USC Sea grant program

MARINA DEL REY:
A STUDY OF ENVIRONMENTAL VARIABLES IN A SEMI-ENCLOSED COASTAL WATER

Frank R. Bowerman and Kenneth Y. Chen
Environmental Engineering Program
University of Southern California
Los Angeles, California 90007

December 1971
Sea Grant Publication No. USC-SG-4-71

UNIVERSITY OF SOUTHERN CALIFORNIA • SEA GRANT PROGRAM • LOS ANGELES, CALIFORNIA 90007

MARINA DEL REY:

A STUDY OF ENVIRONMENTAL VARIABLES
IN A SEMI-ENCLOSED COASTAL WATER

Frank R. Bowerman and Kenneth Y. Chen
Environmental Engineering Program
University of Southern California
Los Angeles, California 90007

December 1971

Sea Grant Publication No. U.S.C. - SG - 4 - 71

ACKNOWLEDGMENTS

The authors would like to express their appreciation to the following persons for their contributions:

Mr. Mohsen Moussavi for Analysis of Chlorinated Pesticides

Dr. Benjamin Akpati for Field Measurements of Temperature pH, Clarity, Salinity and Gasometric Analysis of Total Carbon.

Mr. Naresh Rohatgi for analysis of heavy metals

Mr. Michel Petridis for the preparation of the manuscript drawings, sampling, and miscellaneous work.

Dr. Sagar Raksit, Mr. J. Patrick Freemon and Mr. R. Addis Lockwood for their help in the initial stage of this study.

Mrs. Jane Stuart for typing the manuscript.

We gratefully acknowledge the help of the following persons in expediting the research program: Arthur Bruington, Myland Ranson, John Mitchell and Craig Brockman of the Los Angeles County Flood Control District; Arthur Will, Victor Adorian, James Quinn, Leo Bialis of Los Angeles County Small Craft Harbor Commission; Chief Leo Porter and his colleagues in the harbor patrol.

CONTENTS

The work herein was supported by grants (GH-89 & 2-35227) from the National Sea Grant Program, U.S. Department of Commerce to the University of Southern California.

FIGURES

TABLES

I. INTRODUCTION

Public concern for the protection and enhancement of coastal waters has grown during the past few years. There is every indication that concern of environmental pollution will persist and that public interest will increase its demand for correction of man-induced pollution.

This report is the result of a short term general survey of the environmental variables of a semi-enclosed coastal water, but with full recognition of the importance of the long term nature of any meaningful ecological survey. Because variation in environmental quality can occur in a water body from time to time, point to point, long term monitoring of the essential parameters is an important step for the preservation of environmental quality, and as the basis for the management of coastal environmental and resources.

The Marina del Rey boat harbor of Southern California was opened to the public in 1962, and since then, no extensive study has been done on the water quality of its channels. In the light of anticipated rapid population growth around the Marina and the ever increasing number of small crafts using the channels, it became important to estimate the quantitative changes in the water quality. The objective of this study is to examine the current environmental conditions of the marina, and to investigate potential sources of contamination from the surrounding environment.

There are three inclusions in this report. Chapter II contains detailed analytical methods pertaining to chemical analysis used in this study. Chapter III contains results on the analysis of storm water, water samples and sediment of the marina. Chapter IV presents discussion and summary on the data.

This work was supported by the National Sea Grant program under the auspices of the National Oceanographic and Atmospheric Administration, under the Department of Commerce. The report represents our effort over the working period of October 1970 to September 1971.

II. EXPERIMENTAL METHOD

1. Field:

Storm water samples were collected by the Los Angeles County Flood Control District at the Boone Olive Pumping Plant and the Oxford and Lincoln outlets. One hundred and twenty five stations were located (Fig I) for studying the environmental variables in the Marina based on the following: The changing bathymetric history of the channels (1962, 1966, and 1969 depth studies by the Los Angeles County Engineers), proximity to inlets and potential sources of pollution, the breakwater and Ballona estuary. Surface water and samples from approximately half a meter from the bottom were taken with a Van Dorn water sampler. Depth of water was determined with a depth meter and the clarity with a Secchi Disc. The temperature of both top and bottom waters was determined in situ with a portable combined dissolved oxygen - temperature meter. Each sample for D. O. determination was first fixed with $MnSO_4$ and NaOH + KI in the field and titrated in the laboratory using the Winkler method within four hours after collection. A conductivity meter was used for in situ salinity measurements of the surface and bottom waters. Bottom sediments were collected with a Phleger corer and an orange-peel grab.

2. LABORATORY

The turbidity of the storm water was determined by the Jackson Candle Method. Samples for the determination of hydrogen sulfide concentration were fixed with zinc acetate in less than one minute after they were collected. The determination of total sulfide was carried out colorimetrically at a wave length of 670 mμ. The colorimetric method used was the well-known formation of methylene blue by the mixing of ferric ion, N, N-dimethyl-P-phenylene-diamine and sulfide in HCl solution, molar absorptivity of sulfide for the formed methylene blue was $3.25 \pm 0.02 \times 10^{4}$ l., mol^{-1}. cm^{-1}. Oxygen concentrations were determined by the Azide modification of the Winkler Method in 300-ml BOD bottles.

Measurement of Chlorinated Hydrocarbons

The measurement of chlorinated pesticides in the storm water, in water samples and in the sediments from Marina del Rey was carried out in a Varian Aerograph Model 600-D gas chromatograph equipped with a concentric tube electron capture detector. The characteristics of the columns used in this experiment were:

	1	2	3
Column	6' x 1/8" pyrex	6' x 1/8" pyrex	6' x 1/8"pyrex
Support	Gas Chrom Q (80/100 mesh)	Chromosorb P (80/100 mesh)	H/P Chromosorb W (80/100 mesh)
Liquid phase	11%(QF1-OV17)	5% DC 200	5% DC 200

For the sediment study, only the first column was used.

The gas-liquid chromatograph operating conditions were set as follows:

temperature: injection port 250°C
column 200°C

Nitrogen Carrier Gas Flow: approximately 30 ml/min.

Injections of 1 to 2 μ l of each fraction of eluate were made for identification and measurement.

The extraction of pesticide residues from water samples were done by applying n-hexane as the solvent, the ratio of distribution of pesticides between water and solvent was lowered by adding 10 ml of saturated NaCl solution into the system.

For the extraction of the pesticides from the water sample, 200 ml of n-hexane were applied in 4 portions, 50 ml at a time to one liter of clarified sample in a separatory funnel, and the extracting solvent was reduced to 100 ml in a 70^{o}C oil bath and the concentrated solvent was then passed over a bed of anhydrous sodium sulfate and florisil to remove the final traces of water.

Initially, about 10 ml of saturated sodium chloride was added to the water sample in order to reduce the concentration of remaining pesticides in water after extraction. This might be because of the difference in the ionic strength of the system which goes up by adding electrolyte.

After the solution was filtered its volume was reduced to 1 ml in the same oil bath of 70^{o}C and the sample was ready to be injected.

The exact procedures for the extraction of pesticides in the sediment are described as follows:

1. Take a 250 ml (clean and dry) conical flask and weight it, W_1.
2. Mix the sample with a scalpel, (use the same covered sample that was used for measurement of moisture).
3. Transfer about 10 grams of sample into the flask and weight it, W_2.
4. Add 150 ml of distilled water and shake it to obtain a uniform mixture.
5. Add 10 ml of saturated solution of NaCl.
6. Add 50 ml of 24% ethyl ether in n-hexane.
7. Stir the mixture by a mechanical stirrer for 10 min.
8. Transfer the mixture to four centrifuging test tubes immediately and centrifuge for about 10 minutes at approximately 2000 rpm.

9. Transfer the upper clear layer of the extract from the test tubes to a clean and dry 250-ml conical flask. Avoid carrying any of the thick sludge layer from the lower part of the tube into the flask.

10. Transfer the thick sludge layer from the test tubes to the first conical flask, add 50 ml of n-hexane, stir, centrifuge it again and transfer the upper clear layer to the flask which contains the extract phase of the first period. Discard the remainder in the test tubes.

11. Pass the extract through a chromatographic cleanup column which contains 5-in of activated florisil below 2-in of granular anhydrous sodium sulfate, Na_2SO_4. Let the hexane solution of pesticides extracts penetrate into the adsorbents.

12. Collect the filtrate in a 150-200 ml conical flask which has been cleaned very carefully (rinsed with pure acetone and dried in the oven) and blow the acetone vapors out with dry air.

13. Rinse the column with three 10 ml. increments of n-hexane and add it to the filtrate.

14. Evaporate the extract to 1 ml in a glycerine bath of $80^{o}C$.

15. Transfer the concentrated solution into a 5 ml test tube with ground glass stopper and rinse the container twice with 2 ml increments of n-hexane and add them to the test tube.

16. Evaporate the solution in the test tube to reach a volume of 1 ml, this solution is now ready for injection.

CALCULATION:

If the area under each peak is A squares and each square represents M nanograms of pesticide, the concentration will be:

$$\text{Concentration} = \frac{MA \times 10^{-9} \times 1000}{(W_2 - W_1)(1-H) \times v} \times 10^{6}$$

$$= \frac{MA}{v(1-H)(W_2 - W_1)} \quad \text{PPM}$$

where

H = moisture in %

V = volume of injection in μl.

Proceedings for the measurements of moisture content are described as follows:

1. Take a clean and dry petri dish, bottom or top, and weigh it, W_1.
2. Mix the sample by the aid of a scalpel (sample must be kept in a covered container).
3. Transfer 2-3 grams of the sample into the weighed petri dish by the same scalpel. The sediment must spread only over the surface.
4. Weigh the sediment, W_2.
5. Leave it in an oven of $105^{\circ}C$ for one hour.
6. Weigh it when it is cooled down then put it in the same oven for another 10 minutes.

If there was no change in the weight take the reading as W_3.

If there was a change repeat the above process as many times as to obtain a constant weight.

CALCULATION:

Calculate for the moisture % by using the following equation:

$$H = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

MEASUREMENTS OF METALS

Divalent metals were analyzed in a Unicam model SP90A Atomic Absorption Spectrophotometer. No attempt was made to differentiate the form of these metals, i.e. bare ion, complex or colloid. Total concentrations of calcium, manganese, iron, and mercury were determined without preconcentration. Determination of other hazardous heavy metals such as lead, cadmium and antimony required pre-concentration by extraction. The extraction solvents include diphenyl thiocarbazone, 8-quinolinol and acetyl acetone on ethyl propionate solution. pH of each solution was adjusted to 7.0 ± 0.5 by adding ammonium tartrate. Ethyl propionate was selected among other solvents because the metal dithizone and metal oxine complexes are easily extracted by this solvent and remain stable for about one week. The method includes:

1. Add 10 ml of extract solvent and 10 ml of IM ammonium tartrate to 100 ml of sample in a 150 ml separatory funnel.
2. Shake the solution briskly for 1 to 2 minutes, then allow to stand approximately half an hour until the two layers are separated.
3. Drain out the aqueous solution and pour the organic phase into a dry glass stoppered tube. The organic solvent is concentrated by ten times before determination.

By the use of an organic solvent the rate of aspiration of sample to the flame is decreased. Because the organic solvent used for the extraction also acts as a secondary fuel, it alters the nature of the flame. It was found that the rate of aspiration of 3 ml/min provides the optimum sensitivity. The increase in the rate of aspiration was achieved by attaching a polyethylene capillary tube.

From the sediment samples kept originally in plastic tubes slices of 1 and 2 inches were taken and kept into other plastic containers. The half of each sample was used to determine the dry weight, and the other half for digestion.

Reagents:

1 + 1 Nitric Acid + Water

1 + 4 Perchloric Acid + Water

Hydrofluoric Acid 40% (A. R.)

Hydrochloric Acid 36% (A. R.)

Lanthanum chloride solution containing 65,000 ppm lanthanum

The sediment samples were digested with a hydrofluoric-perchloric-nitric acid mixture and evaporated to dryness on a sand bath. The residue was then treated with 1 + 4 perchloric acid and evaporated to dryness to make sure of complete digestion. The final residue, about 10 drops of concentrated hydrochloric acid was added, followed by 15 ml of distilled water; this was subsequently digested on a steam bath for another 20 minutes. After cooling, the sample was centrifuged to remove the leftover solid particles and transferred to a 100 ml volumetric flask. 10 ml of lanthanum chloride solution was added and adjusted to the mark with distilled water.

For analysis of mercury in both water and sediment, the well-known flameless atomic absorption spectrophotometric technique was employed. Stannous chloride was used as the reducing agent.

III. RESULTS

A. ENVIRONMENTAL SURVEY OF THE MARINA

The Marina may be divided into four major areas based on differences in depth, physical and chemical properties of the water mass, and the compositions of bottom sediment:

(1) Basins: These lie almost perpendicular to the mid-channel (Fig. 1). They have relatively lower water circulation than the mid-channel. The mean depth is 3.5 m. The Secchi disc reading is about 2.2 m. and there is no significant difference between the D.O. of bottom and top waters (Table I). The bottom sediment is mostly gray mud.

(2) Mid-Channel: This area is characterized by a mean depth of 7.5 m. with mean values of 6.5 mg/l dissolved oxygen for the surface and bottom waters respectively. Water movement is generally higher than in the basins. The bottom sediment consists of silty to sandy mud, becoming sandy in the breakwater region.

(3) Breakwater: Water movement appears to be highest in this area but surprisingly, the level of dissolved oxygen in the bottom water is extremely low, the bottom consists of black organic-rich sandy mud that contained hydrogen sulfide odor. The mean depth is 7.8 m.

(4) Ballona Creek Estuary: The water is highly turbid, with a mean Secchi disc reading of 1.7 m. There is some stratification between surface and bottom waters which have mean salinities of $31.1^{o}/oo$ and $33.1\ ^{o}/oo$ respectively. The bottom sediment is composed of black organic-rich mud.

Physical and Chemical Characteristics

TEMPERATURE: There is a slight temperature difference of about 1°C between the top and bottom waters. Because of the shallowness of the water, the temperature of the surface and bottom is likely to be dependent on the season and the time of the day. Higher temperature differences occur in the Basins where water circulation is relatively less pronounced than in the Mid-channel.

SALINITY: The salinity of the water ranges from 34 to 29 ‰, and generally, 0.2 ‰ difference exists between surface and bottom waters. The present data indicates a slight stratification in the Marina water. In the Ballona Creek estuary, stratification of top and bottom waters becomes more pronounced, 29 ‰ and 32.6 ‰ respectively.

pH: The pH ranges from 7.4 to 8.1 and about the same values from top to bottom.

CLARITY: The clarity from Secchi disc readings ranges from 1.5 to 3.5 m. It was observed that the clarity is influenced by boat traffic and the depth of water. In general, the Ballona Creek water and the shallower basins are less clear than the constantly used deeper mid-channel water.

DEPTH: Comparative study of the 1962, 1966 and 1969 bathymetric maps of the Marina by Los Angeles County Engineer reveals depth changes particularly in the mid-channel. These depth changes might be due to modifications in the flow pattern of water in the channel caused by the construction of the breakwater in the mouth of the Marina. Changes of ± 2 ft. are common. The basins have a mean depth range of 3.5 m. increasing to 7.5 m. toward the mid-channel and breakwater.

Depth, temperature, salinity, turbidity and pH data collected at the stations in Figure 1 are tabulated in Table II.

DISSOLVED OXYGEN: In general there is no problem regarding the D.O. level inside the Marina at times other than the red tide season. Data shown on Table 1 indicate that sufficient oxygen is maintained in all locations throughout the basin except in the Marina entrance. Concentrations of dissolved oxygen near two storm drain inlets, i.e. Oxford and Lincoln, are slightly lower than that of other regions. However, there is no serious concern from the viewpoint of the oxygen budget.

The level of dissolved oxygen during and after the red tide period was one of the great concerns. Since a minimum level of 3 to 4 mg/l of dissolved oxygen is deemed to be necessary to support propagation of aquatic life, a prolonged existence of dissolved oxygen below this level will cause migration of marine life and eventual destruction of ecology systems of the marina.

During the month of August 1971, the Southern California coastal waters were swarmed with phytoplankton G. Polyedra and other dinoflagellates and diatoms, commonly called "red tides". The blooming of red tides affect significantly the level of dissolved oxygen in the Marina which has less circulation and mixing than the open water.

Figures II and III show the dissolved oxygen of different stations during a non-red tide day of July, it is clearly shown that D.O. levels are above the critical levels of 4 mg/l, generally considered to be a satisfactory level for aquatic life. Greater variations at Station 108 were due to wave motion and busy boat traffic in the breakwater area. Figure IV gives a clear picture of the effect of red tide on the dissolved oxygen concentration. At the beginning of the red tide onslaugth, dissolved oxygen dropped to around 2.5 mg/l at 1.5 meters below the surface. The dissolved oxygen levels improved somewhat afterwards, possibly due to photosynthetic reaction of red-tide itself. Another critical period came within several days after red-tide disappeared, dissolved oxygen in the hypolimnion dropped to another lower level, most likely due to the decomposition of algal mass. From figures V and VI it is noticed that concentrations of dissolved oxygen in the epilimnion were usually in supersaturation due to intensive photosynthesis, however, the lower part of the water was somewhat depleted of oxygen due to the microbial respiration on the decomposition of algal mass. Figure VI shows that in a tubulent water, (Station 102 is located in the breakwater area) dissolved oxygen went back to saturation level almost immediately after the red tide disappeared. The dissolved oxygen concentration of the surface water during red tide in early morning was about 7.2 mg/l. As the wind changed directions from westward to southwestward, this station was gradually cleared from red-tide, the dissolved oxygen rose to saturation level due to reaeration.

It is clearly demonstrated that so long as there is enough turbulence and photosynthetic action, the concentration of dissolved oxygen in the surface can be maintained at high levels. However, in the absence of reaeration and photosynthesis, which can happen in a stagnant water in the evening, the presence of red tide can be quite detrimental to water quality. An episode occurred on August 18, 1971 in the undersea gardens of the Marina best demonstrated this effect .

The water in the aquariam of the Undersea Gardens is circulated from the sea, water with red tide was found to have seeped through the joints of the walls of the aquarium. On the afternoon of August 18, 1971, about 700 fish were killed at the Undersea Gardens. It was found that the D.O. concentration in the aquarium immediately below the surface was around 2 mg/l. Other chemical analysis showed that composition of water was not different from the water in the marina. The direct cause of death for the 700 fish and organisms was the low D.O. concentration.

The water body of the Undersea Gardens is characterized by low circulation and the absence of photosynthetic action. The presence of red-tide biomass led to bacterial decomposition which depleted the concentration of dissolved oxygen. Fish weighing more than 10 lbs, like the smelt and the garibaldi survived, but all those weighing less than 10 lbs died. Among the Moray eels, seven out of ten survived. The three sea turtles which are air breathers also survived.

The list of dead fish and organisms included:

Scientific Name	Common Name	Quantity
Invertebrates		
Asteroidea	Starfish	100
Echinoidea	Sea Urchin	20
Nudibranchia	Nudibranch	3
Porifera	Sponges	all
Filibranchia	Mussels	all
Vertebrates		
Amphisticus argenteus	Barred Surperch	10
Paralabrax nebulifer	Sand Bass	30
Girella migricans	Opal eye perch	6
Platyrhinoides Triseriata	Thronback bando ray	5
Chromis punctipinnis	Blacksmith perch	70
Sebastodes carnatus	Gopher rockfish	3
Sebastodes umbrosus	Honeycomb rockfish	4
Pimelometopon pulch rum	California sheephead	5
Triakis henlei	Brown smoothhound shark	15

The rest of the fish included blue and yellow rockfish, kelp and grass rockfish, ocean white fish, tommy croakers and brown, starry rockfish also died.

HEAVY METALS: Results on heavy metal determinations in the water of the Marina are tabulated in Table III. Specific attention was given to the most toxic substances such as mercury, lead, cadmium, and antimony. In general, concentration of mercury in the Marina water column is less than 0.3 parts per billion, lead ranges from 0.1 to 0.2 ppm, cadmium from 2.5 to 5.0 ppb and antimony from 1.0 to 0.3 ppm.

A general survey of other areas in the Southern California coastal waters is shown in Table IV. It is clearly indicated that concentration of heavy metals in the Marina is somewhat less than those of other regions. In the sediments, a comparison of data between stations 66, 54 and 1 (Table V) shows that lead and cadmium concentrations decrease from station 66 to station 54 then to 1. Mercury concentrations are also higher in station 66 than station 1. The distribution of those concentrations provides a clear indication of the impact of storm water on the accumulation of heavy metals. Both sampling stations 1 and 66 are located at the outlet of storm drains, however the storm drain into station 1 is interupted by a duck pond before flowing into the marina. Station 54 is located at mid-channel. Data on the distribution of those metals indicate that they have a short resident time in solutions and due to floculation, sedimentation and other complex biogeochemical processes they settle within a short distance from the source of discharge.

An analysis of sediments of station 66 showed that the maximum concentrations of calcium manganese and iron were 1000, 61 and 4.38×10^4 mg/kg (dry weight) respectively. Figures VII to IX show the vertical profiles of mercury, cadmium and lead in the sediments of Marina.

PESTICIDES: In general, concentrations of pesticides in water samples (Table VI) from the Marina show no definite pattern, and are well below 1.0 ppb. This indicates that the water body of the Marina del Rey Harbor is relatively free of chlorinated hydrocarbons.

However, analyses of sediments of stations 1, 56, 61, and 66 (Table VII) showed that BHC, 2.4 DB, and DDE were distributed among all of them significantly in different depths, especially at the top four inches of the sediment. The general availability of the same pesticides in each station makes strong the belief that there is a mixing up process going on down in the beds of those stations.

Data in Table VII also show that stations 1 and 66, where two storm water inlets are located, have a higher level of pesticides accumulation than those of stations 61 and 56.

The apparent contradiction of pesticide concentrations in the sediment and water samples can be attributed to either of the following two mechanisms: (1) there is less usage of these pesticides in recent years, or (2) pesticides can be removed out of water rather quickly upon entering the marina.

COMPOSITION OF THE BOTTOM SEDIMENT: The sediments in Marina del Rey are composed mostly of gray to grayish brown muddy sand with mean grain size of 0.250 mm. Muddy sediments dominate the basins in the Marina and toward the breakwater. They interfere with sand. The breakwater and Ballona Creek area is characterized by black, organic rich sandy mud which becomes coarser upstream. Size distribution of sediment is tabulated in Table VIII and Carbon contents of sediment are shown in Table IX.

BENTHIC ORGANISMS: SCUBA diving in the Marina and Ballona Creek areas in the course of this study reveal no detectable flora on the generally soft bottom of the Marina. Examinations of the bottom sediment also show poor fauna, but with the polychaetous annelids forming the dominant macroinvertebrates. The low faunal density and diversity may be due to either seasonal factors (samples collected in March) or that the process of colonization of the Marina is not yet completed. It may be that unfavorable bottom conditions are responsible.

B. STORM WATER ANALYSIS

TURBIDITY: Variation of turbidity in two separate storms are shown in figures X and XIB. The average turbidity of the first storm is about twice that of a second storm. These data indicate that storm water was relatively turbid as it was collected in the pumping station. However, water samples collected from mid-channel near Tahiti Way and Basin E near Oxford outlet two days after the 11/29/70 storm have shown turbidity values of less than 25 units. Obviously, most of the turbidity can be settled within a short period. Figure XIB shows a good correlation between turbidity and total solids present in storm water.

TOTAL AND SETTLEABLE SOLIDS: The general fluctuations of total and settleable solids in several storms are shown in Figures XII and XIII. These diagrams do not intend to give the impression of the continuity of storm over the entire period. It shows the general level and variation of total and settleable solids in four storms.

Possible accumulation of settleable solids from storm water in the Marina is one of the major concerns in this study. From figure XIII, the average value of settleable solids is about 0.15 mg/l, or

1.5×10^{-2}% volume of settleable solids per volume of water. By extending the hydrological data of Boone Olive station to drain #5243, it is estimated that roughly 2×10^{-3} acre-ft of solids will be accumulated during the storm period from November to May. If we assume that all settleable solids are deposited in the Marina before reaching the ocean, then, by spreading the total settleable solids over a surface area of 4.5 acres, which is roughly 1% of the total surface area of the Marina, the sediment accumulation is less than one hundredth of an inch, which is quite insignificant.

Data of total and settleable solids in storm water are tabulated in Table X and shown in Figures XII and XIII, and data on runoff volume for the Boone Olive Station in Table XI.

HEAVY METALS: Results on heavy metal determinations in the storm w ater are tabulated in Table XII. General levels of lead and cadmium in storm water are shown in Figure XIV. It is noticed that concentrations of lead and antimony in storm water are roughly twice that of sea water samples, and concentrations of cadmium in storm water are roughly twenty times higher than that of sea water samples. This level of cadmium concentration is about five times that of drinking water limit of 0.01 mg/l, set by the U.S. Public Health Service in 1962; however, it is not of a concern due to the large dilution ratio. Nevertheless, a study to trace sources of cadmium contamination seems desirable. The general high level of lead in both storm water and water samples from the Marina seems to be a cause of some concern; however, the contribution from storm water is negligible if the volume ratio is considered. Concentration of mercury has not been measured in storm water.

<u>CHLORINATED PESTICIDES</u>: Results on the determination of chlorinated hydrocarbons in the storm water are shown in Table XIII.

Generally speaking, concentrations of pesticides in storm water are well below 1.0 ppb (parts per billion). These data indicate that the Marina del Rey region is relatively free from contamination of chlorinated hydrocarbons, especially persistent pesticides such as DDT, aldrin, dieldrin, heptachlor, toxaphene and chlordane. By comparing the concentration of chlorinated pesticides in storm water with those of water and sediment samples of the marina, it is reasonable to conclude that there is less usage of chlorinated pesticides in recent years.

IV. DISCUSSION AND SUMMARY

This is a general survey to assess the physical, chemical and biological properties of the water body and sediment of Marina del Rey. It is also the purpose of this study to evaluate the possible effect of the storm water discharge to the environmental conditions of the Marina.

The data of this study suggest that environmental conditions of the Marina are moderately satisfactory. Concentrations of dissolved oxygen are maintained at adequate levels except during the period of red-tide.

In general, levels of toxic substances such as pesticides and heavy metals are relatively low in water, except for the presence of high level of lead in both water and sediment. However, this seems to be the general characteristics of the Southern California coastal waters (See Table IV).

In comparing results obtained for heavy metal distribution in Southern California estuarine waters and sediments, it is reasonable to conclude that Marina del Rey region is subjected to less contamination of heavy metals than other neighboring estuarine waters.

A number of chlorinated hydrocarbons have been identified in both storm water and water samples from the marina. However, their concentrations are relatively low that they can be considered to be harmless. Accumulations of relatively high concentration of several chlorinated pesticides in some locations of the sediment indicate these substances had been used in large quantity in the past, with some drastic cutback recently. The data from analysis of storm water suggests that there is limited effects from storm water discharge. However, it is suggested that caution should be taken to detect any change in storm water quality; a periodic monitoring program can serve this purpose.

The study on the types of leaves and other organic materials found at the entrance to the Marina indicates that detritus from Ballona Creek accumulates in the breakwater area and some is transported into the Marina by tide and long shore currents. Bottom sediments from most of the Marina show almost no hydrogen sulfide except in the outlet of Ballona Creek and breakwater areas where black organic rich sediment contains some H_2S odor; it is not possible to say at this time whether the observed condition is a seasonal phenomenon.

Cursory examination of sediments from Stations 115, 116, and 117 indicate that Ballona Creek is the main source of the organic detritus found in the area. It will be interesting to find out how and from where these materials get into the creek. It is important to note that the conditions of the bottom sediment directly affect the quality of water column. Decaying organic materials exert an oxygen demand and contribute to the formation of anaerobic conditions, i.e. formation of hydrogen sulfide, methane and other undesirable gases. They also affect the existence of benthic organisms, reducing both diversity and density.

In general, the following conclusions can be drawn:

(1) The measurements of the dissolved oxygen, pH, alkalinity, turbidity and salinity show that the environmental variables of the Marina are within satisfactory levels.

(2) The biological indices such as diversity and density of benthic life are very low in the Marina.

(3) The quality of storm water analyzed is considered to be relatively harmless to the water quality of the Marina.

(4) Chlorinated hydrocarbons are largely absent in storm water and in water samples of the Marina. However, in some locations of sediment, significant amount of chlorinated pesticides have been detected.

5. Higher than normal concentrations of lead in both the Marina and storm water samples probably stem from automobile and marine exhausts.

6. Concentrations of heavy metals such as mercury and cadmium are generally low in water samples. However, significant accumulations in sediment have been detected.

7. Accumulation of sediment from storm waters is insignificant.

8. Debris from Ballona Creek in the breakwater region appear to affect the bottom conditions of the Marina; in turn this affects the water quality near the mouth of the Marina.

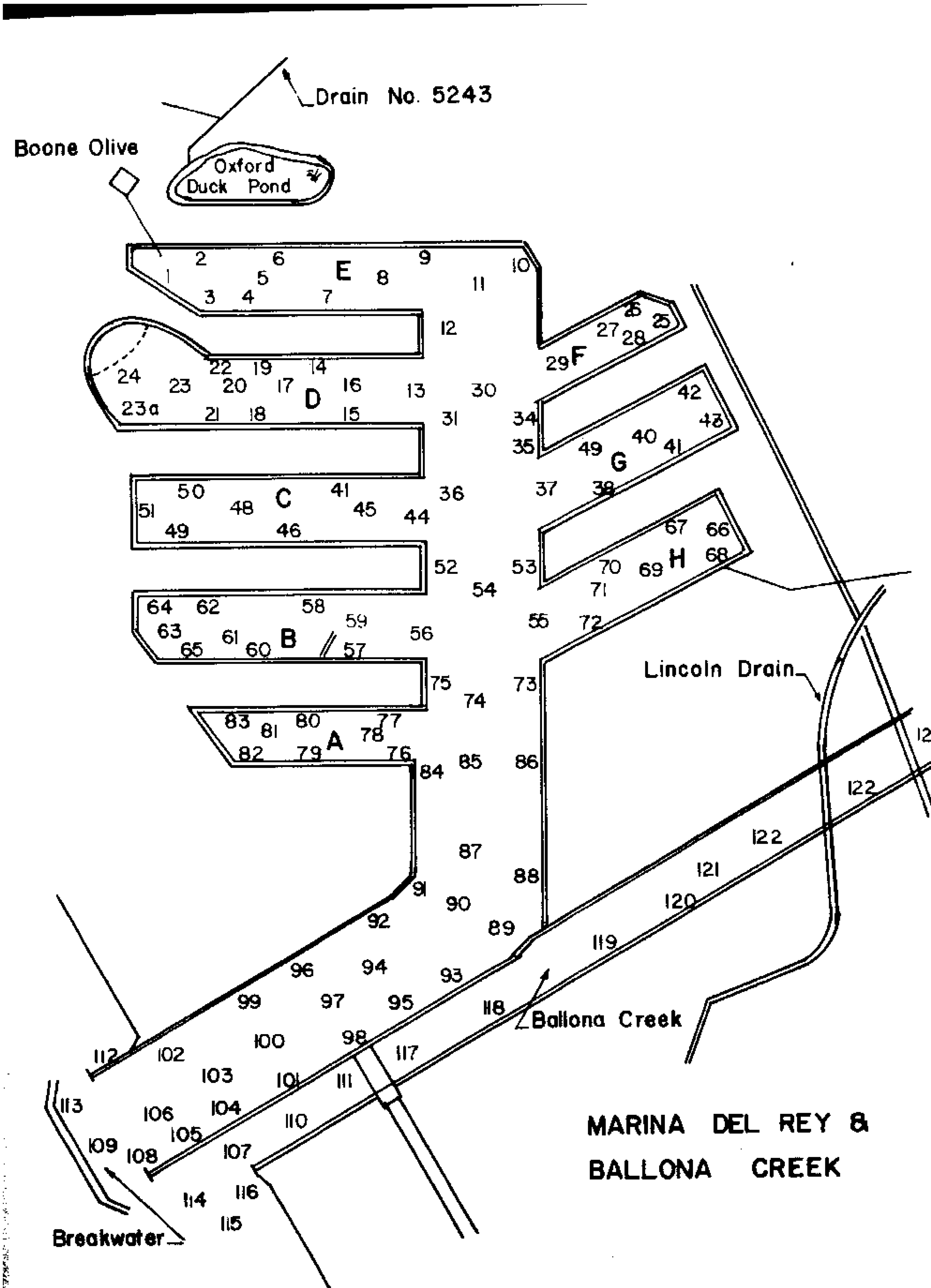
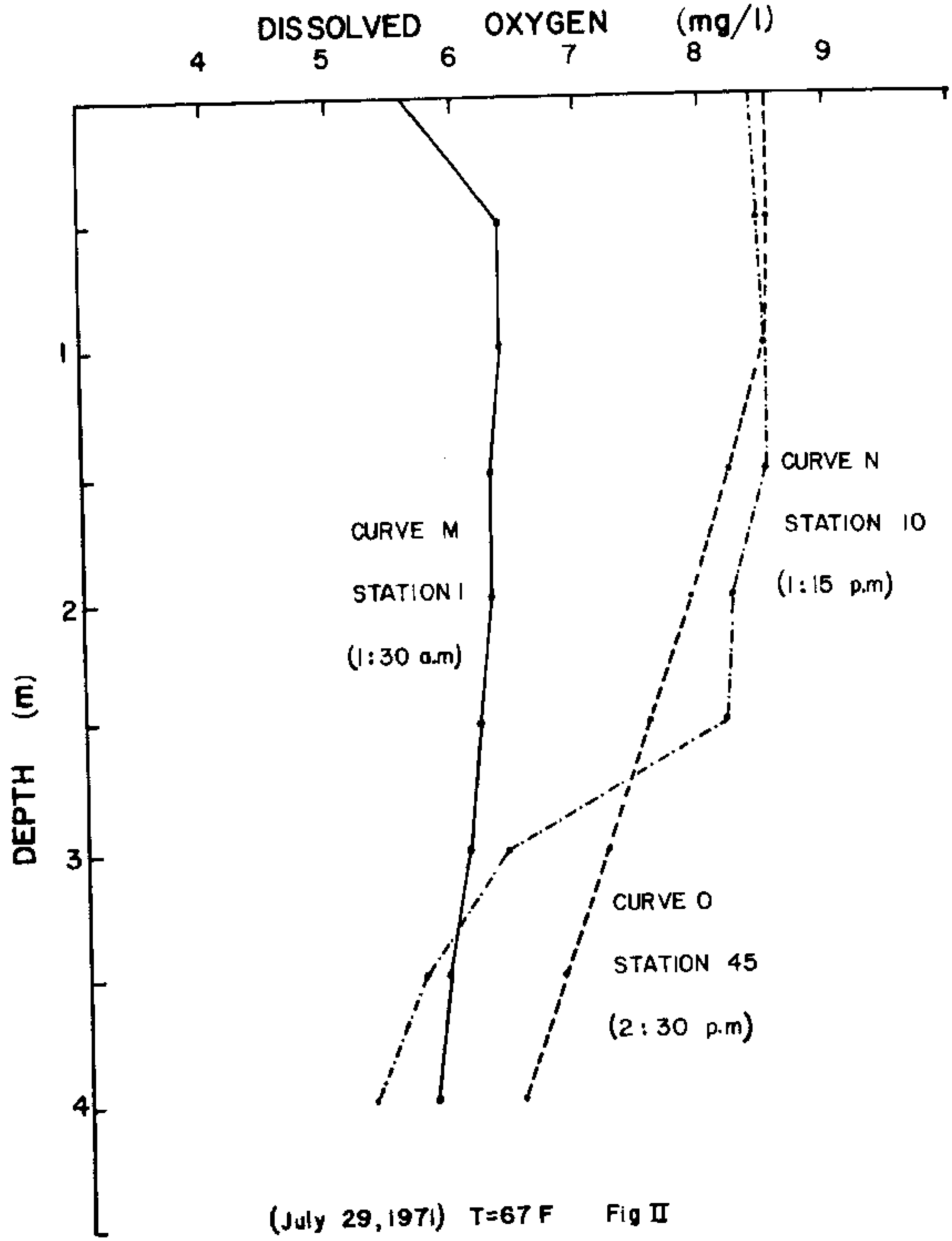
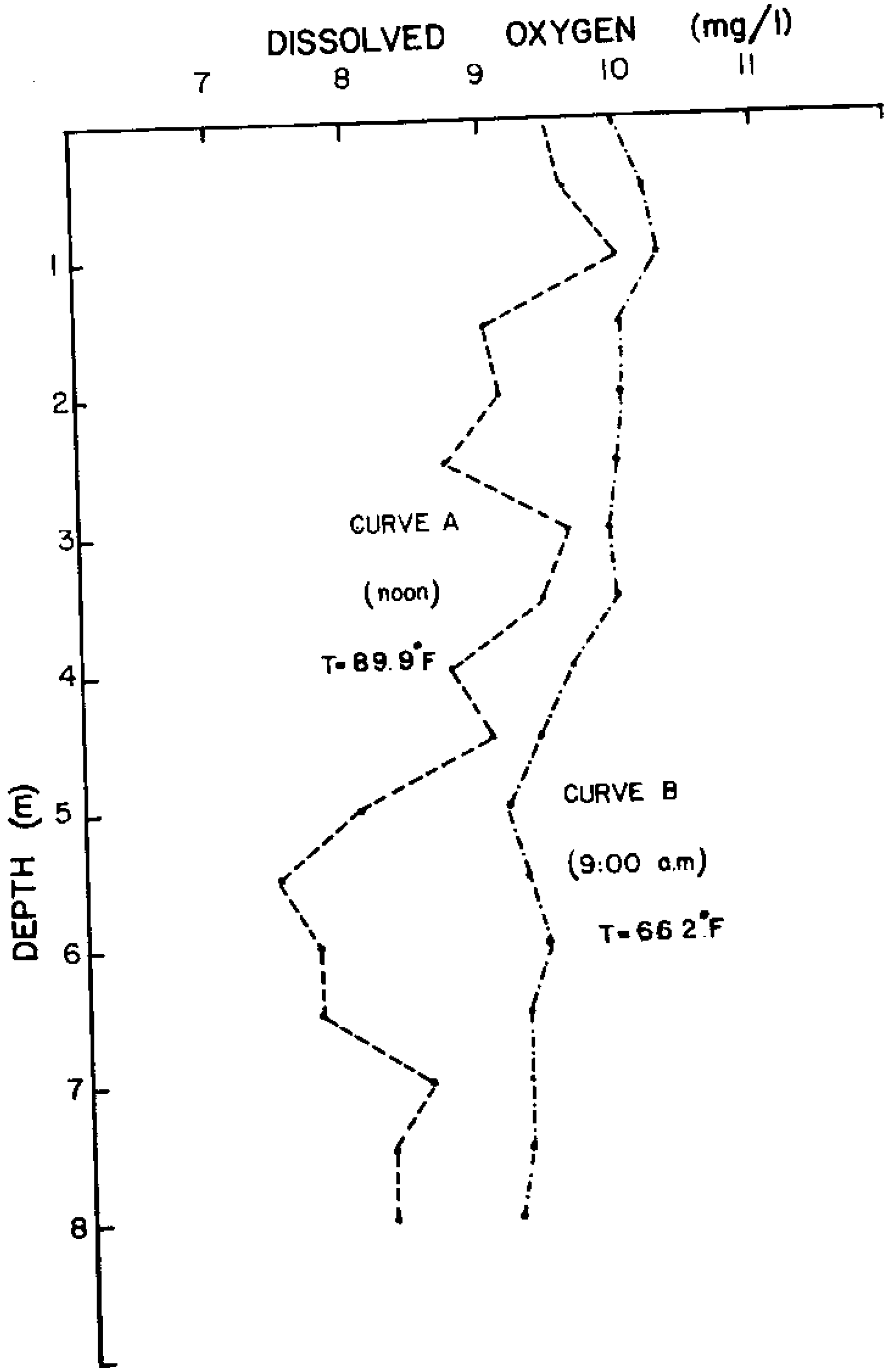

Drain No. 5243
Boone Olive
Oxford Duck Pond
E
D
C
B
A
F
G
H
Lincoln Drain
Ballona Creek
Breakwater
MARINA DEL REY &
BALLONA CREEK

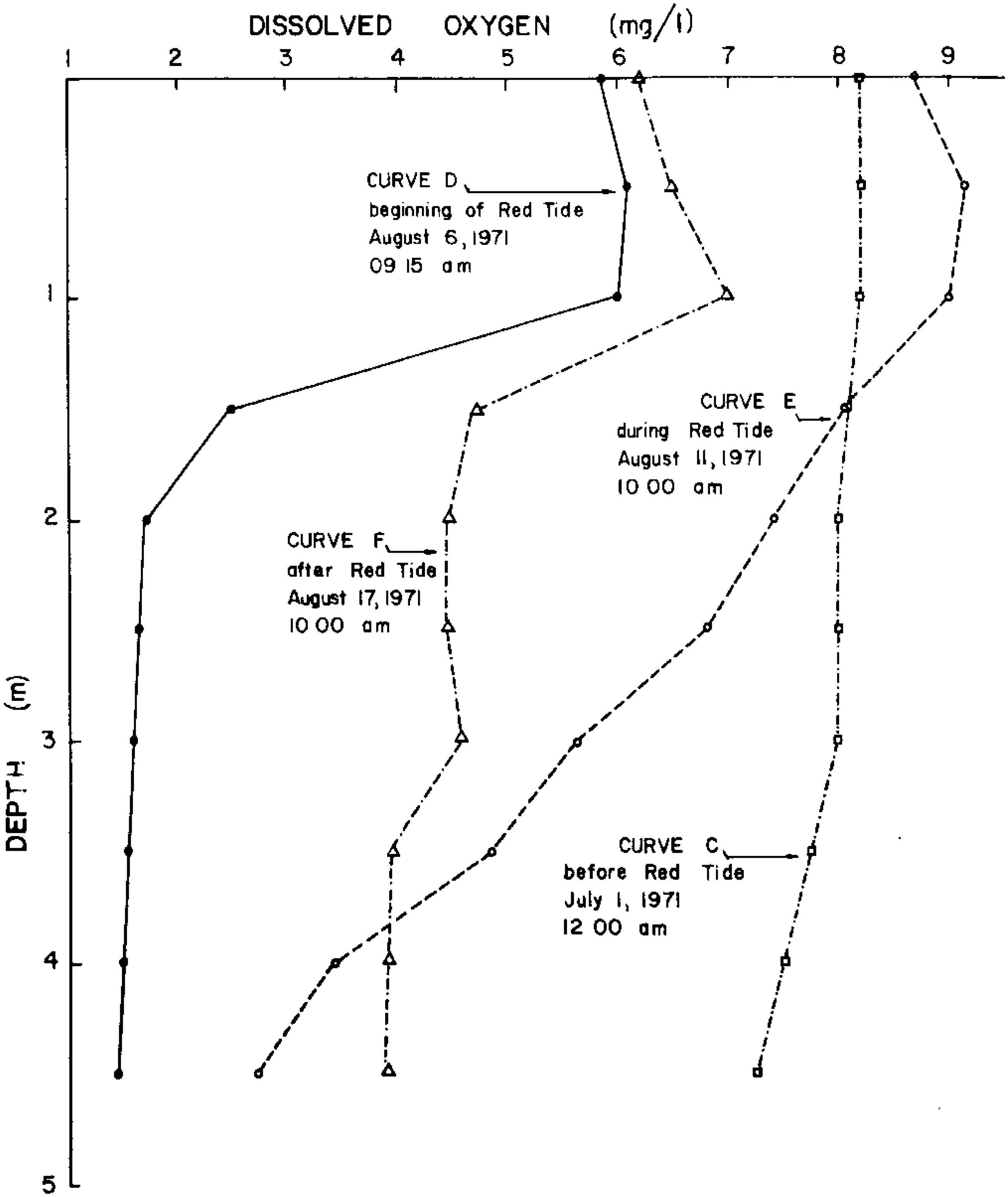
Fig I



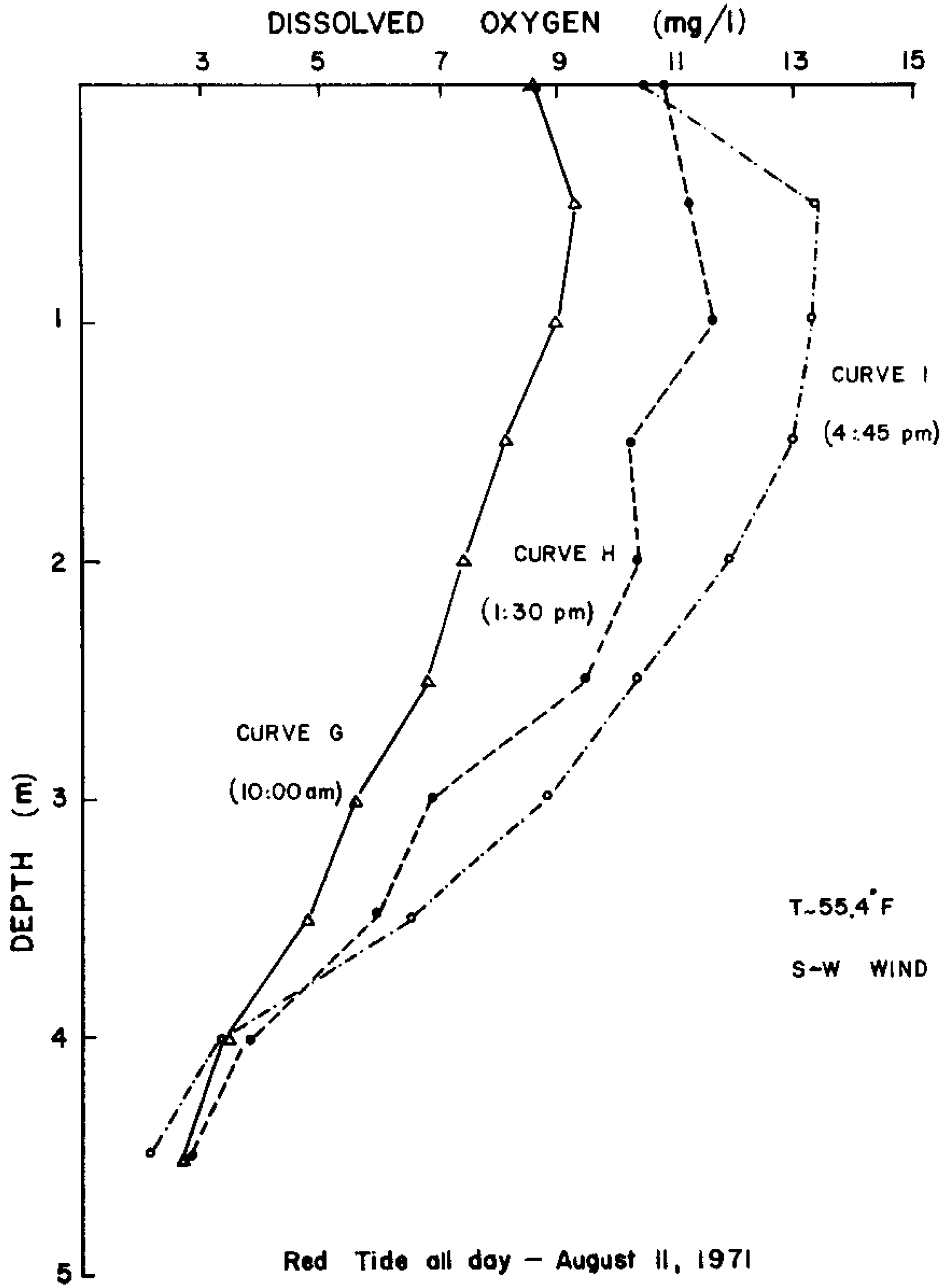
(July 29, 1971) T=67 F Fig II



STATION 108 (July 71) Fig III

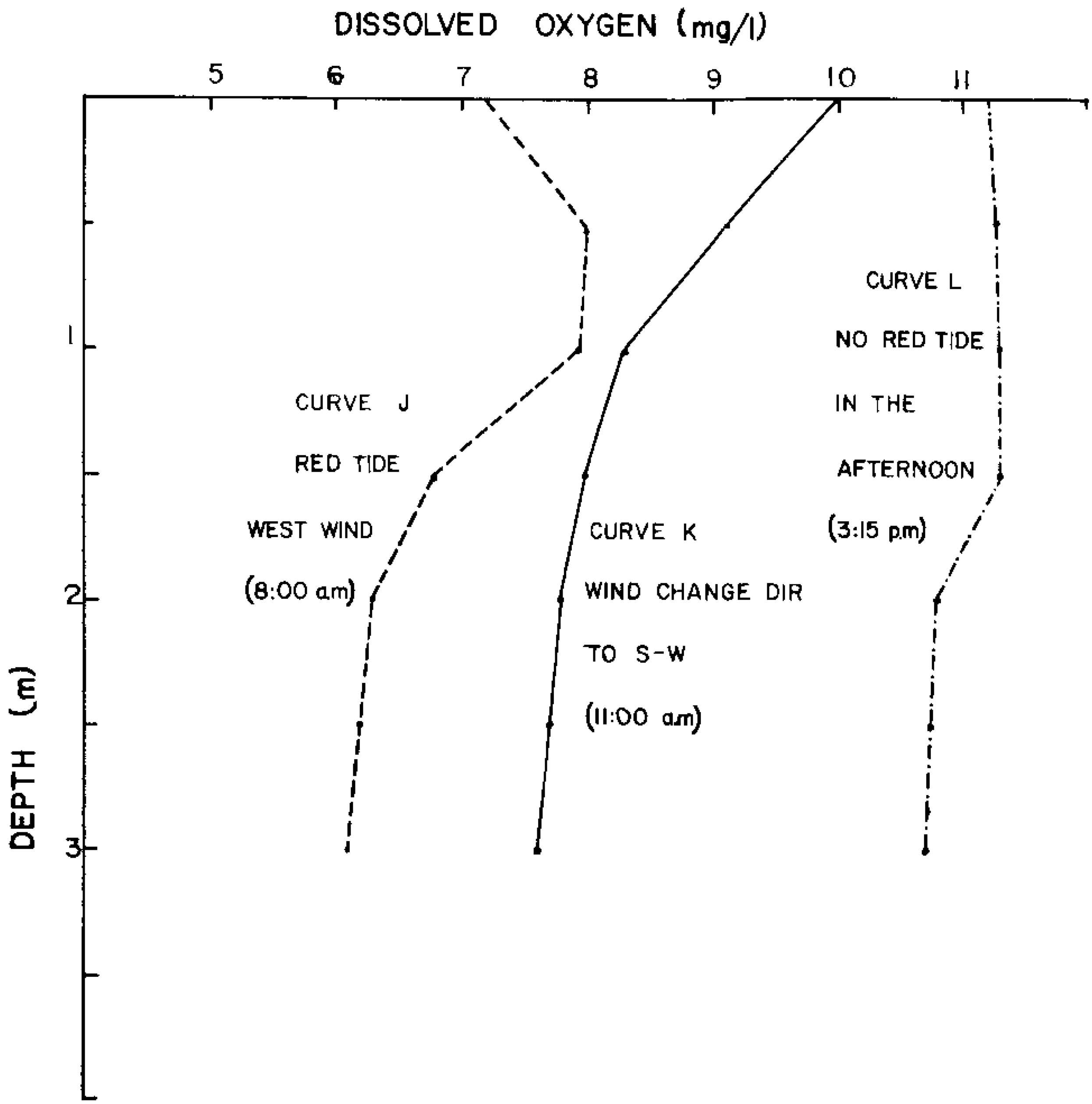


STATION 71 Fig IV

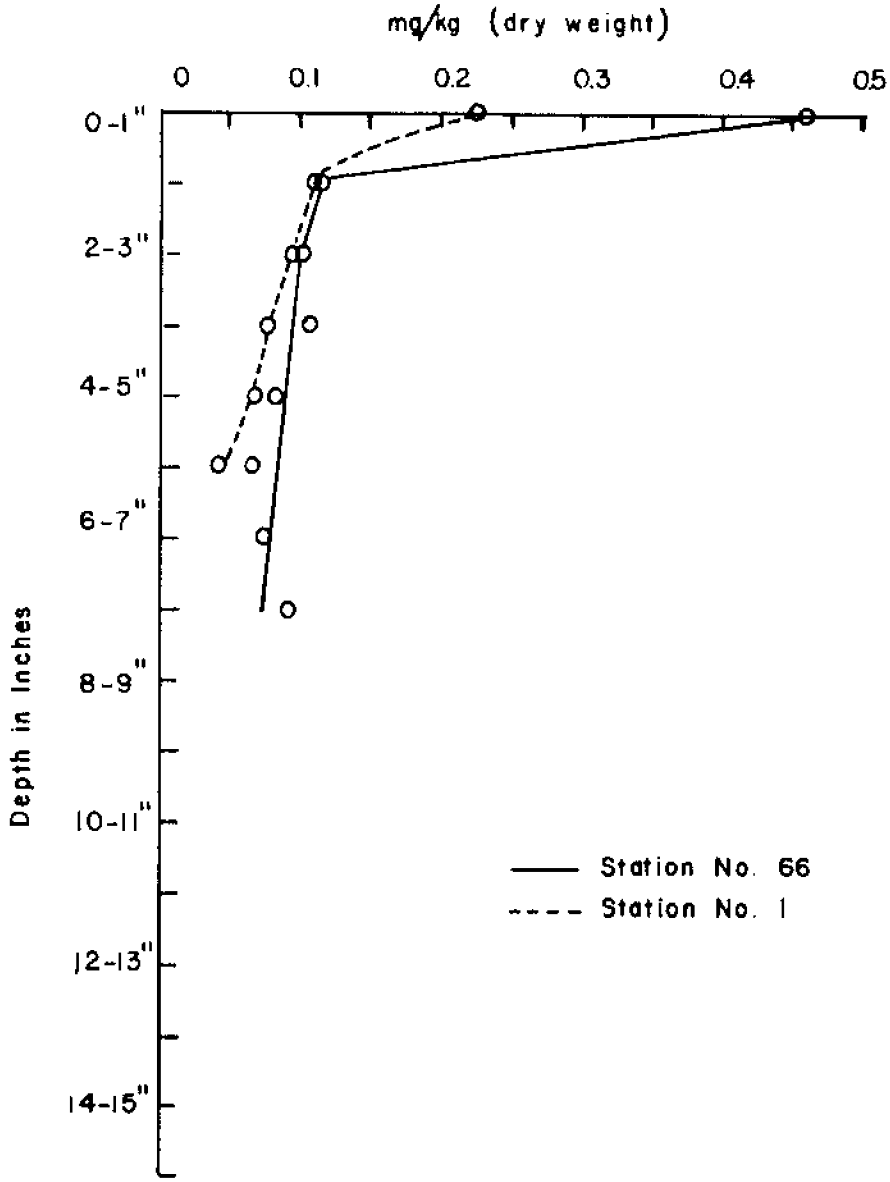


Red Tide all day — August 11, 1971

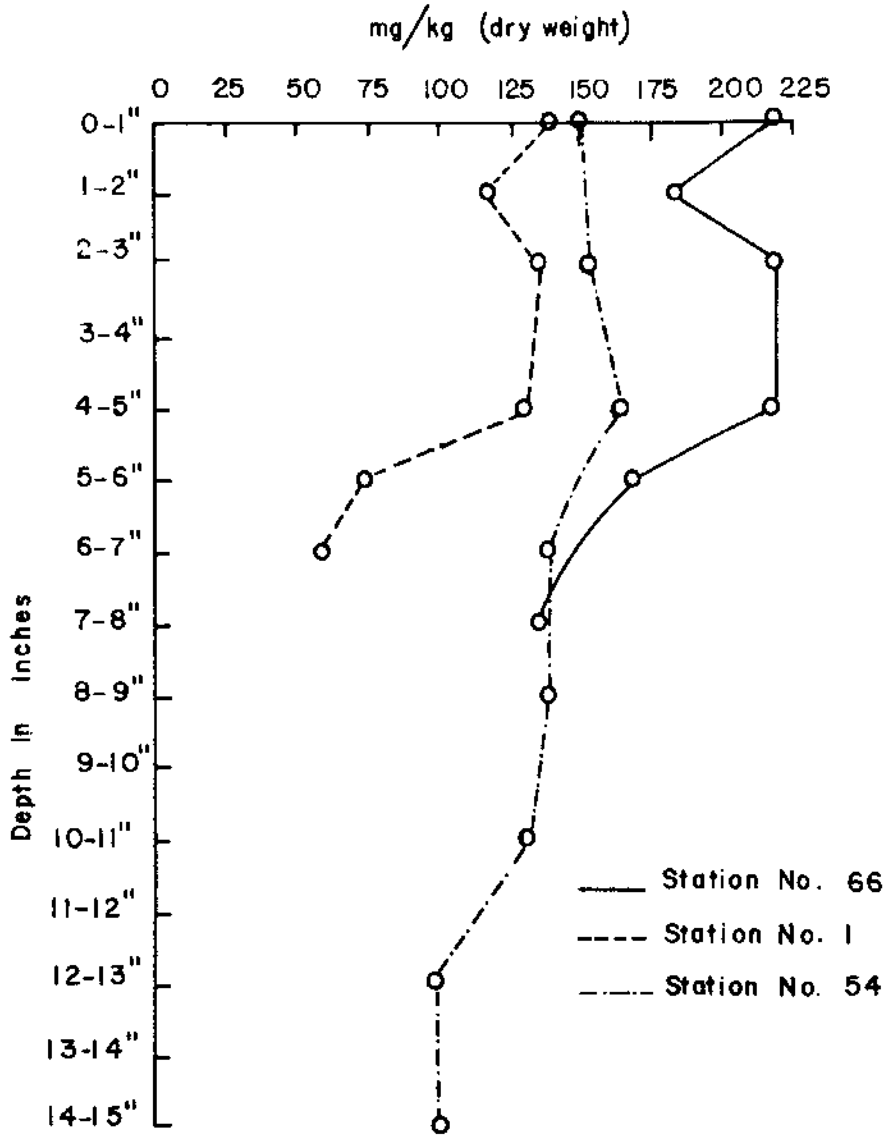
STATION 71 Fig V



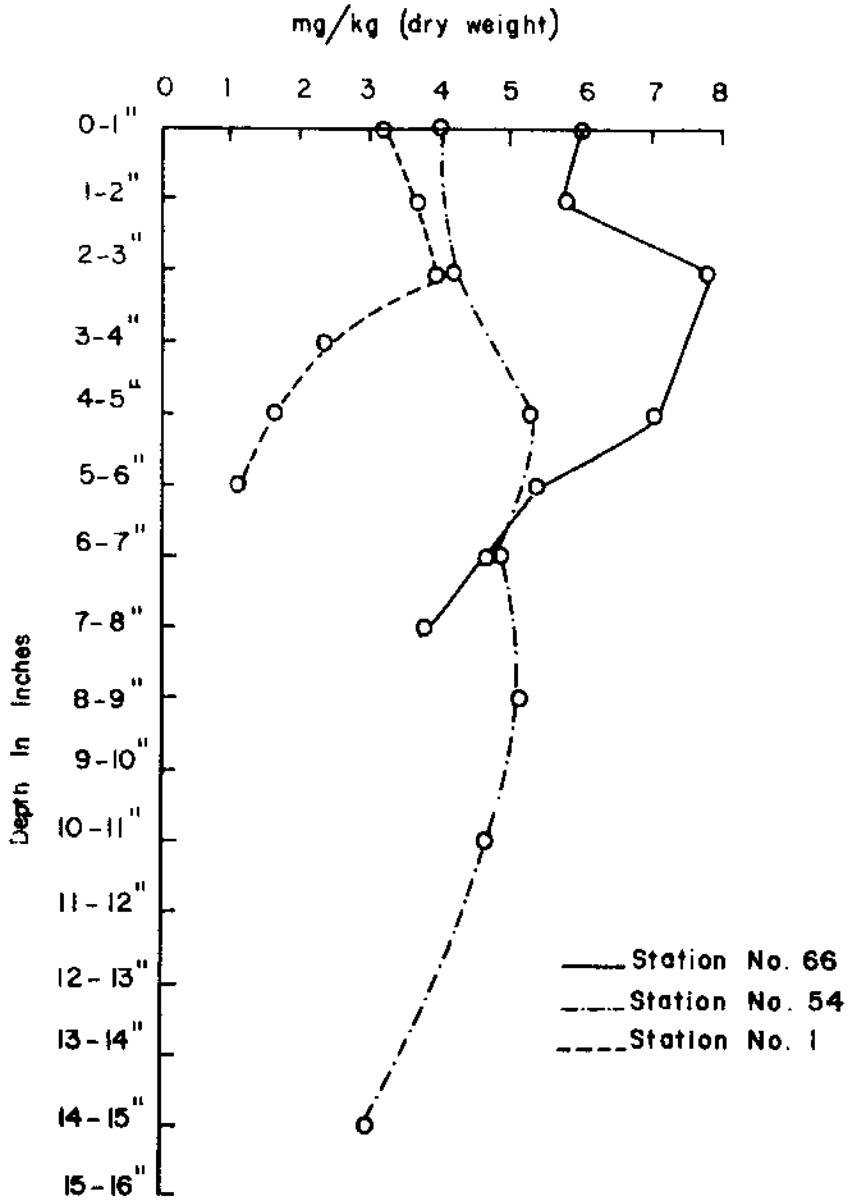
STATION 102 Fig VI



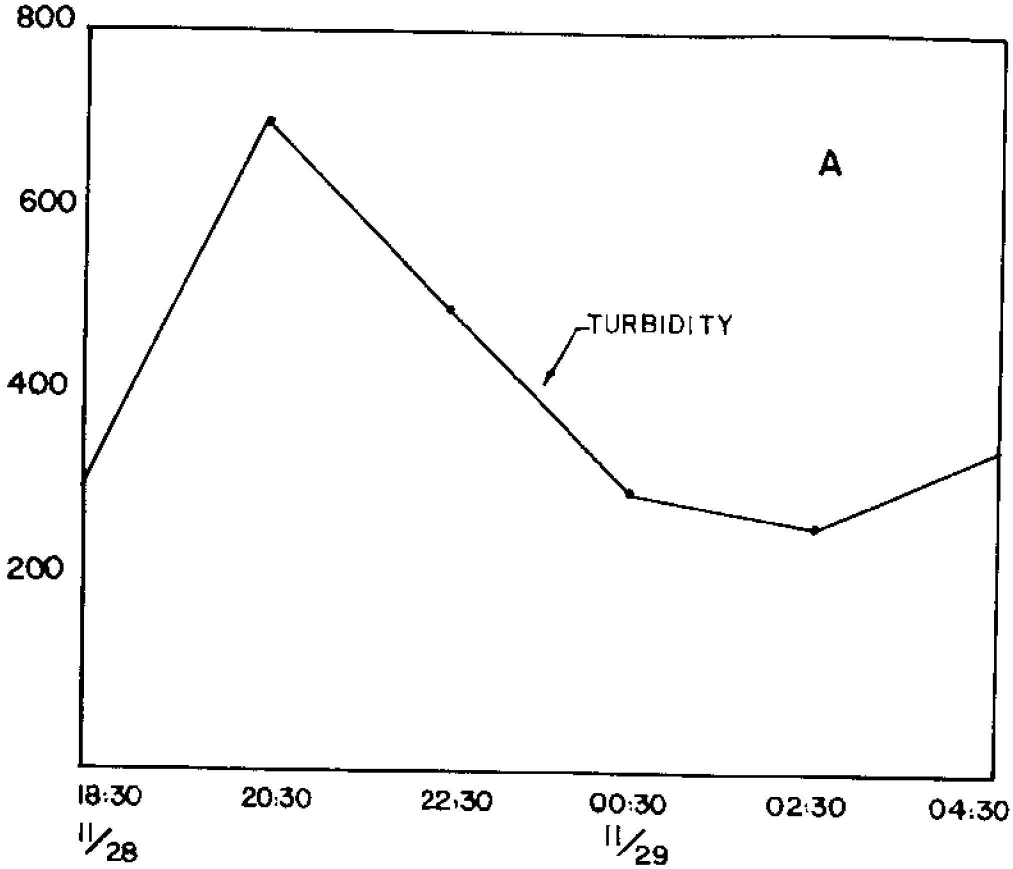
Mercury distribution in Marina Sediment
Fig VI



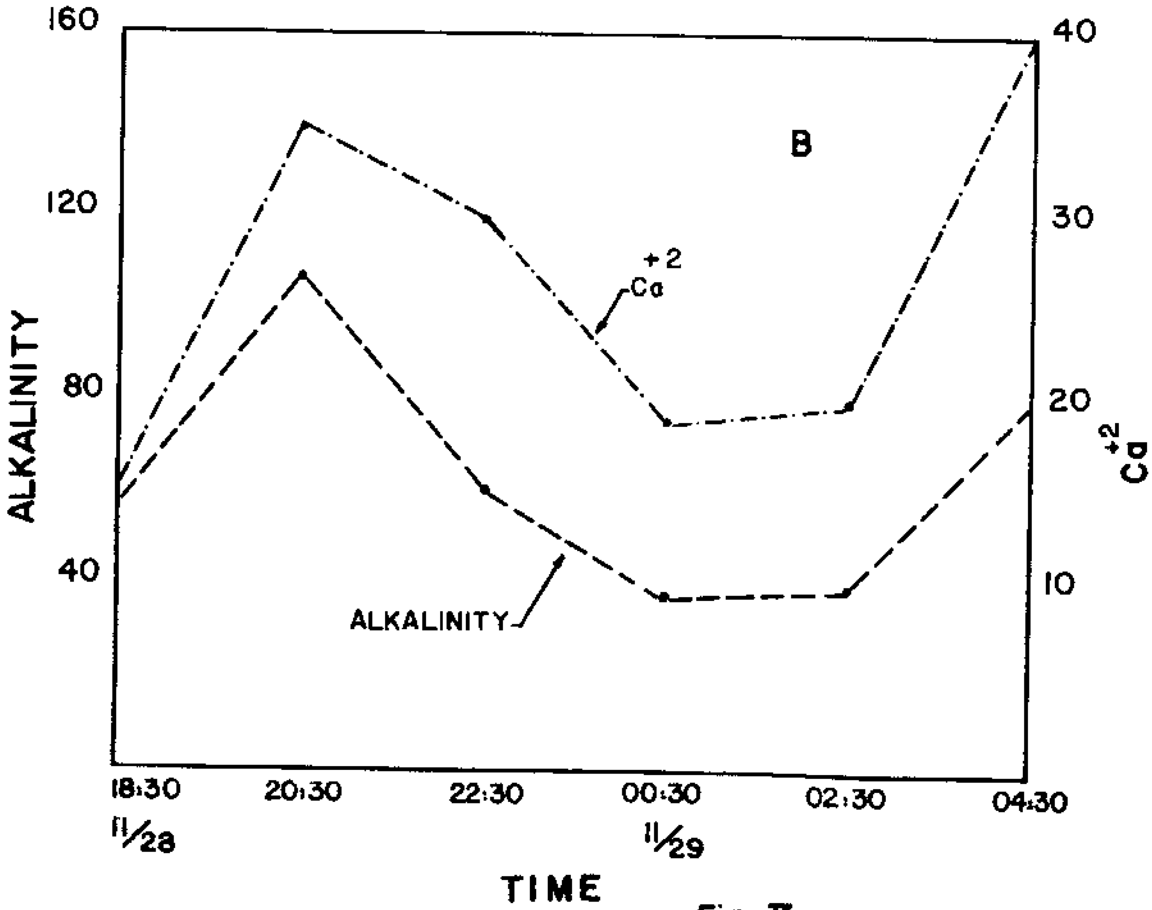
Lead distribution in Marina Sediment
Fig VIII



Cadmium distribution in Marina Sediment
Fig IX

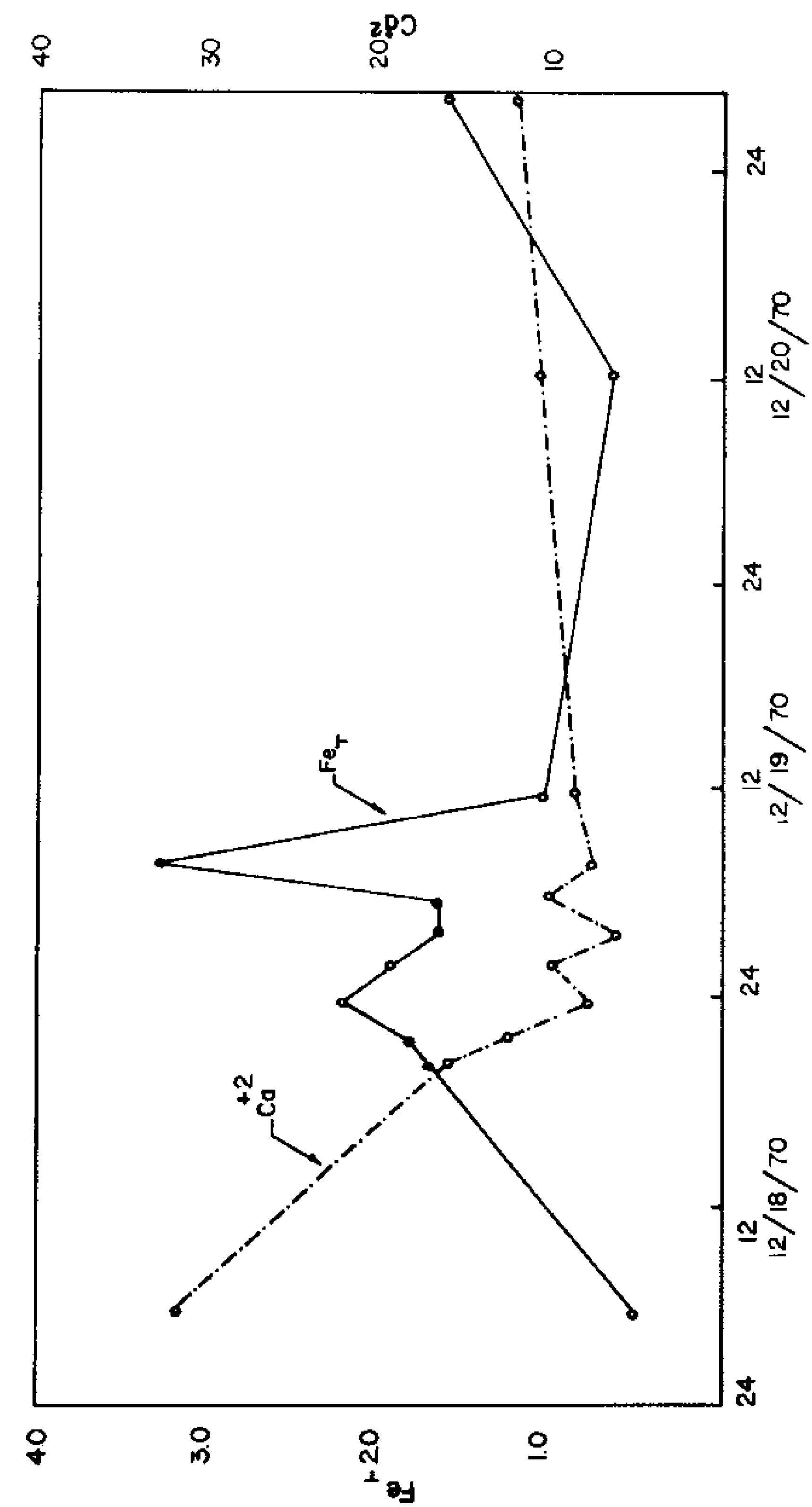


800
600
400
200
A
TURBIDITY
18:30
11/28
20:30
22:30
00:30
11/29
02:30
04:30



160
120
80
40
ALKALINITY
B
+2
Ca
ALKALINITY
40
30
20
10
Ca+2
18:30
11/28
20:30
22:30
00:30
11/29
02:30
04:30
TIME

Fig X



4.0
3.0
2.0
1.0
Fe
T
40
30
20
10
Ca
+2
Fe
T
24
12
12/18/70
24
12
12/19/70
24
12
12/20/70
24

Fig XI A

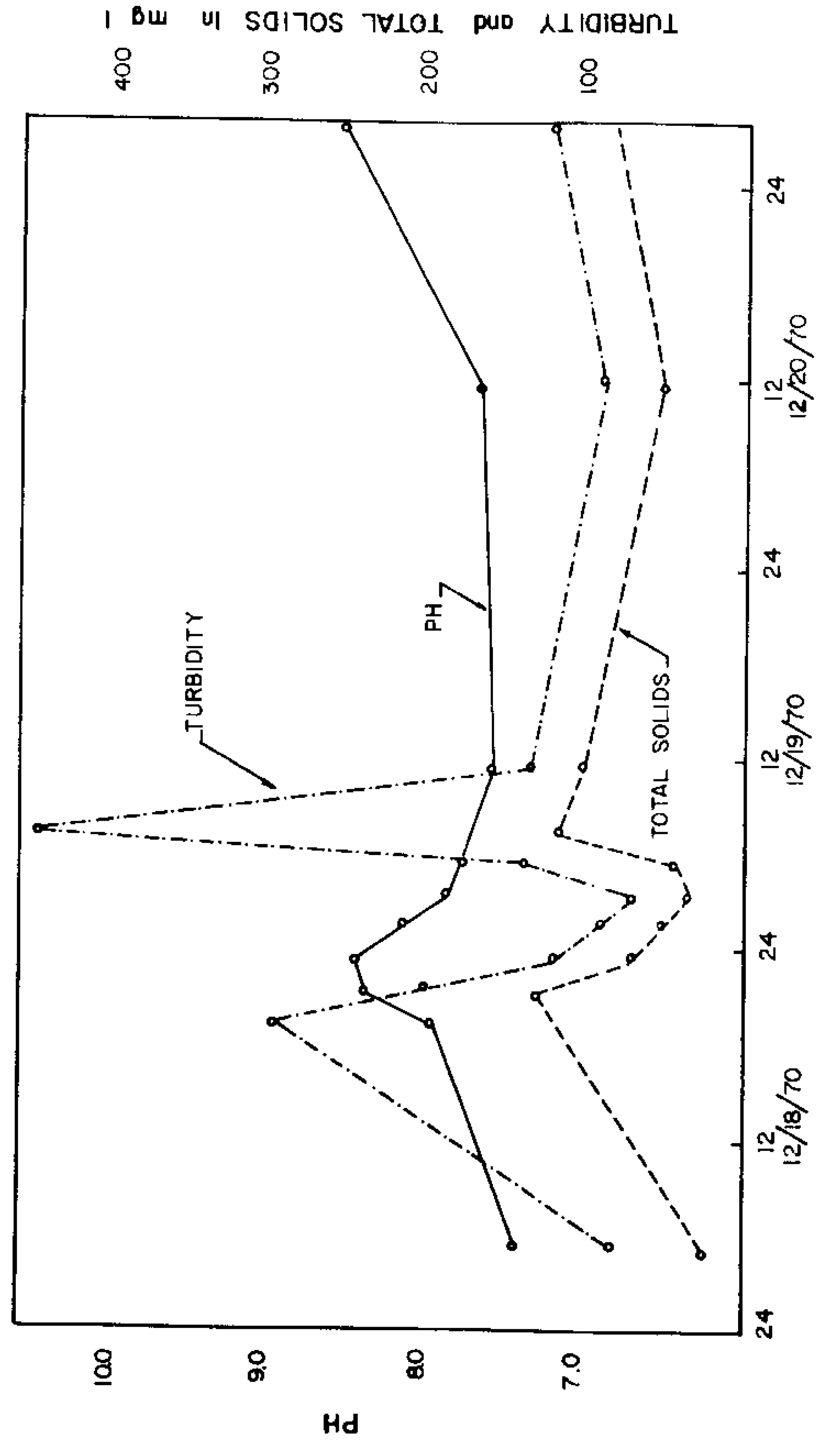

TURBIDITY and TOTAL SOLIDS in mg l
400
300
200
100
TURBIDITY
PH
TOTAL SOLIDS
PH
10.0
9.0
8.0
7.0
24
12
12/18/70
24
12
12/19/70
24
12
12/20/70
24

Fig XI B

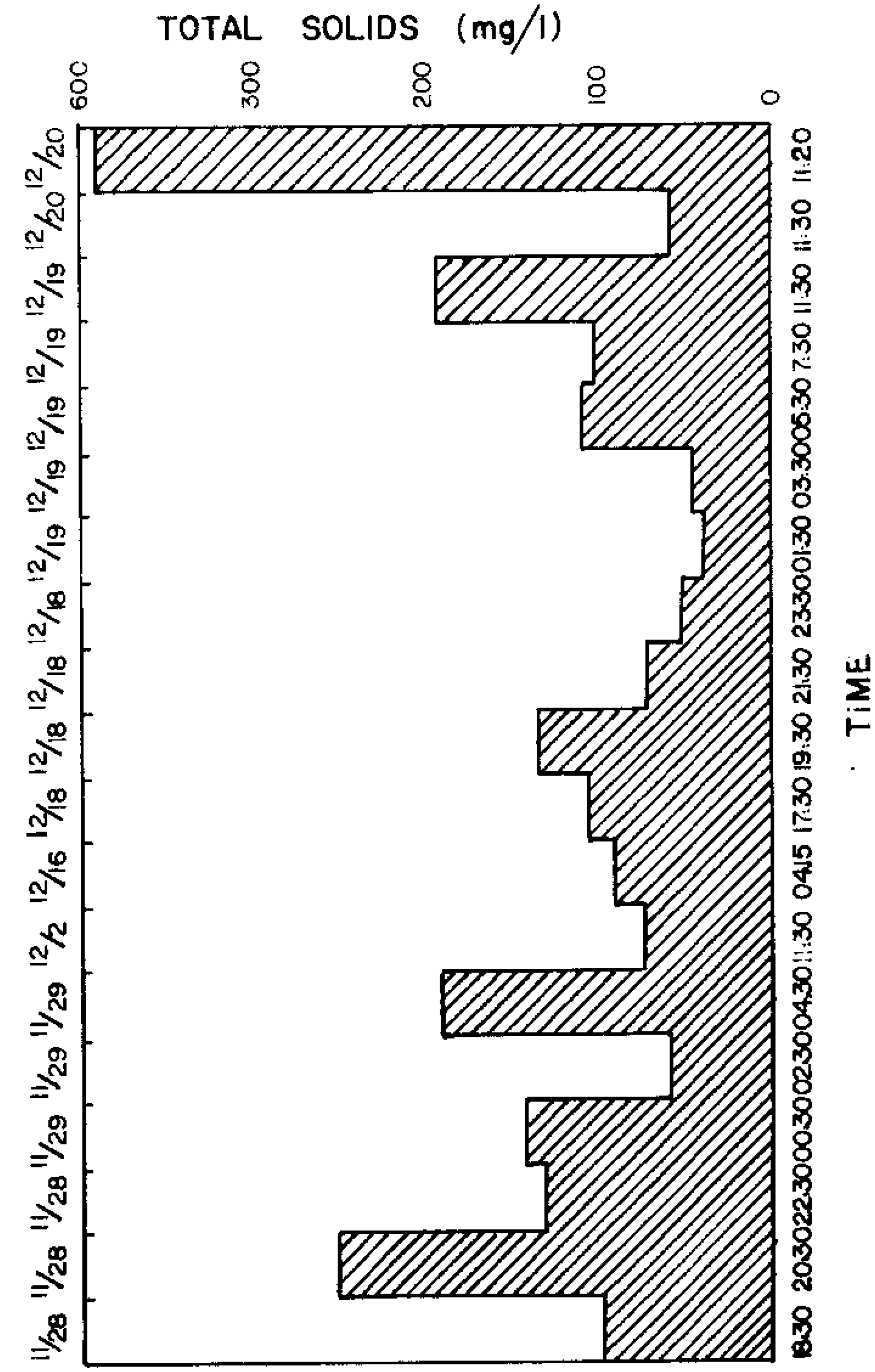


Fig XII

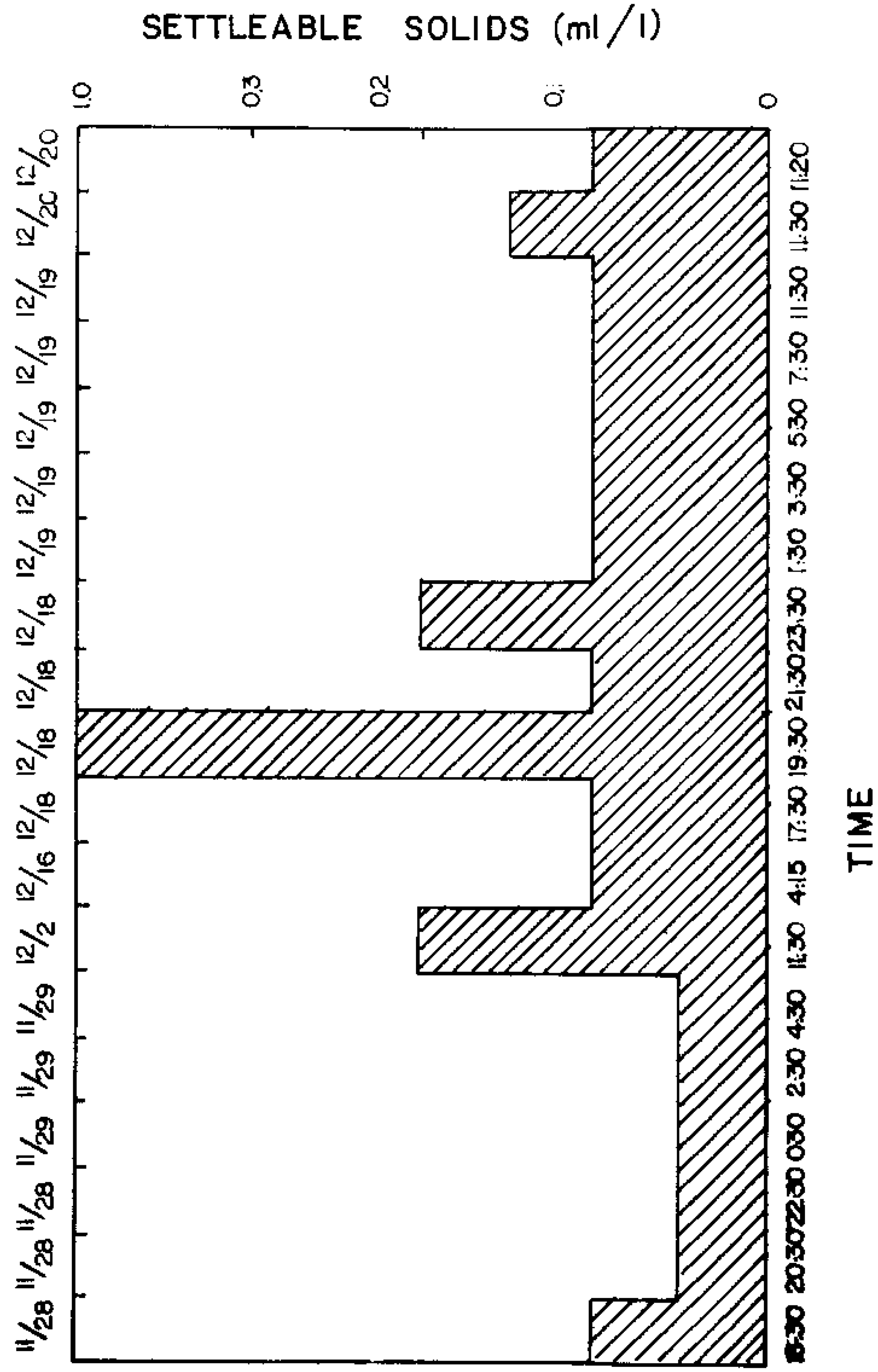

SETTLEABLE SOLIDS (ml/l)
1.0
0.3
0.2
0.1
0
TIME
11/28 11/28 11/28 11/28 11/29 11/29 11/29 12/2 12/16 12/18 12/18 12/18 12/18 12/19 12/19 12/19 12/19 12/19 12/20 12/20
18:30 20:30 22:30 0:30 2:30 4:30 11:30 4:15 17:30 19:30 21:30 23:30 1:30 3:30 5:30 7:30 11:30 11:30 11:20

Fig XIII

Fig XIV

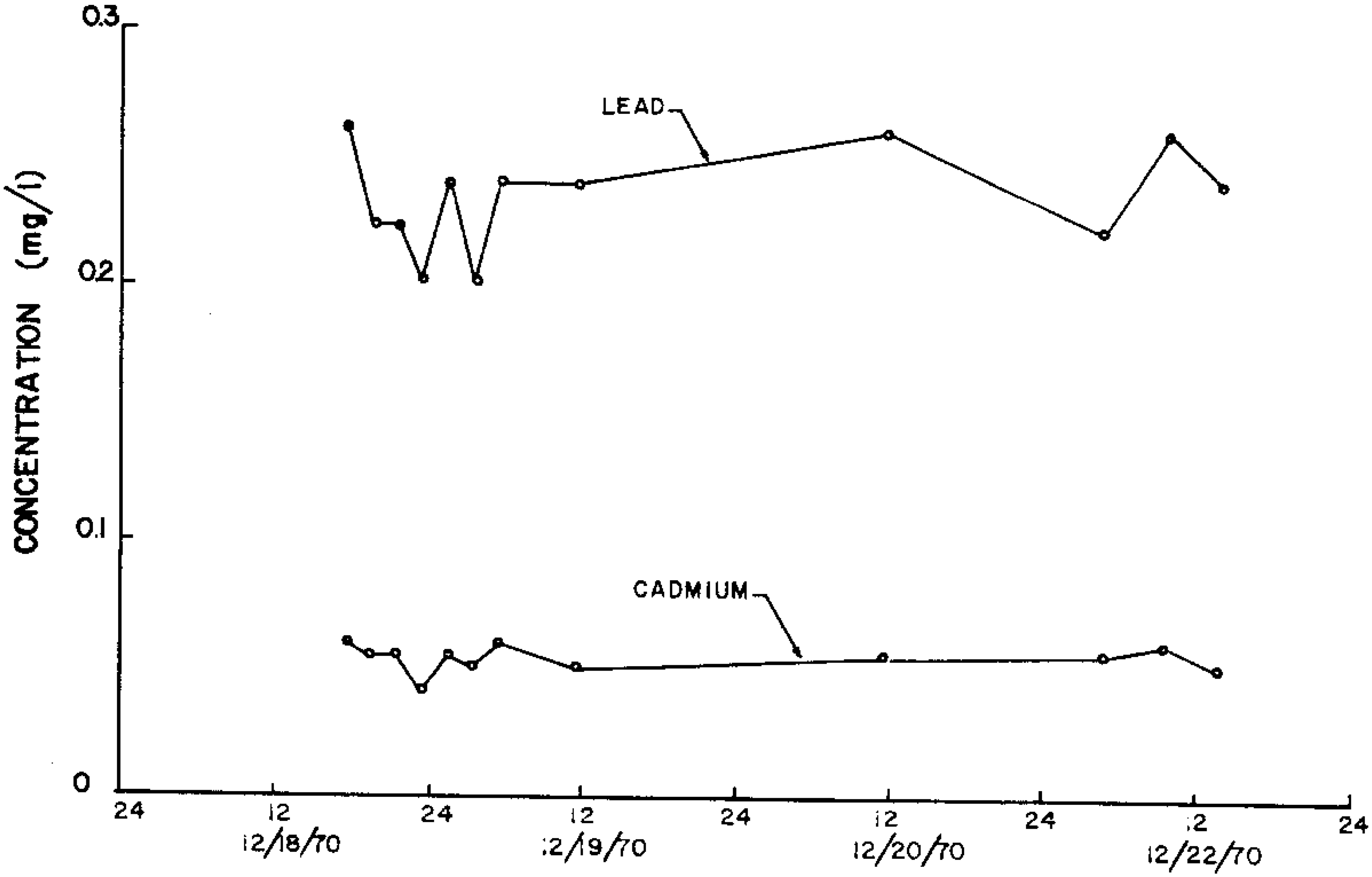

CONCENTRATION (mg/l)
0.3
0.2
0.1
0
LEAD
CADMIUM
24
12
12/18/70
24
12
12/19/70
24
12
12/20/70
24
12
12/22/70
24

TABLE I

TYPICAL DATA OF DISSOLVED OXYGEN
(June, 1971) (mg/l)

Station & Location	Top	Bottom	Remarks
#1, Basin E	5.1	4.4	Oxford pond and pumping station inlets
#11, Mid-channel, between basins E & F	6.0	6.0	
#24, Basin D	6.2	6.1	near beach area
#27, Basin F	5.5	5.7	
#40, Basin G	6.2	5.7	
#48, Basin C	5.4	5.4	
#54, Mid-channel encircled by basins BCGH	7.6	6.1	
#61, Basin B	5.0	5.2	
#66, Basin H	5.8	5.6	Lincoln storm drain inlet
#79, Basin A	5.95	4.95	
#94, Mid-channel between UCLA boat house and Marina Admiralty	6.80	6.90	
#109, Center of breakwater	8.0	6.50	
#114, Breakwater and Ballona Creek	8.3	6.60	
#112, Marina entrance	2.9	0.8	
#113, Marina entrance	7.6	1.1	

TABLE II

GENERAL PHYSICAL CHARACTERISTICS
OF WATER BODY OF THE MARINA

Stations	Depth (m)	Temperature (C^o)		Salinity $^o/oo$		Clarity Secchi (m)	pH		Date
		Top	Bot	Top	Bot		Top	Bot	
1	3.8	15	14	31.8	32.2	1.9	7.8	8.1	2/23/71
2	3.2	15	14	31.5	31.0	1.5	--	--	"
3	3.0	15.5	14.5	31.5	32.2	1.5	--	--	"
4	3.0	15.5	14.2	31.5	32.0	2.0	--	--	"
5	3.1	15.2	14.0	31.5	31.0	1.5	--	--	"
6	3.2	15.5	14.1	31.8	32.0	2.0	--	--	"
7	3.0	15.2	14.0	31.8	31.2	2.0	--	--	"
8	3.0	15.5	14.0	31.8	31.2	1.9	--	--	"
9	3.3	15.5	14.5	31.8	32.2	2.0	--	--	"
10	3.4	12.0	11.5	33.2	33.4	2.5	8.0	7.8	3/3/71
11	3.4	11.5	11.5	33.4	33.4	3.2	7.8	7.7	"
12	3.3	11.3	11.5	33.4	33.4	2.1	8.0	7.8	"
13	3.5	12.0	11.2	33.2	32.6	2.0	8.0	8.2	"
14	2.8	12.0	11.6	33.2	33.0	2.0	8.0	8.1	"
15	3.0	12.0	11.5	33.2	33.0	2.0	8.1	8.1	"
16	3.3	12.0	11.5	33.2	33.0	1.5	8.1	8.0	"
17	2.8	12.0	11.5	33.4	32.8	1.8	8.1	8.1	"
18	2.9	11.8	11.5	33.0	33.0	2.0	8.1	8.1	"
19	3.4	12.3	11.5	33.3	33.0	2.1	7.9	7.9	"
20	3.5	11.9	11.3	33.2	32.8	2.3	7.9	7.8	"

Continued
Table II

Stations	Depth (m)	Temperature (C^{o})		Salinity $^{o}/_{oo}$		Clarity Secchi (m)	pH		Date
		Top	Bot	Top	Bot		Top	Bot	
21	3.3	11.9	11.3	33.2	32.8	2.1	7.8	7.8	3/3/71
22	3.5	12.0	11.4	33.2	33.0	2.3	7.9	7.9	"
23	3.5	11.8	11.2	33.2	32.8	2.5	7.9	7,9	"
24	3.8	11.8	11.4	33.2	32.8	2.4	7.9	7.9	"
25	4.0	12.8	11.7	33.2	33.2	2.5	7.5	7.5	"
26	3.9	12.4	11.6	33.4	33.4	2.0	7.5	7.5	"
27	4.0	12.5	11.6	33.4	33.4	2.1	7.8	7.8	"
28	3.5	12.2	11.7	33.4	33.4	1.9	7.6	7.6	"
29	4.1	12.5	11.2	33.4	33.4	2.0	7.8	7.8	"
30	4.1	12.4	11.5	33.4	33.4	2.5	7.6	7.6	"
31	4.4	12.2	11.0	33.4	33.5	2.3	7.6	7.5	"
32	4.5	12.0	10.9	33.2	33.0	2.5	7.5	7.5	"
33	4.2	12.2	11.0	33.2	33.5	2.4	7.6	7.6	"
34	4.4	12.4	11.0	33.4	33.5	2.4	7.6	7.6	"
35	4.5	12.3	10.8	33.4	33.6	2.4	7.7	7.6	"
36	4.4	12.0	10.8	33.2	33.6	2.0	7.8	7.6	"
37	4.5	12.2	11.2	33.2	33.4	2.2	7.8	7.8	"
38	4.2	12.3	11.8	33.4	33.4	2.2	7.9	7.8	"
39	4.0	12.3	11.6	33.4	33.4	2.4	7.9	7.8	"
40	4.4	12.2	11.8	33.4	32.9	2.4	7.9	7.7	"

Continued
Table II

Stations	Depth (m)	Temperature (C°)		Salinity ⁰/oo		Clarity Secchi (m)	pH		Date
		Top	Bot	Top	Bot		Top	Bot	
41	4.1	11.5	11.3	33.4	33.5	2.4	7.8	7.6	3/3/71
42	4.3	12.8	11.9	33.4	33.4	2.6	7.6	7.6	"
43	4.1	12.6	11.7	34.0	33.8	2.4	7.6	7.6	"
44	5.0	12.8	12.1	33.4	32.9	2.3	7.6	7.5	3/9/71
45	4.8	12.7	12.2	33.2	33.2	2.4	7.6	7.6	"
46	4.2	12.6	12.5	34.0	33.6	2.5	7.6	7.4	"
47	4.2	12.7	12.4	33.2	33.2	2.4	7.4	7.5	"
48	4.4	12.6	12.7	33.2	33.8	3.0	7.5	7.5	"
49	4.4	12.5	12.6	33.2	33.8	2.5	7.4	7.5	"
50	4.8	12.7	12.4	33.2	33.8	2.4	7.5	7.5	"
51	5.6	12.9	11.8	33.0	33.4	2.2	7.5	7.5	"
52	5.4	12.9	11.9	33.0	33.4	2.3	7.5	7.5	"
53	5.5	12.9	11.9	33.0	33.4	2.3	7.5	7.5	"
54	5.4	13.0	11.9	33.0	33.4	2.3	7.5	7.5	"
55	5.3	12.8	11.8	33.2	33.4	2.7	7.9	8.0	"
56	5.0	12.6	11.9	33.2	33.4	3.5	7.8	7.8	"
57	4.0	12.8	12.2	33.2	33.2	2.4	7.9	7.8	"
58	4.3	13.0	12.1	33.0	33.2	2.5	8.0	8.0	"
59	3.8	12.6	12.4	33.2	33.2	3.0	7.9	7.8	"
60	4.1	12.9	12.3	33.2	33.2	3.1	7.8	7.8	"

Continued
Table II

Stations	Depth (m)	Temperature (C^o)		Salinity $^o/oo$		Clarity Secchi (m)	pH		Date
		Top	Bot	Top	Bot		Top	Bot	
61	3.8	13.0	12.4	33.0	33.2	2.8	7.2	7.6	3/9/71
62	4.0	13.0	12.3	33.2	33.2	2.5	7.7	7.7	"
63	4.2	12.8	32.3	33.2	33.2	3.0	7.8	7.7	"
64	3.9	12.8	12.4	33.2	33.2	3.0	7.6	7.6	"
65	3.6	13.4	12.9	33.4	33.3	2.0	7.7	7.6	"
66	3.5	13.5	12.4	33.4	33.4	2.0	7.7	7.7	"
67	3.5	13.1	12.2	33.4	33.3	2.0	7.7	7.7	"
68	3.2	13.1	12.3	33.4	33.3	2.0	7.7	7.7	"
69	3.1	13.2	12.6	33.4	33.2	2.0	7.7	7.7	"
70	3.3	13.4	12.9	33.4	33.3	2.0	7.7	7.6	"
71	4.5	13.2	12.3	33.4	33.4	2.0	7.6	7.6	"
72	4.8	13.2	12.8	33.4	33.4	2.0	7.7	7.7	"
73	4.7	13.0	12.7	33.4	33.4	2.0	7.7	7.7	"
74	4.8	12.9	12.1	33.4	33.3	2.0	7.8	7.7	"
75	5.0	13.0	12.3	33.4	33.2	2.3	7.6	7.7	"
76	4.3	12.9	12.2	33.2	33.2	2.3	7.6	7.6	"
77	3.8	12.8	12.2	33.6	33.2	2.4	7.6	7.6	"
78	4.3	12.9	12.2	33.6	33.3	2.3	7.6	7.6	"
79	3.8	12.8	12.2	33.4	33.3	2.4	7.6	7.6	"
80	3.5	13.0	12.3	33.6	33.3	2.6	7.7	7.6	"

Continued
Table II

Stations	Depth (m)	Temperature (C°)		Salinity ‰		Clarity Secchi (m)	pH		Date
		Top	Bot	Top	Bot		Top	Bot	
81	3.5	13.5	12.4	33.6	33.3	2.8	7.7	7.6	3/9/71
82	3.3	12.9	12.2	33.6	33.3	2.2	7.6	7.5	"
83	7.5	12.8	12.3	33.2	33.8	2.0	7.7	7.7	3/11/71
84	6.8	12.4	12.8	33.3	33.2	2.3	7.7	7.8	"
85	7.0	13.0	12.5	34.0	34.0	2.3	7.7	7.7	"
86	7.3	12.7	12.4	34.0	34.0	2.8	7.8	7.4	"
87	7.0	12.6	12.4	34.0	34.0	2.3	7.8	7.8	"
88	7.2	12.5	12.3	34.0	34.0	2.3	7.8	7.8	"
89	8.4	12.6	12.3	34.0	34.0	2.5	7.8	7.8	"
90	8.3	12.6	12.4	34.0	34.0	2.0	7.8	7.8	"
91	7.8	12.8	12.0	34.0	33.4	2.0	7.9	7.9	"
92	8.5	12.7	12.0	34.0	33.6	2.3	7.8	7.8	"
93	8.1	12.7	11.9	34.0	33.6	2.2	7.9	7.9	"
94	3.5	12.7	12.3	34.0	33.6	2.6	7.9	7.9	"
95	2.3	12.8	12.6	34.0	33.6	1.8	8.0	7.9	"
96	8.0	12.8	11.8	34.0	11.4	2.4	7.8	7.9	"
97	3.5	12.5	12.7	34.0	33.4	3.0	7.9	7.9	"
98	7.8	12.8	11.8	34.0	33.6	2.3	7.9	7.9	"
99	7.6	12.7	11.7	34.0	33.8	2.3	8.0	7.9	"
100	5.4	12.8	11.8	34.0	33.8	3.0	8.0	7.8	"

Continued
Table II

Stations	Depth (m)	Temperature (C°)		Salinity °/oo		Clarity Secchi (m)	pH		Date
		Top	Bot	Top	Bot		Top	Bot	
101	7.5	12.8	11.8	34.0	33.8	2.3	7.9	7.8	3/11/71
102	7.2	12.9	11.6	34.0	33.8	2.4	7.9	7.8	"
103	5.4	12.4	11.9	34.0	33.4	3.2	7.8	7.8	"
104	6.5	12.8	11.5	34.0	33.8	3.0	8.0	7.8	"
105	6.8	13.2	11.9	33.6	33.6	2.2	----	7.2	"
106	3.25	13.5	11.8	32.6	33.2	1.9	7.9	7.9	"
107	7.6	13.2	11.8	33.6	33.4	2.4	7.9	7.9	"
108	7.9	13.0	12.1	32.6	33.2	2.5	7.9	7.9	"
109	2.3	14.9	13.1	29.6	33.3	1.5	7.9	7.9	"
110	2.5	14.8	13.1	33.2	33.3	1.6	7.9	7.7	"
111	6.0	13.0	11.9	34.0	33.4	3.4	7.8	7.9	"
112	7.2	13.0	12.1	34.0	33.2	2.3	7.9	7.9	"
113	7.3	13.1	11.8	34.0	32.9	2.6	7.9	7.9	"
114	9.8	13.5	11.3	32.6	33.8	2.5	7.9	7.9	"
115	7.5	13.8	11.8	32.0	33.4	2.5	7.9	7.9	"
116	2.3	15.1	13.3	29.0	32.6	1.6	7.7	7.7	"

TABLE III

Concentration of Heavy Metals in Water of Marina del Rey

Station Number	Mercury μg/l	Lead mg/l	Cadmium μg/l	Antim[illegible] mg/l
1	<0.3	0.12	2.5	----
18	<0.03	0.14	2.7	----
36	<0.03	0.17	2.5	----
51	<0.03	0.10	2.5	----
54	<0.03	0.20	2.5	----
63	<0.03	0.17	2.5	----
71	<0.03	0.17	2.5	----
25	<0.03	0.14	2.5	----
40	<0.03	0.10	2.5	0.17
81	<0.03	0.12	2.5	----
125	<0.03	0.14	2.7	----
96	<0.03	0.10	5.0	0.08
108	<0.03	0.10	5.0	0.17
111	<0.03	0.08	4.0	0.30
112	<0.03	0.08	4.0	0.08

TABLE IV

Concentration of Heavy Metals in
Southern California Coastal Water

		Lead in ppb	Cadium in ppb	Mercury in ppb
Marina del Rey		100-170	2.5- 5.0	<0.03
San Pedro	Top	180-266	6.0-11.0	<0.03
Harbor	Bottom	192-266	6.0-11.0	<0.03
Long Beach	Top	144-160	6.5- 6.5	<0.03
Harbor	Bottom	160	6.5- 7.2	<0.03
Santa Monica	Top	120-160	10.0-11.0	<0.03
Bay	Bottom	160-240	10.0-11.0	<0.03

TABLE V

Concentration of Heavy Metals in Sediments
of Marina del Rey

Station #	Depth (inch)	Cadmium mg/kg Dry Wt.	Lead mg/kg Dry Wt.	Mercury mg/kg Dry Wt.	Manganese mg/kg Dry Wt.	Iron mg/kg Dry Wt.
1	0-1	3.21	137.2	1.140	----	----
1	1-2	3.72	107.3	0.580	----	----
1	2-3	4.08	110.0	0.525	----	----
1	3-4	2.41	67.5	0.306	----	----
1	4-5	1.69	45.0	0.184	----	----
1	5-6	1.195	37.8	0.175	----	----
54	0-2	3.98	149	----	----	----
54	2-4	4.12	156	----	----	----
54	4-6	5.36	165	----	----	----
54	6-8	4.87	143	----	----	----
54	8-10	5.30	146	----	----	----
54	10-12	4.70	134.5	----	----	----
54	12-14	5.20	100	----	----	----
54	14-16	3.00	102	----	----	----
66	0-1	6.029	220	0.457	54.4	$3.36x10^4$
66	1-2	5.780	184	0.159	0.159	$4.38x10^4$
66	2-3	7.794	218	0.100	0.100	$4.07x10^4$
66	3-4	----	----	0.105	----	----
66	4-5	7.080	215	0.080	54.0	$3.82x10^4$
66	5-6	5.447	170	0.064	52.3	$3.34x10^4$
66	6-7	5.025	140.5	0.073	47.8	$2.79x10^4$
66	7-8	3.603	137.4	0.090	34.4	$2.06x10^4$

TABLE VI

Concentration of Chlorinated Pesticides in Water Samples of Marina del Rey (in ppb)

Sample #	Para-thion	PCNB	Telo-dren	2.4D	Methyl Ester 2.4D	2.4.5T	Ethyl Hexyl Ester 2.4D
1	0.05	N.D.	0.1	N.D.	N.D.	0.5	N.D.
2	0.02	0.05	N.D.	0.01	N.D.	0.05	N.D.
3	N.D.	N.D.	N.D.	0.05	N.D.	0.05	N.D.
4	N.D.	N.D.	N.D.	0.02	N.D.	N.D.	N.D.
5	N.D.	N.D.	N.D.	0.01	N.D.	0.01	N.D.
6	N.D.	N.D.	0.03	N.D.	N.D.	N.D.	N.D.
7	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
8	N.D.	N.D.	N.D.	0.04	N.D.	N.D.	0.1
9	N.D.	N.D.	N.D.	N.D.	0.03	N.D.	N.D.
10	N.D.	N.D.	N.D.	N.D.	0.03	N.D.	N.D.
11	0.01	N.D.	N.D.	N.D.	0.03	N.D.	N.D.
12	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
13	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
14	N.D.	N.D.	N.D.	N.D.	N.D.	0.04	N.D.
15	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

N.D. is less than 0.01 ppb

Table VI
Continued

Sample #	Dyrene	Endrin	Hepta-chlor	Hepta-chlor Epoxide	Hexa-chlor Benzene	Lindane	Neburo
1	N.D.	0.2	N.D.	0.06	N.D.	0.07	N.D.
2	0.5	N.D.	0.1	N.D.	N.D.	0.05	0.01
3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.03
4	N.D.	N.D.	0.2	N.D.	N.D.	N.D.	0.02
5	N.D.	N.D.	N.D.	N.D.	0.01	0.04	0.03
6	N.D.	N.D.	N.D.	N.D.	N.D.	0.02	N.D.
7	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
8	N.D.	N.D.	0.04	N.D.	N.D.	0.04	0.2
9	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.1
10	N.D.	N.D.	N.D.	N.D.	N.D.	0.01	0.2
11	N.D.	N.D.	N.D.	N.D.	N.D.	0.02	0.02
12	N.D.	N.D	N.D.	N.D.	N.D.	0.01	0.05
13	N.D.	N.D.	N.D.	N.D.	N.D.	0.05	0.3
14	N.D.	N.D.	N.D.	N.D.	0.07	N.D.	2
15	N.D.	N.D.	N.D.	N.D.	0.03	N.D.	1

TABLE VII

Concentration of Chlorinated Pesticides Residues
In The Sediments of Marina del Rey (PPM)

Column Packing: 11% (OF1-OV17) Gas Chrom Q 80/100 @200°C

Station #	Depth (inch)	2.4D	2.4D.B.	BHC	Chlorodane	DDE	Lindane
1	1	N.D.	4.5	3.6	N.D.	31	N.D.
1	2	N.D.	14	10.5	N.D.	45.5	N.D.
1	3	N.D.	7.7	1.9	N.D.	40	N.D.
1	4	N.D.	5.6	1.8	3	19.2	N.D.
1	5	N.D.	1.4	<1	5	8.9	N.D.
61	1	N.D.	N.D.	1.1	N.D.	2.5	0.1
61	2	N.D.	2.3	3	N.D.	6.2	N.D.
61	3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
61	4	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
61	5	N.D.	<0.1	0.7	N.D.	0.4	<0.1
61	6	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
61	7	N.D.	0.3	0.6	N.D.	0.5	<0.1
61	8	N.D.	0.5	0.3	N.D.	1.8	N.D.
61	9	N.D.	0.3	N.D.	N.D.	1	N.D.
61	12	N.D.	N.D.	N.D.	N.D.	1	N.D.
66	1	N.D.	15.2	N.D.	N.D.	23	N.D.
66	2	N.D.	1.8	N.D.	N.D.	6.9	N.D.
66	3	0.9	3.7	N.D.	N.D.	7.2	N.D.
66	4	N.D.	1	N.D.	N.D.	2.9	N.D.
66	5	N.D.	2.9	N.D.	N.D.	3	N.D.
66	6	N.D.	0.7	N.D.	N.D.	1.6	N.D.

Table VII
Continued

Station #	Depth (inch)	Methyl ester 2.4-D	Ethyl ester 2.4D	Ethyl ester 2.4D	Heptachlor	op. DDT	Toxaphene
56	1	4.3	0.4	8.6	0.4	N.D.	N.D.
56	2	1.3	1.3	2.7	1.3	N.D.	N.D.
56	6	1.5	N.D.	2.3	N.D.	0.2	0.3
56	9	1.7	N.D.	1.7	N.D.	0.1	0.1
56	12	2.3	N.D.	3.4	N.D.	N.D.	N.D.

N.D. - less than 0.1 ppm

TABLE VIII SEDIMENT SIZE DISTRIBUTION IN MARINA DEL REY

Station Number and Location	Total Weight (gms)	1 mm	.5 mm	.250 mm	.125 mm	.0625 mm	$\angle$.0625 mm	Remarks
#1, Basin E	15.055				2.261	5.776	7.220	Sandy mud, near Oxford pumping Station
#11, Between basin E & F	15.042				3.935	5.299	5.900	Muddy sand
#23, Basin D	15.039				3.351	5.861	5.941	Muddy sand
#24, Basin D, Near beach	15.029				1.497	4.685	8.971	Sandy mud
#27, Basin F	15.035				3.265	6.170	5.741	Muddy sand
#38, Basin G	15.065				1.961	5.782	8.444	Sandy mud
#48, Basin C	15.052				4.969	7.371	2.829	Fine sand
#66, Basin H	15.027				1.797	12.761	0.544	Fine sand near Lincon storm drain
#96, Mid-channel	15.045				3.961	5.024	6.109	Muddy sand
#76, entrance of Basin A	15.027	.048	.232	.002	3.597	3.879	7.330	Sandy mud
#100, Mid-channel near Pacific Ave.	15.048				2.092	3.371	9.692	Sandy mud

Continued - Table VIII
Sediment Size Distribution
in Marina del Rey

Station Number and Location	Total Weight (gms)	1 mm	.5 mm	.250 mm	.125 mm	.0625 mm	∠.0625 mm	Remarks
#103, Mid-channel	15.031				1.472	2.910	10.741	Sandy mud
#108, Marina entrance	15.040				4.450	4.518	5.075	Muddy sand
#109, Breakwater	15.064			1.424	5.327	5.746	1.828	Fine sand
#112, Breakwater	15.010			1.040	4.247	5.847	3.885	Fine sand
#113, Breakwater	15.014				2.071	3.741	9.253	Sandy mud
#114, Between Ballona Creek and Breakwater	15.029			2.538	4.920	3.840	3.692	Fine sand
#116, Ballona Creek	15.054				3.391	4.386	7.331	Sandy mud

TABLE IX
CARBON ANALYSIS BY GASOMETRIC LECO METHOD

Stations	Total C	% Inorganic C.	% Organic C.
1	3.030	1.423	1.607
11	4.837	2.184	2.653
23	4.162	2.320	1.842
24	4.233	2.974	1.259
27	6.100	4.382	1.718
38	3.489	2.235	1.254
48	5.847	3.130	2.717
66	4.968	2.235	2.733
74	6.054	3.116	2.938
76	4.928	3.662	1.266
94	5.642	3.758	1.884
100	6.587	3.721	2.866
103	8.448	5.485	2.963
108	9.620	2.915	6.605
109	12.580	5.662	6.918
112	3.856	1.891	1.966
113	8.731	4.922	3.809
114	8.690	5.139	3.551
116	9.250	6.209	3.041
XR	10.940	6.170	4.770

TABLE X
TOTAL AND SETTLEABLE SOLIDS

Source	Date	Time	Total Solids mg/l	Settleable Solids mg/l	Remarks
Storm water	11/28/70	18:30	98.0	0.10	
Storm water	11/28/70	20:30	245.5	0.40	
Storm water	11/28/70	22:30	134.8	0.05	
Storm water	11/29/70	00:30	138.8	0.05	
Storm water	11/29/70	02:30	53.8	0.05	
Storm water	11/29/70	04:30	195.0	0.05	
Boone Olive pumping station	12/2/70	11:30	73.6	0.2	
Mid-channel Marina	12/2/70	03:15	3163.0	0.0	
Basin E Marina	12/2/70	03:30	3055.0	0.0	
	12/16/70	04:15	85.0	0.1	
Boone Olive pumping station	12/18/70	17:30	115.8	0.10	Sample taken 10 minutes after rain
Boone Olive pumping station	12/18/70	19:30	131.0	1.0	
Boone Olive pumping station	12/18/70	21:30	70.0	0.10	
Boone Olive pumping station	12/18/70	23:30	52.0	0.2	
Boone Olive pumping station	12/19/70	01:30	35.0	0.1	
Boone Olive pumping station	12/19/70	03:30	43.6	0.1	

Continued
Table X
Total and Settleable Solids

Sample Number	Date	Time	Total Solids mg/l	Settleable Solids mg/l	Remarks
Boone Olive pumping station	12/19/70	05:30	115.6	0.1	
Boone Olive pumping station	12/19/70	07:30	100.0	0.1	
Boone Olive pumping station	12/21/70	11:30	196.0	0.1	
Lincoln Basin H	12/21/70	11:20	564.2	0.1	
Boone Olive pumping station	12/20/70	04:45	249.0	0.2	

TABLE XI

Runoff at Boone-Olive Pumping Station
1970-71

Date	Outflow Acre-Feet	Rainfall Inches	Percent Yield
11/28/70 11/29/70	9	2.86	44.5
12/16/70	0.01	0	-
12/18/70 12/19/70	6	3.07	27.6
12/21/70	0.7	0.7	14.0
4/14/71	1	0.7	20.0

TABLE XII

Concentration of Heavy Metals in Storm Water

Sample Number	Date	Time	Lead mg/l	Cadmium Cd µg/l	Antimony Sb mg/l
1	12/2/70	11:30	0.26	55	0.35
2	12/16/70	16:15	0.20	50	0.30
3	12/18/70	17:30	0.26	60	----
4	12/18/70	19:30	0.22	55	----
5	12/18/70	21:30	0.22	55	----
6	12/18/70	23:30	0.20	40	0.25
7	12/19/70	1:30	0.24	55	----
8	12/19/70	3:30	0.20	50	0.30
9	12/19/70	5:30	0.24	60	0.30
10	12/19/70	11:30	0.24	50	0.30
11	12/20/70	11:30	0.26	50	0.30
12	12/20/70	11:20	0.24	55	----
13	12/21/70	4:45	0.22	55	----
14	12/21/70	9:30	0.26	60	----
15	12/21/70	13:30	0.24	50	0.30
16	4/14/71	8:10	0.28	60	0.35
17	4/14/71	10:12	0.26	55	0.35
18	4/14/71	11:45	0.32	50	----

TABLE XIII

Concentration of Chlorinated Pesticides in Storm Water in ppb

Marina del Rey Harbor

Sample Description	Aldrin	BHC	pp' DDE	op DDT	Dichlone	Diuron
#1(50-50 of Station 57 & 62 depth 4') Marina del Rey April 12, 1971	N.D.*	0.1	0.02	N.D.*	N.D.*	N.D
#2 Marina del Rey April 14, 1971	0.1	0.05	N.D	N.D.	N.D.	0.01
#3 Stormwater December 8, 1970	0.03	N.D.	N.D.	N.D.	N.D.	0.03
#4 Stormwater December 12, 1970	0.1	N.D.	N.D.	N.D.	N.D.	0.02
#5 Stormwater December 20, 1970	0.5	N.D.	N.D.	N.D.	N.D.	0.03
#6 Stormwater December 20, 1970	0.2	N.D.	N.D.	N.D.	N.D.	N.D.
#7 Stormwater December 18, 1970	0.03	N.D.	N.D.	N.D.	N.D.	N.D.
#8 Stormwater December 18, 1970	N.D.	N.D.	0.05	0.05	N.D.	0.2
#9 Stormwater December 19, 1970	N.D.	N.D.	N.D.	N.D.	N.D.	0.1
#10 Stormwater December 21, 1971	N.D.	N.D.	N.D.	N.D.	0.01	0.2
#11 Stormwater December 19, 1970	N.D.	N.D.	N.D.	N.D.	N.D.	.02
#12 Stormwater December 18, 1970	N.D.	N.D.	N.D.	N.D.	N.D.	0.05
#13 Stormwater December 2, 1970	N.D.	N.D.	N.D.	0.01	N.D.	0.3
#14 Stormwater December 19, 1970	N.D.	N.D.	N.D.	0.04	N.D.	2
#15 Stormwater December 2, 1970	N.D.	N.D.	N.D.	N.D.	N.D.	1

* N.D. - Not Detectable Below 0.01 PPb