LAS VEGAS BAY STUDY

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Report to the Enforcement Division
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LAS VEGAS BAY - FIELD STUDY

Introduction

A one-day survey of Las Vegas Bay and of the inflow into the Bay (called the Las Vegas Wash) was made on August 30, 1973.

The purpose of the survey was as follows:

1. To determine if algal bloom problems presently exist in Las Vegas Bay and to quantify the extent of the bloom.
2. To gather nutrient data that would show whether or not nutrients are in excess for algal growth.
3. To collect data needed for establishing water quality standards.

Rationale for Sampling Site and Parameter Selections

Five sampling sites were chosen in Lake Mead which would show the magnitude of any algal blooms relative to the Las Vegas Wash inflow. Thus, the first station was in Las Vegas Bay about one mile from the Wash, and the last near Saddle Island outside of Las Vegas Bay proper. Samples were also taken in the Wash near a highway crossing.

The sampling parameters in the Wash flow were those which would be measures of its sewage and industrial effluents. Those in Lake Mead were nutrients important to algal growth, physical and chemical measurements affecting or related to algal concentration, and biological measurements indicative of algal mass.

Field and Laboratory Procedures

The sampling in Las Vegas Bay was done on August 30, 1973 from a boat furnished by the U.S. National Park Service. An aerial photograph was taken by EPA NERC personnel during the same time period the boat sampling was being carried out. In addition, photographs of the water were taken from the boat at each station.

The first measurements of the water made at each station in Las Vegas Bay were temperature and Secchi disc depth. Then three samples were taken from each sampling depth, composited, and mixed well. Separate portions were filtered for chlorophyll extraction, preserved with 4% formalin for algal count, preserved with $HgCl_2$ for N and P analyses and put into an ice chest for subsequent bioassay. The filtering for chlorophyll extraction was done on the boat at each station, with the filters stored in dessicant jars which were then put into dry ice. The extraction of the filters was carried out at the Alameda, California EPA Laboratory, with optical density readings taken with a Beckman DU and the formulas of Strickland and Parsons (1970) utilized for the calculation of chlorophyll *a* concentrations. *In vivo* readings were taken with a Turner Model III Fluorometer. Bioassay procedures are described in Region IX, Biology Laboratory Methods (1974). The samples were incubated under constant light (400 foot-candles) and temperature conditions (20°C) and algal concentration determined when growth had reached a plateau. The samples were assayed with and without nutrient additions. The nutrients were added

in separate series of 1.0 mg NO_3-N/l and 0.2 mg PO_4-P/l. These concentrations would make these limiting nutrients in excess of needs for algal growth.

Samples and field measurements in the Las Vegas Wash were taken twice: on the evening of 8/29/73 and on the morning of 8/30/73. Oxygen and temperature were measured with an IBC oxygen meter. All other parameters were determined after the samples had been brought to the Alameda Laboratory. These were done following EPA procedures (1971). Personnel at the marinas and the rangers who patrol the lake were questioned regarding that summer's algal bloom.

Results

Significant features of the data in Table 1 are the higher surface water temperatures in the protected part of Las Vegas Bay near Las Vegas Wash (29°C), compared to those at the other stations (25-27°C), nearly equal and low concentrations of ortho-phosphate at all stations (<0.01-0.02 mg P/l), contrasting with declining values for total phosphorus from the inflow with declining values for total phosphorus from the inflow station (0.06 mg P/l) to that furthest from the Wash (0.02 mg P/l). Total Kjeldahl nitrogen values were between 0.29-0.60 mg N/l for all stations with considerable variations in the values from the samples taken at the two depths. Nitrate values were highest at the Saddle Island Station (0.05 and 0.06 mg N/l).

The results of the chemical, physical and biological determinations are shown in Tables 1, 2, 3 and 4.

Table 1 gives the analyses for the five (5) lake stations; Table 2 lists the water quality measurements made on the lake inflow; Table 3 shows algal species and counts at the lake station; and Table 4 gives the bioassay responses.

The sampling locations are shown and identified in Figure 1. A large aerial photograph taken by the Las Vegas EPA Western Environmental Research Laboratory has the stations numbered corresponding to those shown in Figure 1. This is shown reduced in Figure 2. (This photograph is not an integral part of each copy of the report. It will accompany the copy of the report sent to Region IX's Enforcement Division). An example of the photographs taken from the boat of the water at each station is attached in Figure 3.

The inflow into Las Vegas Bay (Las Vegas Wash) had expected high values of orthophosphate (≈3.5 mg P/l) and nitrate (≈8.7 mg N/l) (Table 2). There was very little of either nitrogen or phosphorus in an organic form. The water was well-oxygenated. It was visually turbid, with samples having the indicated Jackson Turbidity Units (25 and 27).

The algal counts were between approximately 3000-8000 cells/ml and roughly approximated the chlorophyll concentration (Table 3). The algal species were mostly blue-greens or diatoms. Dominant species were Oscillatoria, Cyclotella, and Stephanodiscus. There was a noticeable increase in the presence of Navicula in stations furthest from the Wash.

The bioassay responses given in Table 4 are the initial sample chlorophyll a concentrations and the terminal chlorophyll a concentrations of samples without added nutrients and those with 0.10 mg NO_3-N/l and 0.2 mg PO_4-P/l additions. The stations closest to the Wash (No. 1 and 2) clearly showed responses to the additions of NO_3-N. There were no differences in the other samples at the 95% confidence level between the unspiked ones and those with either NO_3-N or PO_4-P additions.

The photographs of the water taken from the boat gave a quasi-uniform view of the algal population so that the photographs at the five stations appear similar. The aerial photograph shows changes in water color which are entirely missed by the ground photographs. In addition, the high in vivo fluorescence near the Black Island station (No. 4) probably results from material seen in the aerial photograph to be in drifts at that station.

The persons questioned about the algal bloom differed in their responses. Those near the Boulder Marina (near Saddle Island) said they experienced no algal problems whereas those at the Las Vegas Marina said the algal blooms were the worst they had ever experienced.

Discussion

The algal population was easy to quantify by chlorophyll extraction, however, the algal species composition should not be overlooked. Thus, blue-greens were very much in evidence

at most of the stations, diminishing in concentration near Saddle Island. In 1967, algal counts were less than 2000/ml at Saddle Island and in the unpolluted parts of Lake Mead (Anon, 1967). Counts made in 1970 of water from the Boulder Canyon area of Lake Mead were approximately the same (Anon, 1970). Counts made during this survey yielded higher cell concentrations of about 3000 cells/ml. According to the 1967 FWPCA report, Saddle Island was free of Wash influence, but judging from the algal counts, does not appear to be so now. However, the proportion or concentration of blue-greens was not given in the previous studies. They were very much in evidence at all stations during this survey and it would have been useful to have them counted in previous surveys.

Las Vegas Bay nutrient concentrations were not easy to relate to the algal concentrations. It would be expected that algae biomass would have a relation to organic phosphorus and organic nitrogen concentrations. The organic fraction of total phosphorus was greatest near the Wash and decreased in magnitude at the stations farthest from its influence. Although most phosphorus in the Wash was in an oxidized form, the concentration of organic phosphorus in the stream was still five-fold higher than in the station closest to the Wash inflow, 0.2 mg P/l and 0.04 mg P/l respectively. In contrast, total Kjeldahl nitrogen values were approximately equal in the Wash and in Las Vegas Bay.

Inorganic nutrients most readily used by the algae, NO_3-N and PO_4-P, were in approximately a 1:1 ratio at the two stations closest to the Wash. At the other stations N and P were at a 4-6:1 ratio. This would not include NH_3-N which was not measured. Based on algal content of N and P (Mackenthun and Ingram, 1967), nitrogen should be limiting at least at Stations 1 and 2. This is verified by the bioassays in which excess nitrate additions gave positive growth over that of the controls at those stations only. These results should not be construed to imply that nitrogen is limiting in all parts of Lake Mead, but only in the area of Lake Mead nearest the Wash where there is an excess of inflow phosphorus with an N to P ratio of 3 to 1. Previous extensive data shows N and P in most of Lake Mead to be in a 20-100 to 1 ratio with phosphorus definitely limiting (Anon, 1970).

In Las Vegas Wash, NO_3-N and PO_4-P were at concentrations 200 times those found in Las Vegas Bay. Undoubtedly this nutrient input would contribute to or be almost entirely responsible for the algal blooms found in the Bay. Furthermore, these nutrients will eventually lead to an extension of the problem to other parts of Lake Mead and to reservoirs on the Colorado River below Lake Mead.

There was unexpected high *in vivo* fluorescence in samples from Station 4 near Black Island. The *in vivo* fluorescence is usually proportioned to the chlorophyll *a* concentration, since filters are selected to detect chlorophyll *a* fluorescence. However, other materials both dissolved and particulate can

fluoresce within the chlorophyll a limits (Tunzi, 1974). Fluorescence at Station 4 was clarified by the aerial photograph which showed material in drifts at that station. This material could be bottom silt or perhaps Wash inflow coming to the surface. Wash inflow has been shown to flow in a definite density layer, either along the bottom of Las Vegas Bay or above the thermocline (Deacon and Tew, 1973).

Conclusion

1. Algal populations were highest near the marina and diminished in magnitude (as measured by chlorophyll concentration) in samples taken at stations furthest from the Wash. The algal populations on the sampling date could be termed undesireable at the Marina and acceptable at Saddle Island.
2. PO_4-P was found close to its lower limits of detectibility; however, concentrations appeared to be ample for further algal growth.
3. NO_3-N concentration was low when evaluated both in relation to concentrations needed for algal growth and to its rato to PO_4-P judged by algal uptake of N to P in a 10:1 ratio.
4. The presence of chlorophyll in the phaeophytin form does indicate that a larger algal population had been present previous to the sampling.
5. Complaints about algae were related to distance from the Wash, with persons at the Las Vegas Marina experiencing the worst blooms.

6. In vivo fluorescence would not always be a valid approach in measuring algal chlorophyll as other non-chlorophyllous substances in the water can contribute to the fluorescence.
7. Interpretation of some of the field data was only possible because an aerial photograph had been taken.

Recommendations

1. Algal populations should continue to be monitored in Lake Mead. Chlorophyll a determination are the simplest approach.
2. The monitoring should be more frequent, once every 2-3 weeks between March and August appears to be the best.
3. Monitoring should continue even if discharge from the Wash has lower nutrient because of better treatment. Verification of the role of Wash input upon algal population would be extemely important.
4. The EPA Laboratory at Las Vegas, U.S.B.R., or University of Nevada could be contacted to do the sampling.
5. It appears futile to continue measurements other than chlorophyll a. Inflow source and nutrient concentration are well-established. Those in the lake would be in a state of flux depending on algal uptake, mineralization rates, and hydrolic dispersion.

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TABLE 1. Chemical, biological, and physical measurements from the Las Vegas Bay section of Lake Mead (8/30/73).

Parameter	Las Vegas Bay Near Mouth of Wash		Near Las Vegas Marina		Near Sand Island		Near Black Island		Near Saddle Island	
	1 m	2 m	1 m	2 m	1 m	2.5 m	1 m	3 m	1 m	3 m
Temperature (°C)	29.0	27.0	26.0	26.0	26.0	26.0	27.0	26.5	25.0	24.0
mg/l										
Total P	.06	.05	.05	.05	.03	.03	.02	.02	.02	.02
Ortho-P	.02	.01	.02	.02	<.01	.01	.01	.01	.01	.01
Tot. Kjeld. N	.49	.36	.45	.40	.38	.37	.50	.29	.52	.60
NO_3 - N	.02	.04	.02	.01	.04	.04	.03	.04	.05	.06
Algal Cells/ml	7940	7450	4120	7250	5240	4510	4210	5240	3330	2990
Secchi Disc Depth[1]	1.98 m		1.98 m		3.05 m		3.66 m		3.66 m	
Total chl a/l[2]	9.75		15.4		8.49		5.76		3.89	
phaeophytin-free chl a/l	7.40		12.5		7.48		4.72		3.47	
Fluorescence (10 x scale)	19.0		20.0		11.0		19.0		8.5	

1. Measured in feet and converted to meters.
2. Composite value of three equal-volumed samples from each depth.

TABLE 2
Chemical and Physical Measurements of Las Vegas Wash taken near the North Shore Road Bridge

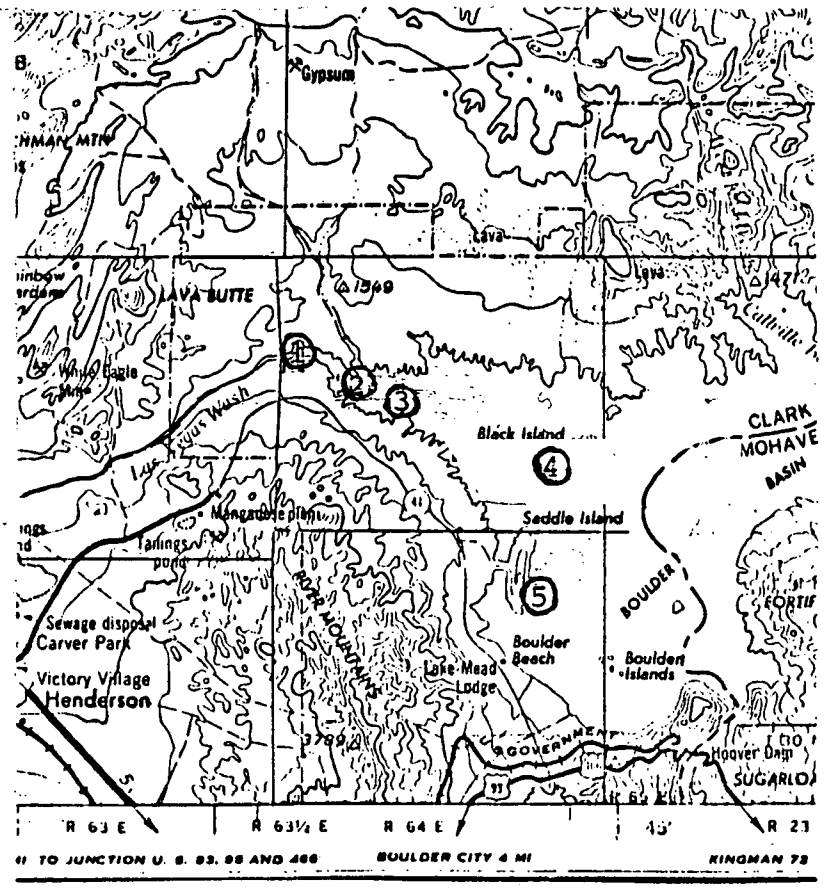
Date and Time	JTU	°C	O^2	pH	Spec. Cond. µmhos/cm	TDS	Tot. P.	Ortho-P	Tot. Kjeld. N	NO_3-N
8/29/73 7:15 pm	25	23.0	9.0	8.0	5,000	3,960	3.4	3.2	.50	8.9
8/30/73 6:45 am	27	17.5	9.7	8.0	4,800	3,830	3.6	3.4	.53	8.4

TABLE 3. Plankton species and counts (no/ml) in samples taken from Las Vegas Bay (8/30/73)

	Saddle Island		Black Island		Sand Island		Near Las Vegas Marina		Mouth of Las Vegas Wash	
	1 meter	3 meters	1 meter	3 meters	1 meter	2-1/2 meters	1 meter	2 meters	1 meter	2 meters
GREEN ALGAE										
Acanthosphaera					49	49			49	
Carteria								98		
Chlamydomonas					49		49		49	
Chlorella									392	
Chodatella								49		
Scenedesmus	49									49
Tetradesmus				49	147	49			98	98
BLUE GREEN ALGAE										
Anabaenopsis								49	98	
Anacystis type	49			196	49	196	980	833	1,568	980
Calothrix							49			
Oscillatoria	637	588	1,470	2,009	1,568	1,372	1,225	1,225	1,078	784
Phormidium	196		245	294	294	98	294	784	490	294
Spirulina		98			294	294	392	686	784	392
DIATOMS										
Centric										
Cyclotella & Stephanodiscus	931	1,029	1,225	1,274	1,519	1,176	4,067	4,165	2,940	4,606
Pennate										
Fragillaria					49	49	49	98	98	
Navicula	1,470	1,274	1,176	1,372	392	686	49	147	147	49
Nitzschia				49	98	147	98	49	49	49
Synedra			98						49	98
DINOFLAGELLATES										
Glenodinium								98		49
Peridinium								147		
EUGLENOIDS										
Trachelomonas									49	
TOTAL/ml	3,332	2,989	4,214	5,243	4,508	4,116	7,252	8,428	7,938	7,448

Table 4
Bioassay responses of Lake Mead samples
with and without nutrient additions

Sampling Sites	Initial	µg chl a/l		
		Terminal		
		Unspiked	1 mg NO_3-N/l	0.2 mg PO_4-P
Las Vegas Bay Near Wash (1)	9.8	13.5	99.4	13.8
Near Las Vegas Marina (2)	15.4	29.3	73.4	27.3
Near Sand Island (3)	8.5	13.0	16.7	14.9
Near Black Island (4)	5.8	5.4	5.8	7.8
Near Saddle Island (5)	3.9	2.4	2.8	3.2



1. Las Vegas Bay near mouth of Wash
2. Near Las Vegas Marina
3. Near Sand Island
4. Near Black Island
5. Near Saddle Island

Figure 1. Sampling stations in the Las Vegas survey of August 30, 1973.