Hydrobiology 96:113-120.

Reuter, J.E. 1983. Inorganic nitrogen metabolism in the periphyton communities of N-deficient, oligotrophic lakes. Ph.D. Thesis, Univer. Calif., Davis.

Reuter,J.E., S.L. Loeb, and C.R. Goldman. In Press. Nitrogen fixation in oligotrophic Lake Tahoe. In: R.G. Wetzel (ed.), Periphyton in Freshwater Ecosystems.

Loeb,S.L., J.E.Reuter, and C.R.Goldman. In Press. Littoral zone productivity: The contributions of phytoplankton and periphyton. In: R.G. Wetzel (ed.), Periphyton in Freshwater Ecosystems.

Axler,R.P.,C.R.Goldman,J.E.Reuter,S.L.Loeb,J.C.Priscu, and R.G.Carlton. In Press. Comparative studies of the nitrogen metabolism of phytoplankton and periphyton in oligotrophic lakes. In: Proc. Combined FOA/IAGA Symp. on the Fate of Agrochemical Residues in Food and the Environment. Rome, Italy, June 1982.

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Professional Memberships

American Society of Limnology and Oceanography
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International Association for Theoretical and Applied Limnology

Selected Publications

Wissmar, R.C., J.E. Richey, and D.E. Spyridakis. 1977. The importance of allochthonous particulate carbon pathways in a subalpine lake. J. Fish. Res. Board Can. 34:1410-1418.

Wissmar, R.C., and R.G. Wetzel. 1978. Analysis of five North American lake ecosystems. VI. Consumer community structure and production. Verh. Int. Ver. Limnol. 20:587-597.

Eggers, D.M., N.W. Bartoo, N.A. Rickard, R.E. Nelson, R.C. Wissmar, and R.L. Burgner. 1978. The Lake Washington ecosystem: The perspective from fish community production and forage base. J. Fish. Res. Board Can. 35(12):1553-1571.

Richey, J.E., R.C. Wissmar, A.H. Devol, G.E. Likens, R.G. Wetzel, O.L. Loucks, W.E. Odum, P.H. Rich, N.M. Johnson, J.S. Eaton, and R.T. Prentki. 1978. Carbon flow in four lake ecosystems: A structural approach. Science 202:1183-1186.

Wissmar, R.C. 1979. Freshwater fisheries inventory of Chile: Workplan and methods. Instituto Nacional de Investigacion de Recursos Naturales (IREN-CORFO). Republica de Chile, Santiago. 41 pp.

Wissmar, R.C. 1979. Marine Fisheries Information Center: Workplan and methods. Instituto Nacional de Investigacion de Recursos Naturales (IREN-CORFO). Republica de Chile, Santiago. 20 pp.

Richey, J.E., and R.C. Wissmar. 1979. Sources and influences of allochthonous inputs on the productivity of a subalpine lake. Ecology 60:318-328.