

A LIMNOLOGICAL SURVEY OF BASS LAKE, POINT REYES NATIONAL SEASHORE, 1976¹

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A description of the physical limnological parameters of this small lake serves as a reference for comparative studies of nearby natural lakes and reservoirs and of bodies of freshwater generally residing in regions of equable oceanic climate. The data also serves as a basis for studies of the lake's biology and for future assessment of park use impact. The area has been and continues to be protected from major deteriorative processes.

Previous work consists of a preliminary survey by Strohschein (1972) in which the presence of moderately sized trout in Bass Lake is documented; and a study on landslides by Clague (1969), which proposes a tectonic theory of the formation, during the past 10,000 years, of the small lake district which includes Bass Lake. The lake lies in a small graben a few kilometers west of the San Andreas fault at an elevation of 117 meters above sea level and at 38 degrees north latitude. It is fed, at least in part, by two rivulets; and it drains into the Pacific Ocean about one kilometer to the west.

The shores of the lake are very steep, and deep water occupies a large part of the total lake area. Riparian trees and macrophytes crowd the shores leaving almost no beach. The small areas of shallow water support a dense submerged macrophytic vegetation rooted in heterogeneously sized gravelly sand. The bottom is covered with a thick, soft layer of black mud containing entrapped gas and emitting the odor of hydrogen sulfide. The lake volume is about 4×10^5 cubic meters. The maximum depth is 17.5 meters. The surface

¹This work was financed partly by a grant from the University of the Pacific, Stockton, California 95211

is about 3 hectares, and the total catchment, about 66 hectares. The large ratio of catchment to lake surface suggests that the ecology of the lake might be quite sensitive to disturbance of the watershed vegetation, which consists largely of chaparral with some small groves of Douglas fir, alders and willows in the moister areas. Water inflow remained quite constant throughout the unusually dry year. No change in lake level was noted.

The water is generally of high transparency with a slate-gray color when viewed from a distance. Secchi disk depths were usually close to ten meters.

Although Bass Lake is very close to the ocean, night frost was observed in the canyons and hollows during winter. Mid-day temperatures ranged from 11 degrees in winter to 22 degrees centigrade in summer.

Bass Lake is of the warm, monomictic type. Temperature-depth profiles (Figure 1) show homothermy in early winter at slightly below 10 degrees. Thermal stratification begins in February, and a well-developed thermocline is evident in April. In late summer the epilimnion approached 22 degrees. By the beginning of October cooling had set in, and the water was homothermal to almost 10 meters.

A quantity of approximately 8,000 calories per square centimeter of surface was gained by the lake over the warming period of January through August. These months represent times of minimum and maximum heat content, respectively. This value is very low and testifies to the moderate character of the thermal environment.

Dissolved chemical substances were determined using the Hach Direct-Reading Engineers Laboratory DR-EL/2. Electrical conductance (Table 1)

indicates a slightly saline water. The salinity can be accounted for to a large extent in terms of sulfates and bicarbonates of calcium and magnesium.

Iron, manganese, hydrogen sulfide, and ammonium ion occurred in the bottom water in appreciable quantities under conditions of relatively low pH and anoxia.

Dissolved oxygen curves (Figure 2) show that this substance was well mixed into the deeper water during homothermy. As the lake became stratified, oxygen was depleted and carbon dioxide increased in the hypolimnion. With the higher concentrations of carbon dioxide lower pH values were observed (Figure 3).

The pH between 3 and 5 meters depth on February 21 reached 8.5, an exceptionally high figure. The Secchi disk reading was 3.3 meters, the shallowest for the study period. Carbon dioxide was also low in this water on that date. These observations indicate the existence of a plankton bloom.

Nitrate nitrogen was present in considerable quantities, 0.32 milligrams per liter at depths 5, 10 and 15 meters in February. By August it had fallen to 0.01 milligrams per liter at 2.5 meters and 0.13 milligrams per liter at 12.5 meters depth. The sparse data suggest that nitrate was removed slowly from the hypolimnion as autumn approached. By November nitrate nitrogen had fallen to negligible amounts in the water column.

Phosphate (Figure 4) and silica (Figure 5) data support those of dissolved oxygen and pH in demonstrating lake turnover during winter. They also show the progressive enrichment of these nutrients in the deep water at the end of summer.

Small clear inflows occur at the north and east sides of Bass Lake. The north inflow contains much more dissolved calcium and magnesium bicarbonates and sulfates, but its composition more closely resembles that of the lake water than the east inflow. The latter is strikingly lower in bicarbonate and considerably higher in silicate (Table 2). Phosphate and nitrate enter the lake through the inflowing water.

Vertical 15 meter hauls with a No. 12 mesh net were made for the collection of the abundant zooplankton. Chaoborus spp., Daphnia pulux and Diaptomus tyrelli are the most obvious representatives of the limnetic zooplankton. Fluctuations in their populations are not great.

The phytoplankton includes species belonging to the following genera: Anabaena, Crysomonas, Cymbella, Fragilaria, Oocystis, Schroederia, Sphaerocystis, and Staurostrum, plus Ceretium hirundinella, Elakatothrix gelatinosa, and Pseudokephrion conicum.

No small planktivorous fish were observed although some catfish were seen on the shallower bottom. As a hypothesis, one might speculate that most of the energy and nutrients which enter the lake support plankton populations which sediment through a highly stable thermocline over the greater part of the year, thereby building up a thick layer of organic mud.

In summary, Bass Lake is a clear, slightly saline, slightly alkaline, warm monomictic lake of markedly equable thermal properties and showing eutrophic characteristics in terms of water chemistry.

Table 1 Summary of Chemical Characteristics in mg per liter

Conductivity ($\mu\text{mhos/cm}$)	570
Alkalinity (as CaCO_3)	115
Hardness (total as CaCO_3)	200
Hardness, Calcium (as CaCO_3)	85
Chloride	30
Sulfate	140
Fluoride	0.5

Nitrite and copper concentrations were negligible

Table 2 BASS LAKE INFLUENTS
Chemical Characteristics, 12 June 1976
in mg per liter

	North Inflow	East Inflow
Conductivity (μ mhos/cm)	925	585
Alkalinity (as CaCO_3)	336	50
Hardness (total as CaCO_3)	356	200
pH	8.2	7.4
Chloride	30	35
Sulfate	172	186
Silica	17	25
ortho-Phosphate	0.27	0.12
Nitrate-N*	0.12	--

* 2 October 1976

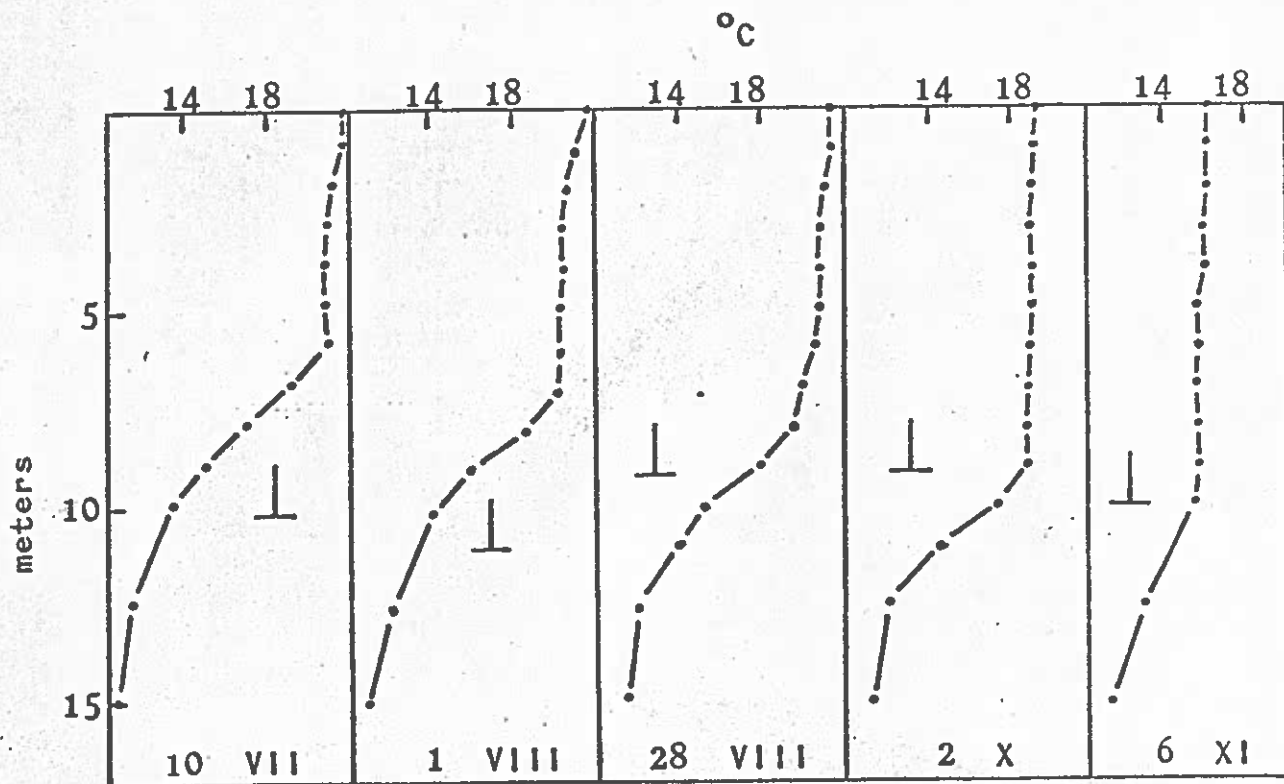
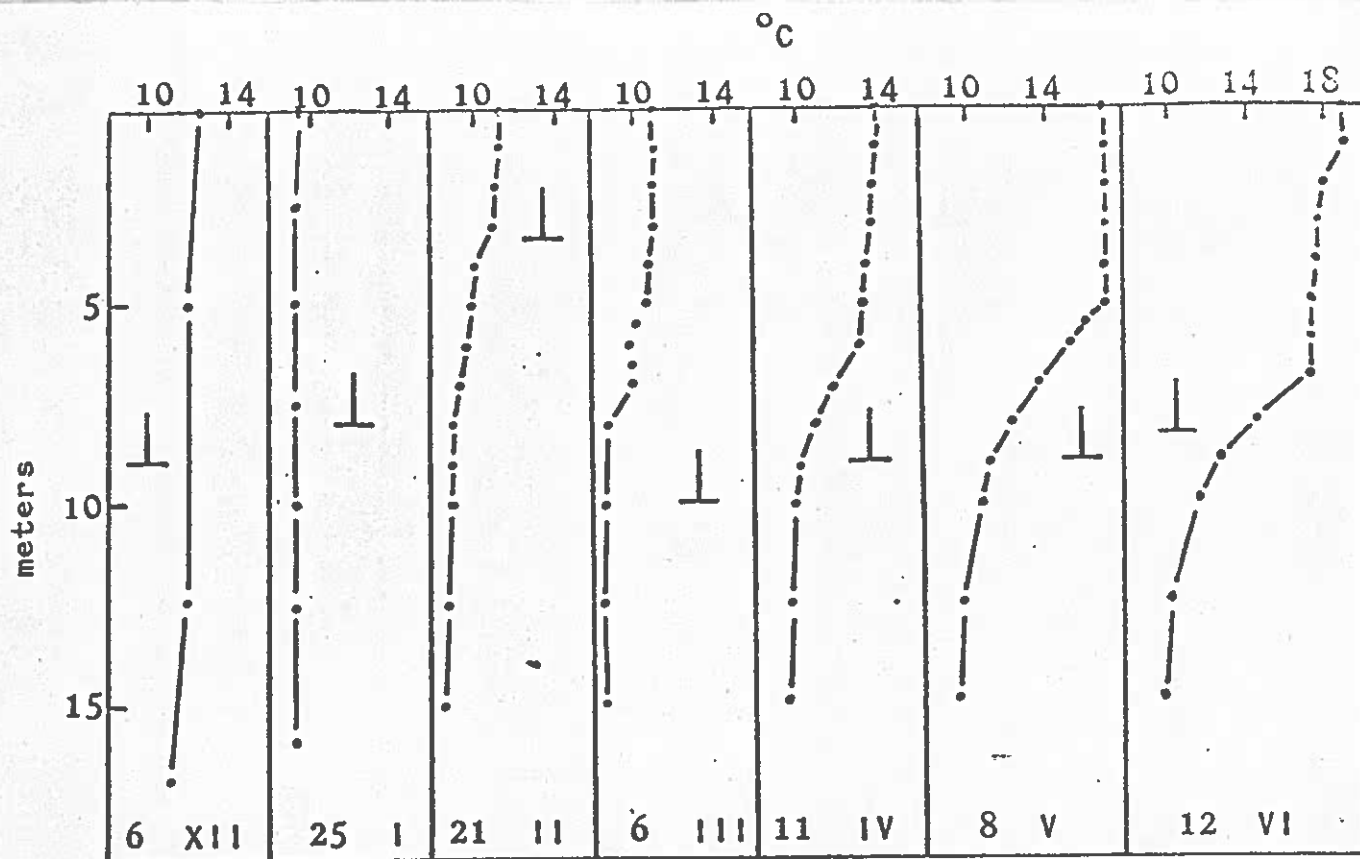


Figure 1. Temperature - Depth Profiles in degrees Celsius.
Inverted T marks Secchi disk depth.

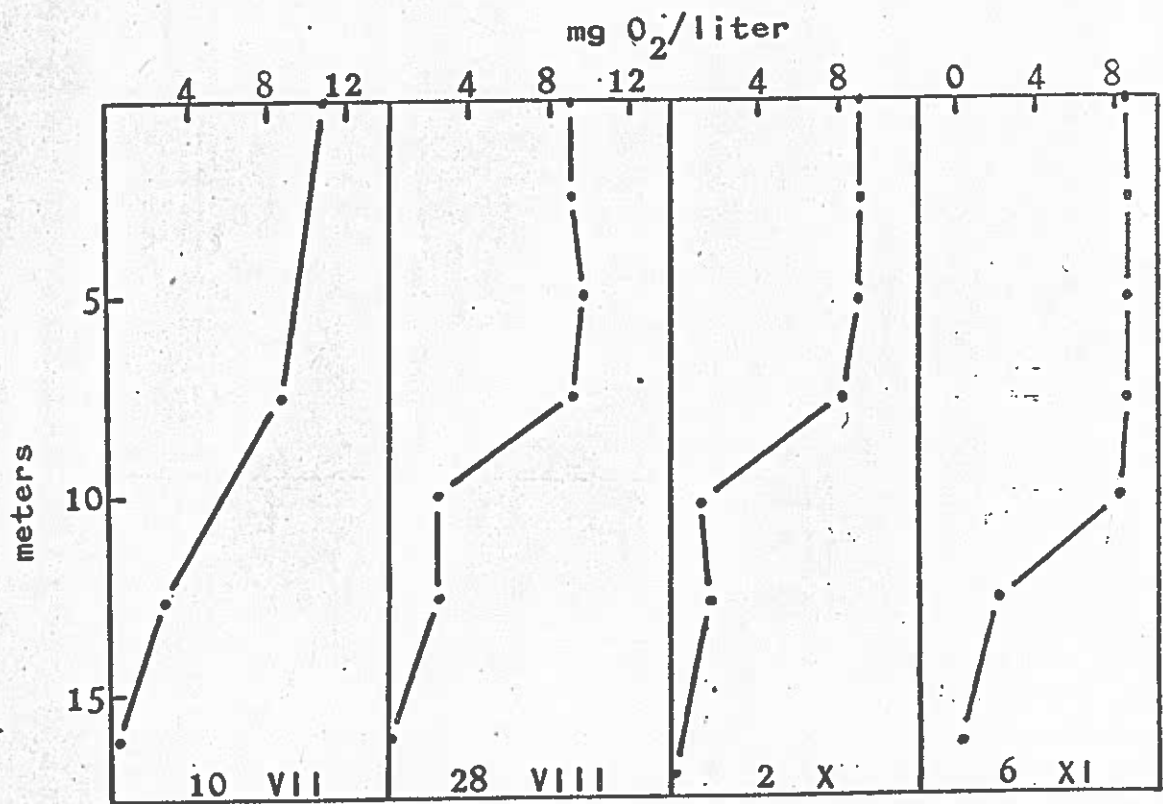
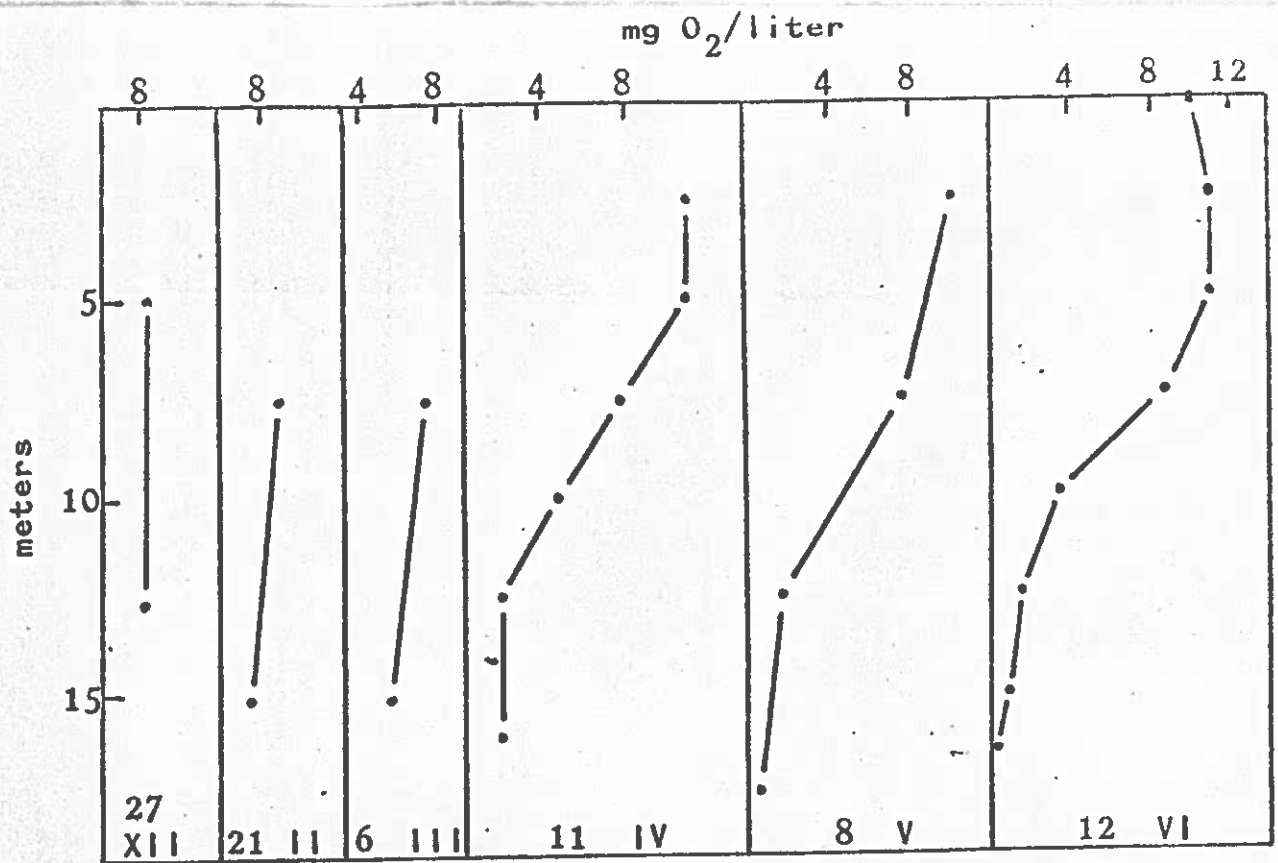


Figure 2. Dissolved Oxygen - Depth Profiles (mg/l)

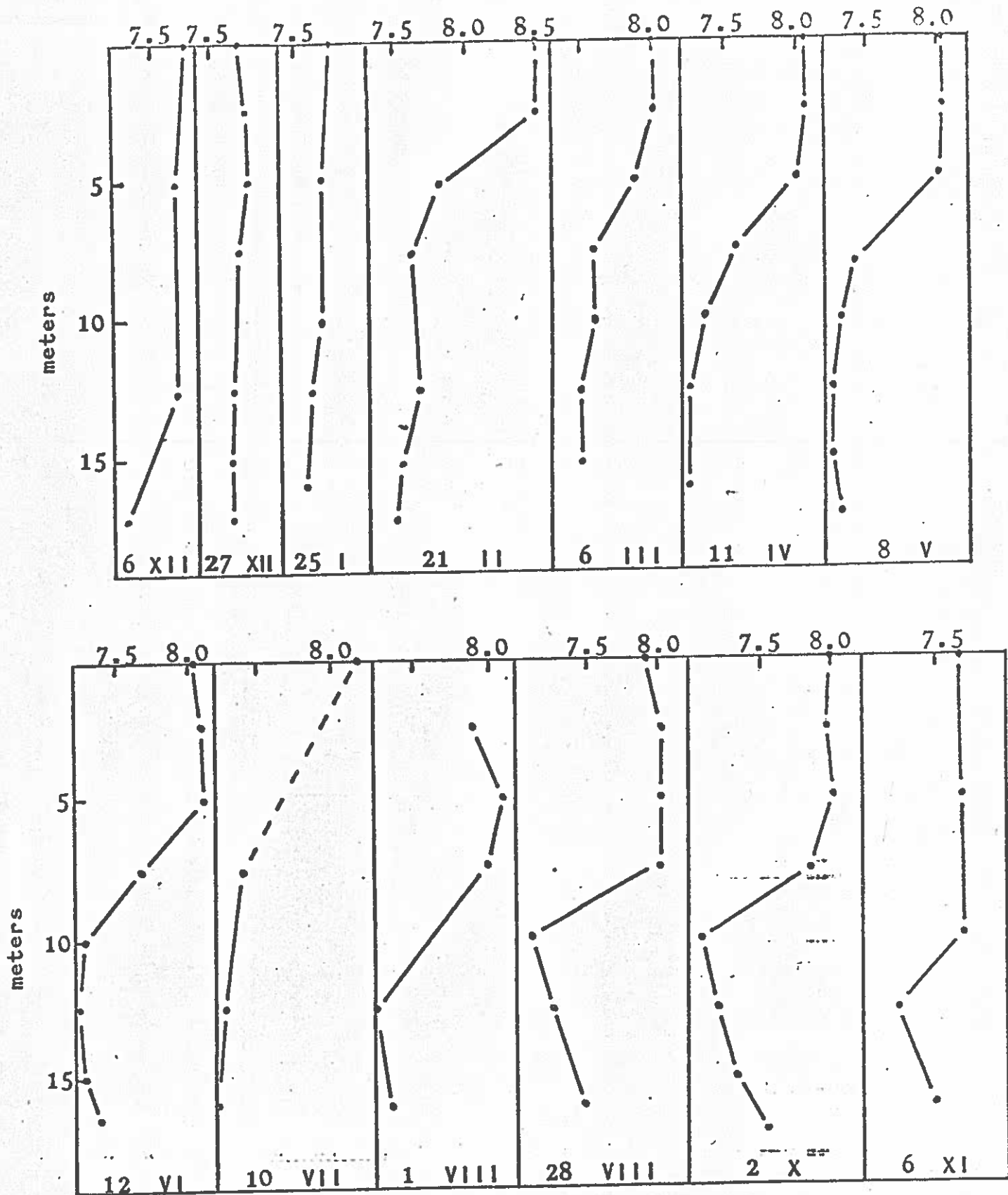


Figure 3. pH - Depth Profiles.

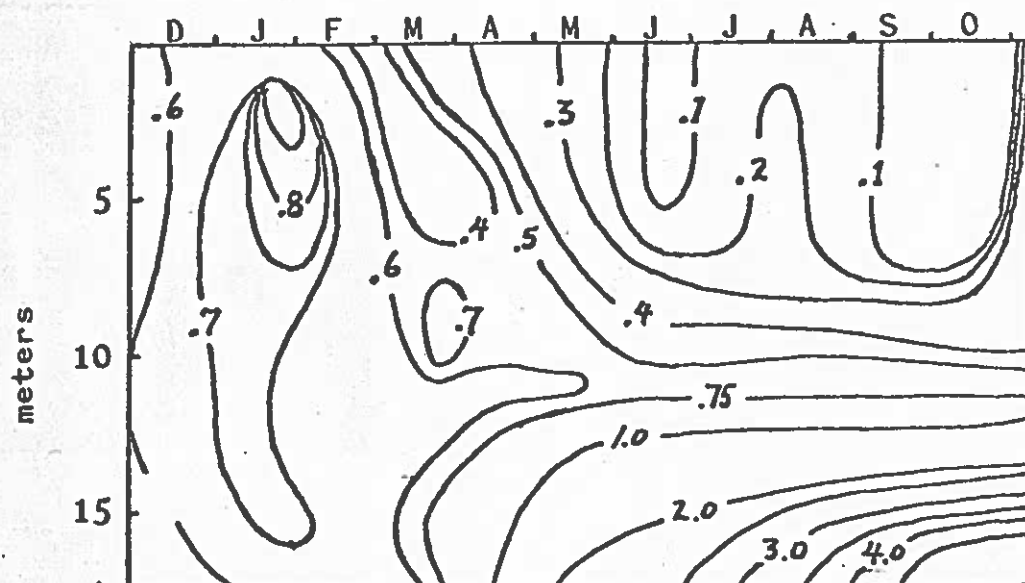


Figure 4. Ortho-phosphate Isopleths.
Concentration (mg/l) : Depth : Month

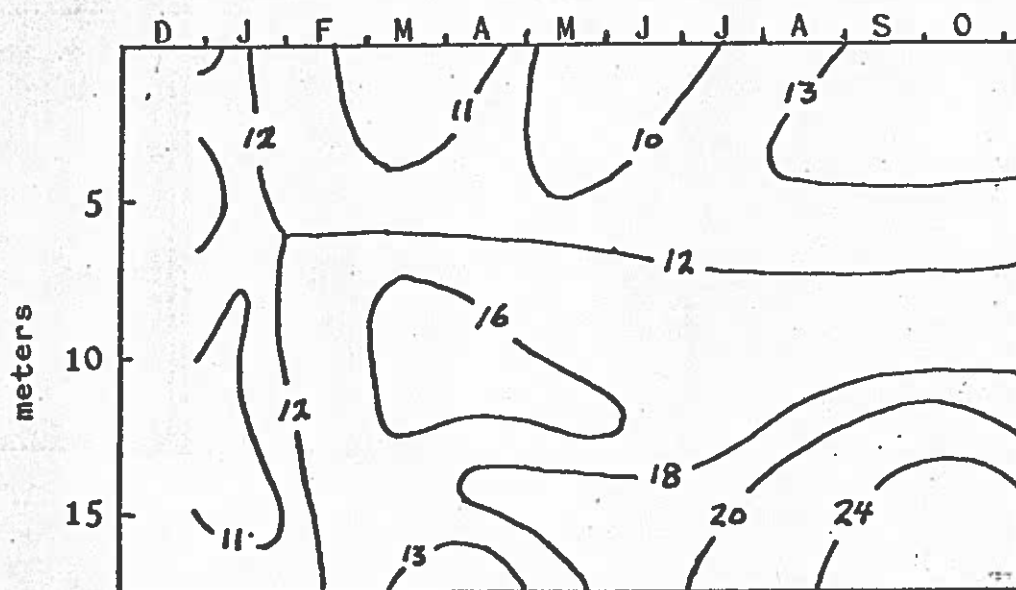


Figure 5. Silica Isopleths.
Concentration (mg/l) : Depth : Month