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Shrimp Production in Louisiana Salt-Marsh Impoundments Under Semi-Natural and Experimental Conditions

1968-1971

Technical Report to Louisiana Land and Exploration and the Sea Grant Program

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by

Alva H. Harris

Sea Grant Director

Nicholls State University

Thibodaux, Louisiana

INTRODUCTION

The Sea Grant Research Project conducted by NSU at Point-au-Chein is an applied research program examining the feasibility of commercial shrimp farming in the Louisiana Salt-marshes. Considerable data has been accumulated concerning the biology and ecology of Brown shrimp (*Penaeus aztecus*), White shrimp (*P. setiferus*), and the Blue crab (*Callinectes sapidus*) since the program was initiated in February 1968.

Unfortunately, basic data from research conducted during 1968 and 1969 is not included in this report and is in the possession of Dr. Curtis Rose, Dr. Rose has assumed full responsibility for publishing the 1968-1969 research results (See attached letter. Appendix attachment #1). A paper describing the net results of the 1968-1969 study was presented to the Association of Southeastern Biologists Annual Meeting in April of 1970. An abstract of this paper was published and is attached as appendix attachment #2. Several featuresstories have appeared in local newspapers and copies are attached in the appendix.

Much of the environmental data presented in this report is in a preliminary form that has not been fully evaluated in terms of its effect upon shrimp production. Closer correlations between environmental parameters and shrimp and crab populations will be attempted as time permits during the immediate months ahead.

Specific objectives of 1970 and 1971 are: (1) Determine the effects of water exchange on shrimp production in Louisiana Salt-marsh Impoundments; (2) Examine the effects of Blue Crab Control on shrimp production in Louisiana Salt-marsh Impoundments; (3) Conduct overwintering survival studies and monitor the subsequent sexual development of adult white shrimp held in marsh impoundments.

The first part of the report deals directly with results of the primary objectives, and is followed by physical, chemical, biological, and management data that may or may not be correlated with results of the primary objectives.

Phase 1 -- 1968-1969 Description of project:

Studies concern factors related to the commercial culture of brown (*Penaeus aztecus*) and white shrimp (*Penaeus setiferus*) in Louisiana. Productivity studied are based upon an extensive culture approach in which supplemental feed is not added. The basic productivity and associated ecological factors are variables of the natural salt-marsh impoundments that determines shrimp production figures.

Two natural areas containing approximately 1/2 water and 1/2 salt-marsh (*Spartina patens*) were selected by aerial reconnisance. Water control was effected by the erection of earthen dykes around the perimeter and the installation of weirs for water exchange. One impoundment contained 20 acres of water and the other 10 acres. Average depth of both impoundments was 2 feet in the center and 1 foot or less near the marsh.

Both ponds were managed with the objectives of (1) determination of the basic productivity of the impoundments as measured in shrimp production and (2) measuring the effect of fish and crab predator control on shrimp production. Natural stocking of ingressing post-larval shrimp occurred across the weirs during night-time flood tides. Plankton samples taken at night during flood tides in adjacent bayous revealed the presence of the ingessing larval shrimp during these periods. Screening through hardware cloth during flooding periods prevented entrance of large shrimp and predators. Post-larvae stocking rates were estimated from plankton samples taken at the weir while flooding. Plankton samples taken during mid-day periods of draining excess water from the impoundments revealed no escapement of post-larvae.

Predator control was exercised in the 20 acre impoundment by rotenone applications for fish and baited wire traps for the blue crab, Callinectes sapidus. Predator control was not exercised in the 10 acre impoundment. Efficient harvesting of both ponds consisted of draining surface water at night across the weir into a net. Shrimp of commercial size rise to the surface and migrate out of the estuarine areas and into the Gulf at night during ebb tides. This behaviorial trait was exploited to efficiently harvest the ponds at the convenience of the investigator. Water levels dropped no more than 2 inches during any harvest period, and were maintained by subsequent flood tides.

Results

A. From 20 acre pond with predator control. Brown shrimp grew to 34 count (heads on number per pound) in 75 days and 12 count in 200 days. White shrimp reached 34 count in 60 days. Total harvest of both species for one season was 125 lbs. of 34 count shrimp per acre.

B. From 10 acre pond with no predator control. Total harvest of brown and white shrimp was 44 lbs of 70 count shrimp per acre. We think this closely approximates the natural productivity of shrimp in the unmanaged estuarine marshes. Seventy count shrimp are the average size of wild shrimp when they begin their return migration to the Gulf.

Dr. Rose has the raw data from the above 2-year study and has assumed publication responsibilities.

Phase 2 -- 1970-1971. Description of project:

Studies are currently evaluating the effects of water exchange and blue-crab predation on shrimp production in the previously described but somewhat altered impoundments. In addition, 2 small ponds (1/50 acre) each were dug and stocked with sub-adult brown and white shrimp for over-winter survival and subsequent sexual development studies.

1. Water Exchange Study

A. Methods

Effects of water exchange studies were conducted in the 10 acre impoundment that was rdduced to 5 acres with an earthen dyke and subsequently partitioned into 3 areas with plywood separations. Two of the partitioned areas were stocked with wild 12-15 mm brown shrimp postlarvae collected from the adjacent bayou with surface plankton nets pushed against the current during flood tides at night. Post-larvae were stocked at the rate of 12,000/acre. Mortality rates during stocking averaged less than 1%. Tidal exchange through 1/4" vinyl-coated screen is allowed in one partition while the other is held stagnant. Both areas contained 2 1/2 acres of water. A small unstocked 1/2 acre area acted as a control and was treated identical to the water exchange pond to measure the ingression of post-larval shrimp while flooding. Shrimp from both treatment ponds were sampled weekly for growth rates, disease, and coefficient of condition.

B. Results

Comparisons between shrimp from the flow and stagnant ponds have revealed no significant differences in growth rates or condition. It must be pointed out, however, that these are natural impoundments that are ecologically balanced, and the same results might not occur in artificial impoundments or even smaller natural ponds. This study terminated on September 16, 1971 when waters from Hurricane Edith flooded the impoundments and destroyed the partitions.

2. Blue-crab (*Callinectes sapidus*) predation study

A. Methods

Vinyl-coated 1/4" wire was used in constructing 9 study pens 50' x 50' square inside the natural 20-acre salt-marsh impoundment. All fish, shrimp, and crabs in the pens were killed by heavy applications of rotenone one week prior to stocking. Three of the 9 pens contained 25% *Spartina* marsh, and were markedly more shallow than the six in the middle of the pond. Juvenile brown shrimp used in the predation studies were collected at night from the surface water of the adjacent bayou during ebb tides in the same manner described previously for post-larvae collecting, except a larger mesh net was used. Crabs for the study were collected simultaneously with the juvenile shrimp. Shrimp were harvested 30 days after stocking by repeatedly seining each pen until all were collected. Supplemental feed was not added to the pens during the predation studies. All pens were being stocked with juvenile white shrimp for another 30-day crab predation study when hurricane Edith flooded the marsh.

B. Results

The following table summarizes the stocking rates of brown shrimp and blue-crabs and presents the results of 2 separate studies of 30 days each.

TABLE I

Stocking Rates and Results of 2 Replications of 30-Day Brown Shrimp - Blue Crab Predation Studies.

	Pen #1	Pen #2	Pen #3	Pen #4	Pen #5	Pen #6
Date 5/10/71 - 6/10/71	------	------	------	Control	------	------
# Shrimp Stocked	500	500	500	500	500	500
Size of Shrimp Stocked	60-90mm	60-90mm	60-90mm	60-90mm	60-90mm	60-90mm
# Crabs Stocked	35	35	75	0	25	75
Size of Crabs Stocked	75-125mm	75-125mm	50-75mm	------	125-165mm	50-75mm
# Shrimp Harvested	454	476	390	408	450	401
% Mortality	9.2	4.8	22.0	18.4	9.0	19.8
Date 6/29/71 - 7/29/71	------	------	------	------	------	------
# Shrimp Stocked	500	500	500	500	500	500
Size of Shrimp Stocked	60-90mm	60-90mm	60-90mm	60-90mm	60-90mm	60-90mm
# Crabs Stocked	35	35	75	0	25	75
Size of Crabs Stocked	75-125mm	75-125mm	50-75mm	------	125-165mm	50-75mm
# Shrimp Harvested	455	467	497	412	435	388
% Mortality	9.0	6.6	0.6	17.6	13.0	22.4
Average Mortality	9.1	5.7	11.3	18.0	11.0	21.1

Crabs were stocked at concentrations considered average or above in the estuarine areas. Stocking rates and average shrimp mortalities for all replications are as follows:

2 Replications of Large Crabs (125-165mm) @ 435/acre = 11.0% Shrimp Mortality
4 Replications of Medium Crabs (75-125mm) @ 609/acre = 7.4% Shrimp Mortality
4 Replications of Small Crabs (50-75mm) @ 1305 /acre = 16.2% Shrimp Mortality
2 Replications of 0 Crabs Stocked @ 0/acre = 18.0% Shrimp Mortality

Crab predationdata from the 3 shallower pens containing 25% marsh are considered unreliable and was not included in the table because of observed heavy predation by egrets, herons and raccoons. These predators were never observed in the six pens containing no marsh.

C. Discussion of crab predation results

It appears that in the Louisiana estuaries, characterized by soft mud bottoms and high turbidity, blue crabs are not serious predators of brown shrimp at the sizes and concentrations used in this study. The results even suggest there might be synergistic beneficial effects from the relationship, since the highest mortalities occurred in the control pens stocked with 0 crabs. These results are at varience with most thinking on shrimp culture. Much time and expense has been expended on crab control in the past on our own project in an attempt to increase shrimp production. If these results are accurate indications of shrimp-crab relationships in the estuaries, a significant expense in shrimp culture will have been removed. Further studies are needed in this area.

3. Overwinter survival and sexual development of White Shrimp study

Date from this study was presented as a paper to the Gulf States Marine Fisheries Commission's 22nd annual meeting on 22 October, 1971, in New Orleans. This paper is included in its entirity as the results of the White Shrimp study.

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OBSERVATIONS ON THE BIOLOGY OF WHITE SHRIMP (PENAEUS SETIFERUS) IN ESTUARINE IMPOUNDMENTS*

by

Alva H. Harris
Department of Biological Sciences
Nicholls State University
Thibodaux, Louisiana 70301

White shrimp generally spawn offshore in the five to ten fathom curve. Some spawning occurs year round but the majority or peak spawning appears to be in late spring or early summer. Gravid females during the spawning peak are often caught inside the five fathom curve and are sometimes found in the surf. There is increasing evidence that some spawning may occur inside the estuaries or inlets both in Texas and in Louisiana.

Mr. Frank Ritchie, late senior vice president of Louisiana Land and Exploration Company, firmly believed that shite shrimp were overwintering, breeding, and producing successive generations in some of the pipeline canals on Louisiana Land property. You would have to know Mr. Ritchie to appreciate his practical knowledge of the marsh.

As a biologist, I seriously doubted Mr. Ritchie's belief, but set up a study to test his theory. The study was not conducted well, and was almost ignored as a side branch of a brown shrimp productivity study. The results have been startling, and made me more aware than ever that technical training is no substitute for practical knowledge.

*Research Supported by Office of Sea Grant Programs, NOAA, and The Louisiana Land and Exploration Company.

METHODS AND MATERIALS

On May 15, 1970, an amphibious dragline dug a hole in the marsh at Point au Chein that was 30 feet in diameter and eventually stabilized its depth at five feet. The pond was filled with 12 PPT brackish water and allowed to age until October 15. Minimum O_2 levels taken early mornings were consistantly near zero or less than one part per million until September 23. After that the minimum O_2 levels were averaging near two parts per million.

One-hundred sub-adult white shrimp, averaging 136 mm or 22 count/heads on, were stocked in this small hole on October 15, 1970. Fifty (50) sub-adult brown shrimp were stocked at the same time. Occasional attempts were made during the winter with a cast net to determine if any live shrimp were in the pond, and we were always surprised to catch one or two whites. We did not take O_2 measurements or water temperatures from November 27, 1970 until March 15, 1971.

GROWTH

The first sample of overwintered white shrimp was weighed and measured on May 25, 1971. Average length was 155.2 mm and the count was 14 (22 when stocked in October). By July 5, the average count was 12.5 and remained at that until August 30. From August 30 until September 15 it decreased to 11 count. No brown shrimp survived the winter. We do not know how many white shrimp were in the pond during this study but we caught ten to fifteen for each growth sample.

The last sample was taken September 15. No feed of any kind was added to the pond during the entire study.

SEXUAL DEVELOPMENT

All male shrimp examined during each sampling period after July 5 showed full developed gonads. These shrimp averaged 13 count.

The first sign of ovarian development appeared on August 3 on an 11 count shrimp. Several shrimp showing ovarian development have been preserved and will be examined microscopically to study egg development.

You may or may not know that a male white shrimp attaches a spermatophore to the female during copulation. On July 13, 1971, we captured a female white shrimp with a spermatophore attached along with the male that had deposited it in the same cast with a cast net. This whole bit of evidence is preserved and it is quite evident the male is spent.

This is positive proof that some breeding occurs in brackish H_2O.

We have no evidence that spawning occurs even though there was ovarian development. The shrimp we were studying had been in captivity for 11 months. We were going to overwinter these same shrimp for another year's study and expect they would have been 6-8 count by next May, but the high waters from Hurricane Edith liberated tham on September 16, 1971.

JUVENILE OVERWINTER RESULTS

We inadvertently overwintered a few juvenile white shrimp in another experiment that lends credence to these results. A 50-foot square vinyl-coated wire pen located in one and one-half feet of water in a natural pond was stocked with 1,000 77 mm average, 130 count shrimp on August 31, 1970. Most of these were harvested with a seine on November 15, 1970 (76 days) and averaged 85 mm, 95 count. Those that were not harvested on November 15, 1970 were seined out on April 15 this year and averaged 97.5 mm, 67 count. We estimate these would have been 30-40 count by the May season. This seems reasonable proof to me that at least some of the big whites around when the May season opens spent the winter in the marshes.

LONGIVITY

These observations also shed light on white shrimp longivity. This study held adult shrimp in captivity eleven months during which time the average count increased from 22 to 11. How old were these 22 count shrimp on October 15 when they were stocked? Using the very fastest growth obtained by the Louisiana Wildlife Commission on Grand Terre as a guide, the eggs would have had to be spawned during May for the shrimp they raised to be 28 count in November, and the shrimp we stocked were 22 count on October 15.

My data suggests, but does not prove, that the small white shrimp (100-150 count) present in the fall are spawned during mid-summer and comprise the 30-40 count shrimp taken during the May season. These shrimp are probably 20-25 count by October, at which time they may be as much as 15 or 16 months old. In another 12 months, or the next fall, they are 10-12 count. I had intended to overwinter this size for another year in the hopes of producing 6-8 count shrimp, at which time they could be three years old.

The characteristics of the life history of white shrimp that confuse this picture is the fact that spawning occurs over a long period of time so that there is continual recruitment, and the growth rates of each spawning peak will vary with the environmental conditions and food.

IN SUMMARY

1. Juvenile white shrimp can be overwintered in brackish water ponds in Louisiana marshes.
2. Significant growth occurs between fall stocking and spring harvest.
3. Growth, sexual development, maturity, and breeding occurred between sub-adult white shrimp that were stocked in brackish pond in October of 1970 and maintained until September of 1971.
4. Spawning was not observed, nor were ripe females sampled; however, several females were collected and preserved for microscopic studies that showed definite ovarian development.
5. The life cycle of white shrimp involves at least two years growth and may be as long as three years.
6. Sub-adult brown shrimp stocked simultaneously and in the same pond with white shrimp did not survive the winter.

More data is needed to back up these preliminary observations and a subsequent study is being planned.

Tables I and Chart I summarize the data that was used in preparing this paper.

1970-71 Pond Study of Over-Winter Male and Female White Shrimp - Growth Rates - - - - - - - -Chart I

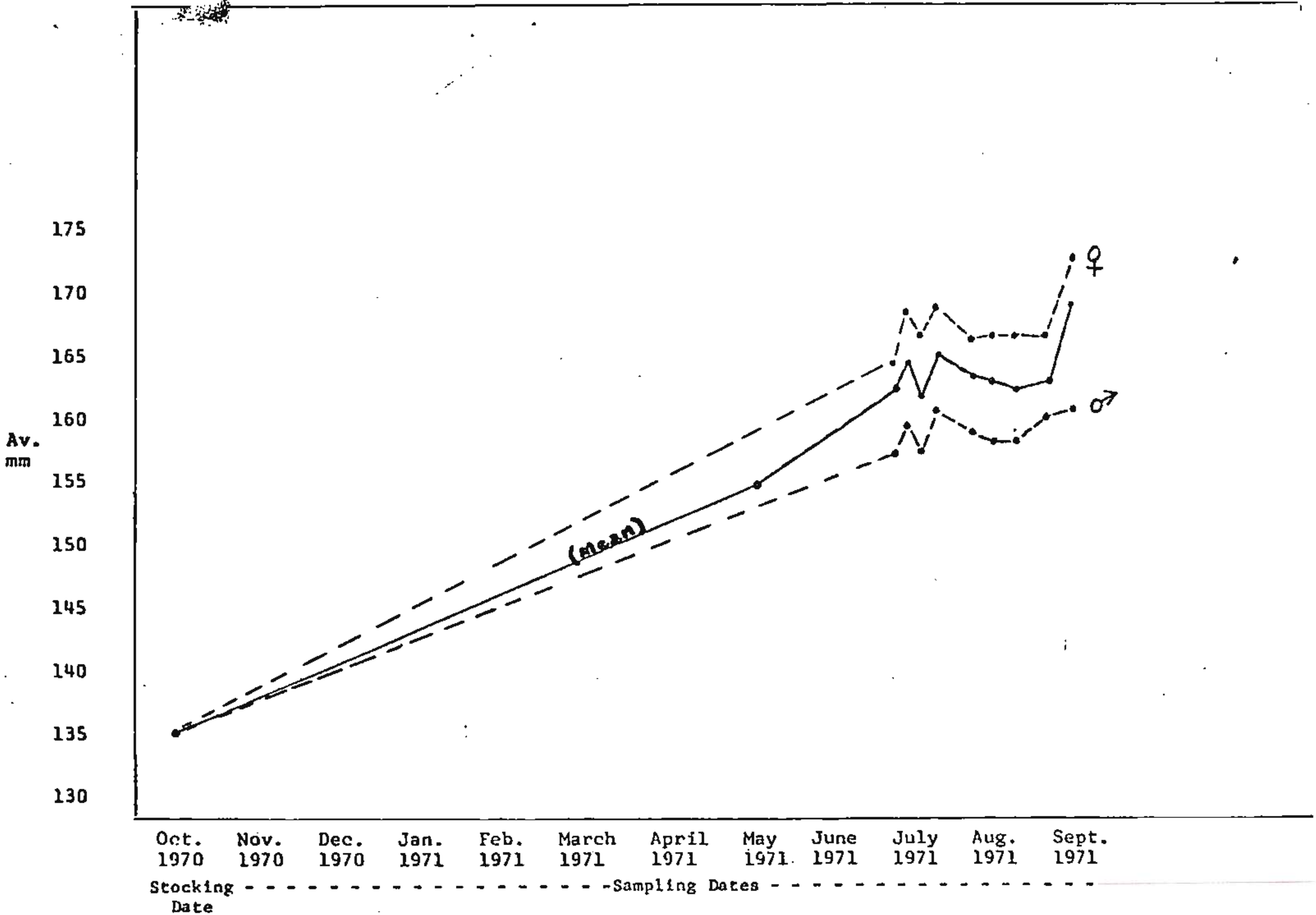


TABLE 1

Data on Over-Winter Study of Sub-Adult White Shrimp

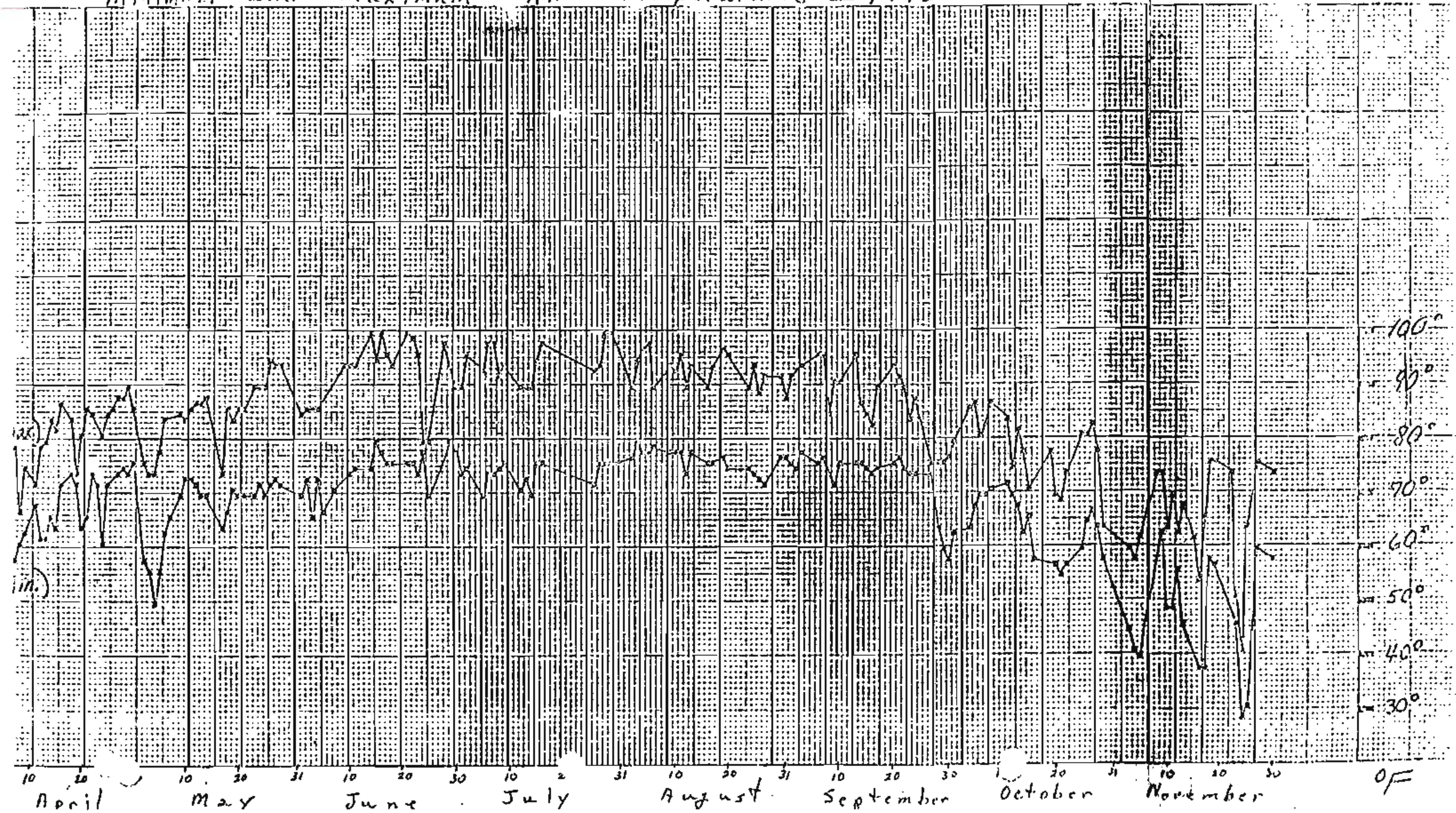
10-21-70 - - Stocked 100 Sub-Adult White Shrimp in 1/45 Acre (30 ft. Diameter) Pond
Average Length = 136.3 mm = 22 Count-Heads-On

Sampling Date	No. Sampled	Av. mm	Av. Count	No. ♂ Sampled	Av. mm	No. ♀ Sampled	Av. mm
5-25-71	12	155.2	14.0	-	-	-	-
7-5-71	13	162.5	12.5	3	156.7	10	164.3
7-12-71	14	163.9	12.5	7*	159.6	7	169.1
7-20-71	14	162.1	12.5	7	156.9	7	167.4
7-26-71	15	165.3	12.0	5	161.2	10	168.9
8-3-71	15	163.5	12.5	6	158.8	9**	165.6
8-9-71	12	163.3	12.5	5	158.0	7	167.0
8-17-71	12	162.5	12.5	6	158.0	6***	167.0
8-30-71	9	163.2	12.5	5	160.2	4	167.0
9-15-71	10	169.1	11.0	3	161.0	7	172.6
9-16-71	Hurricane Edith Terminated Study						

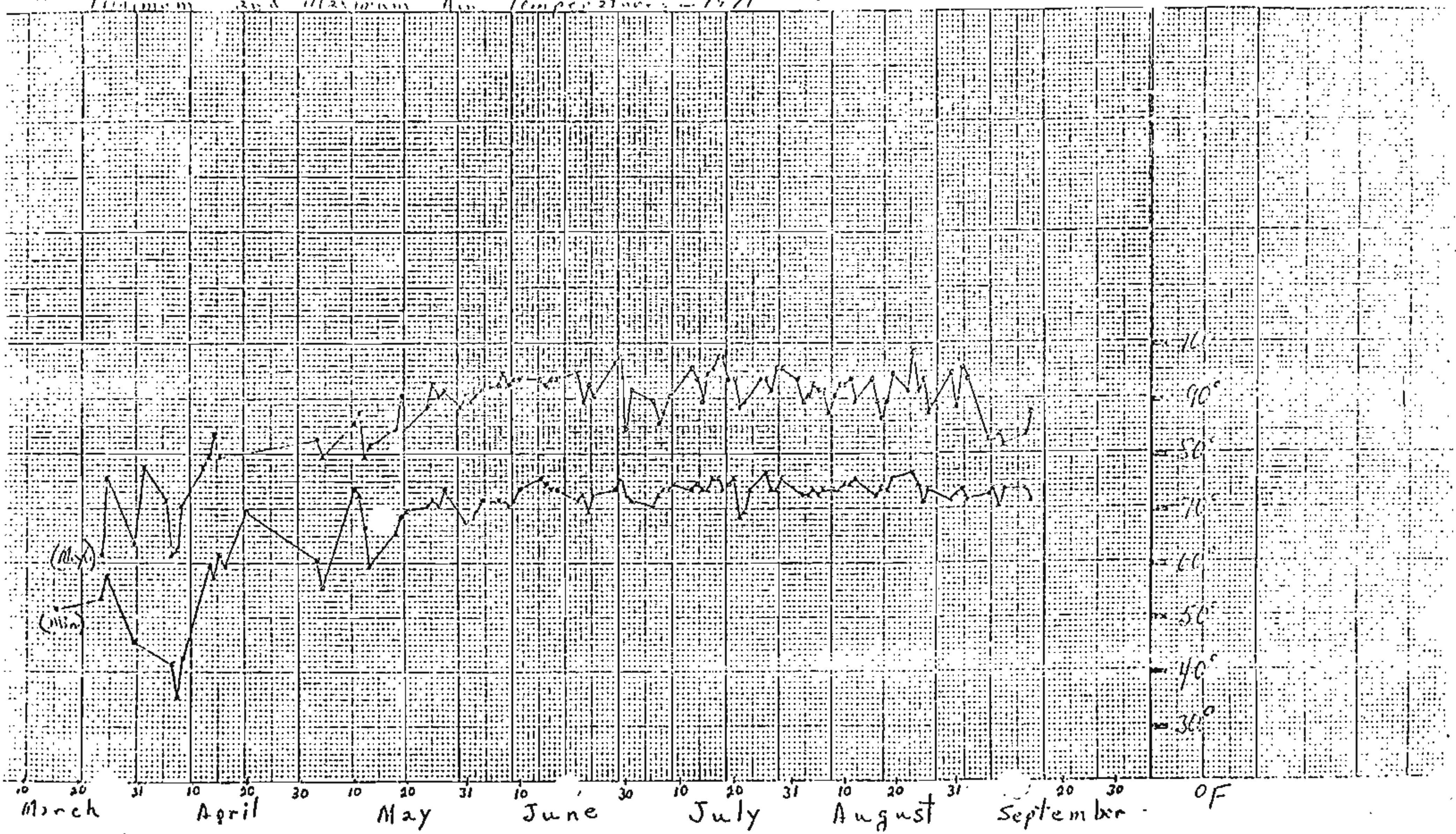
* All males with gonads fully developed from this point until termination of study.
** 11.1% Females with ovary partially developed.
*** 16.6% Females with ovary partially developed.

The following tables, charts, and graphs are a compilation of physical, chemical, biological, and management records that were compiled during the 1970-1971 phase of the research program. They are listed and itemized in the following order.

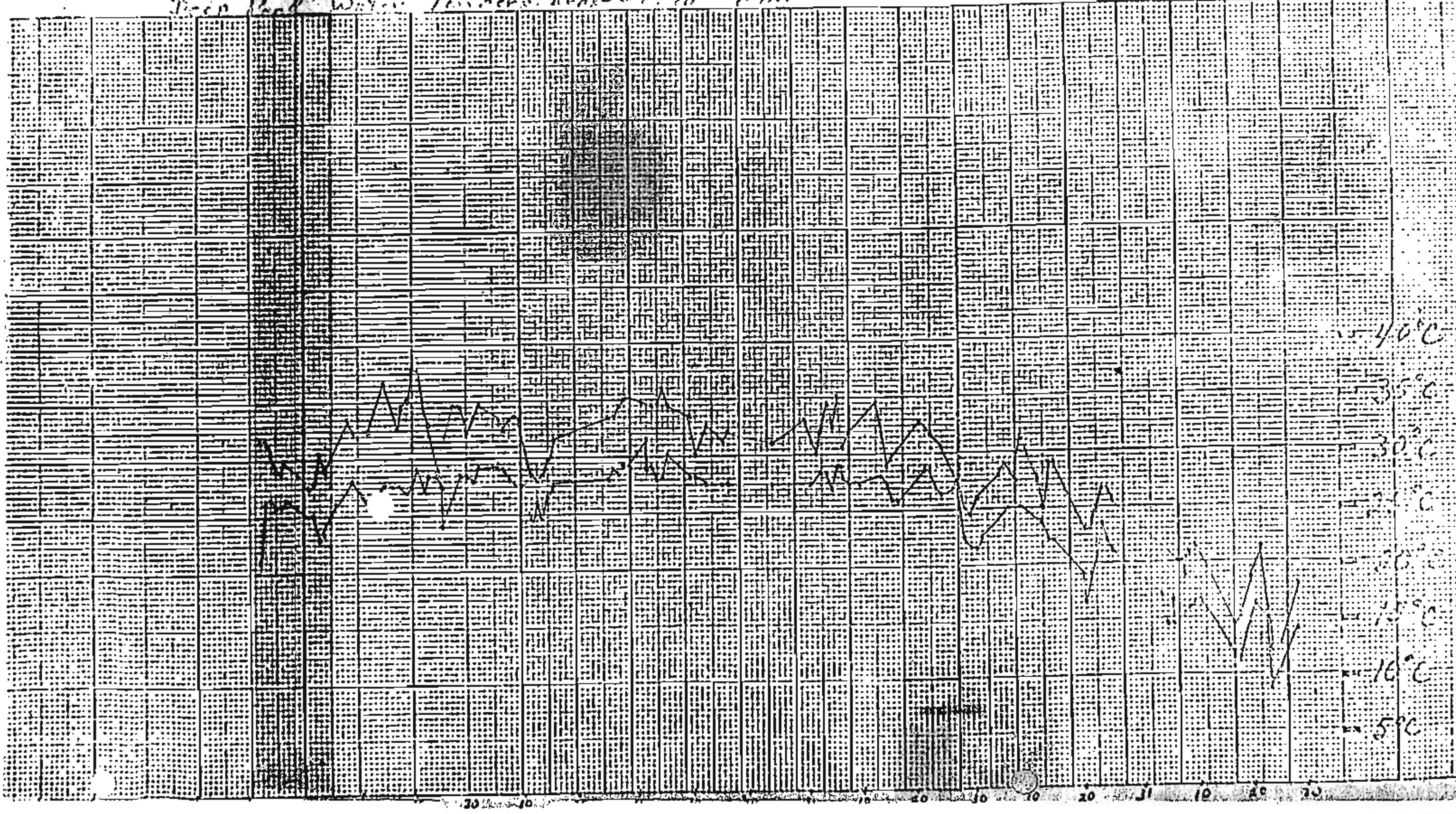
Minimum and Maximum Air Temperatures — 1970

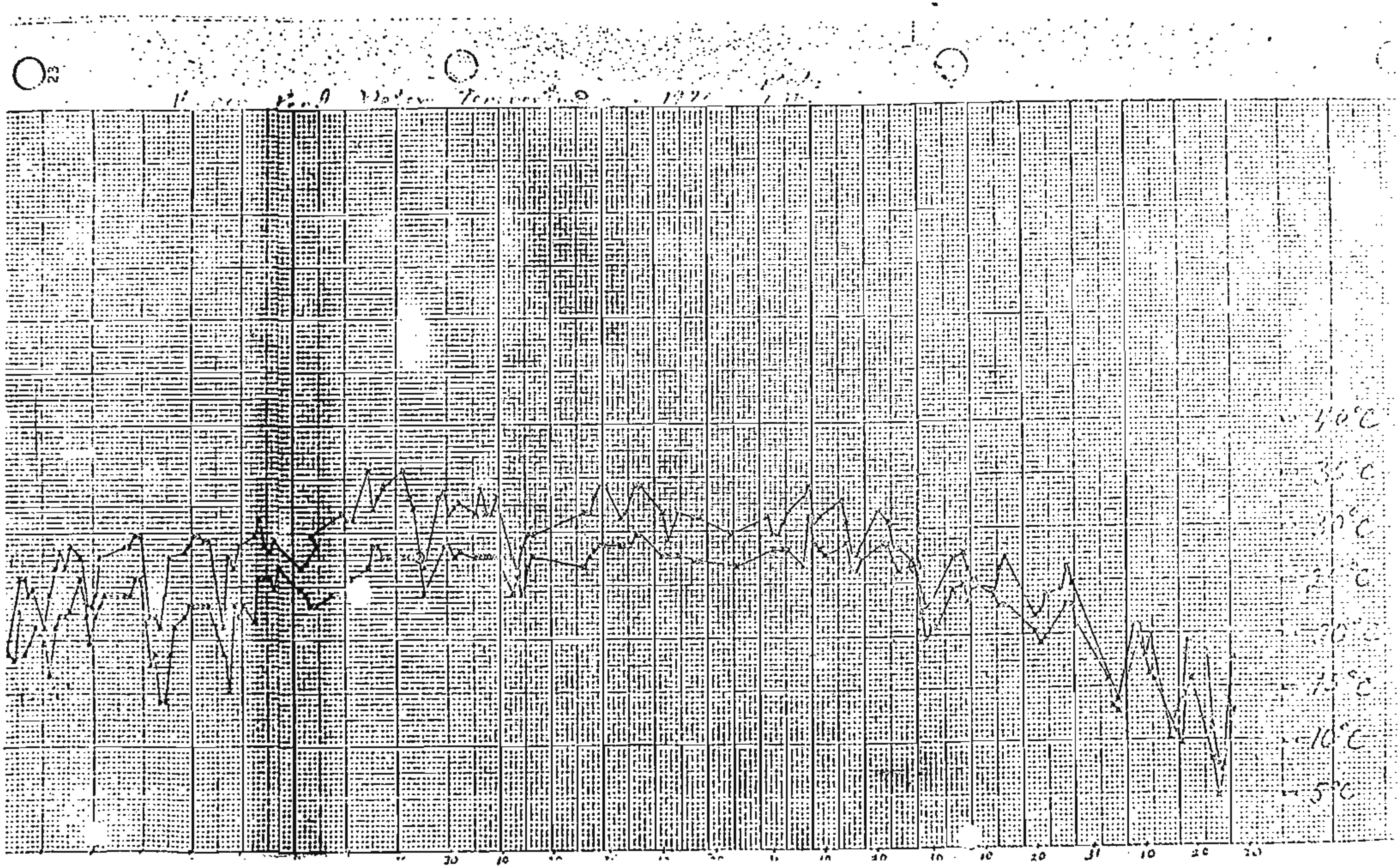


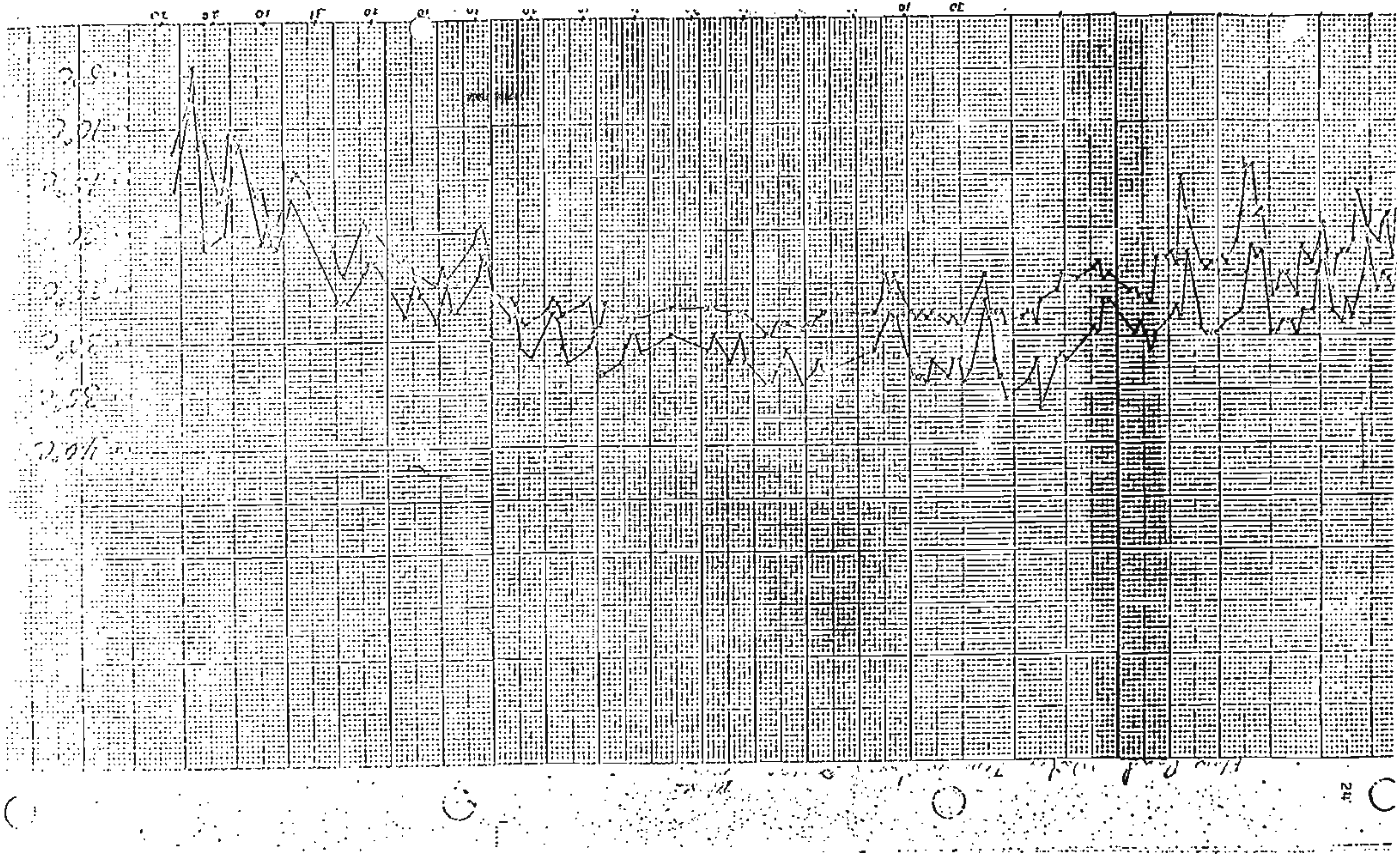
Minimum and Maximum Air Temperatures — 1971

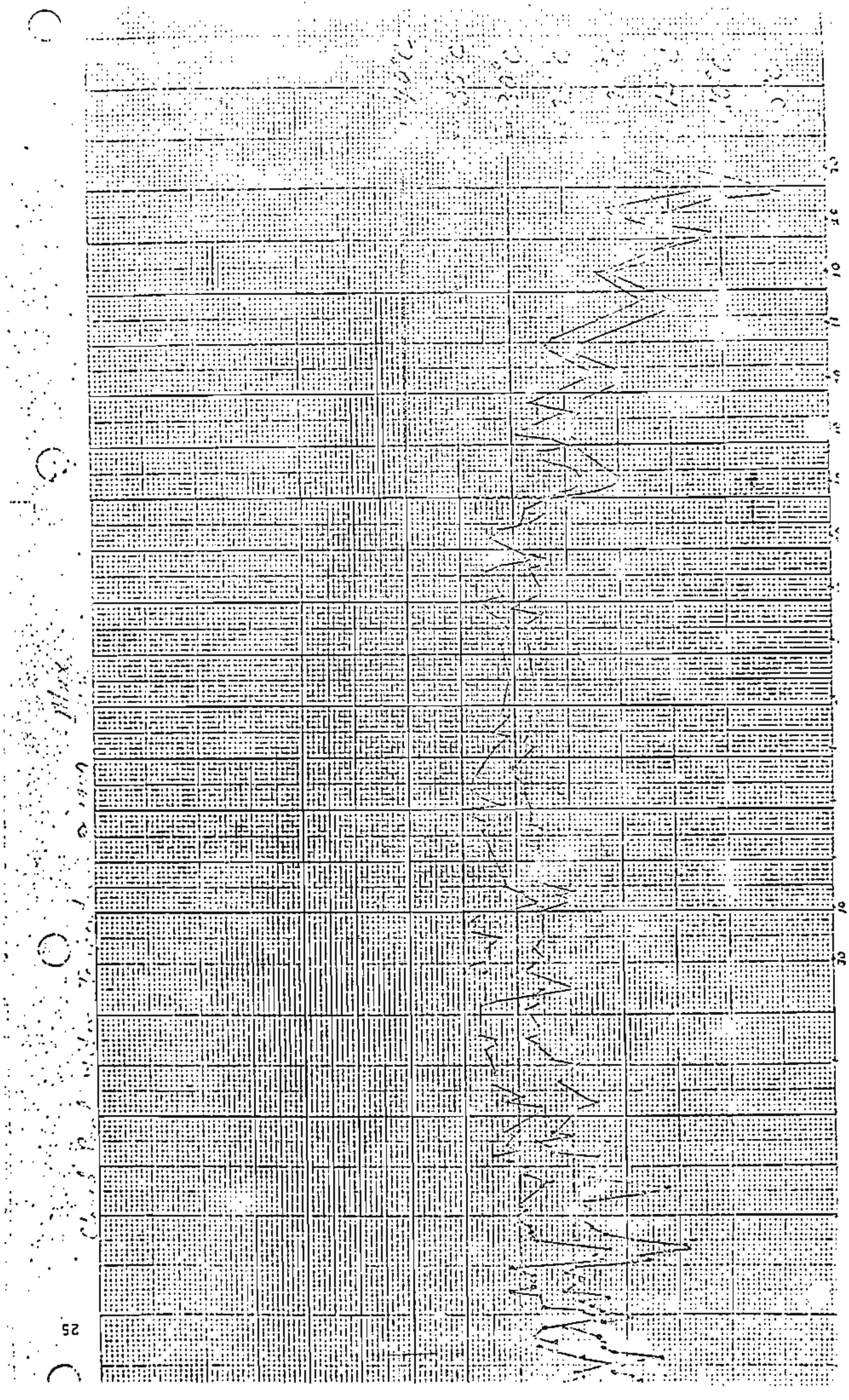


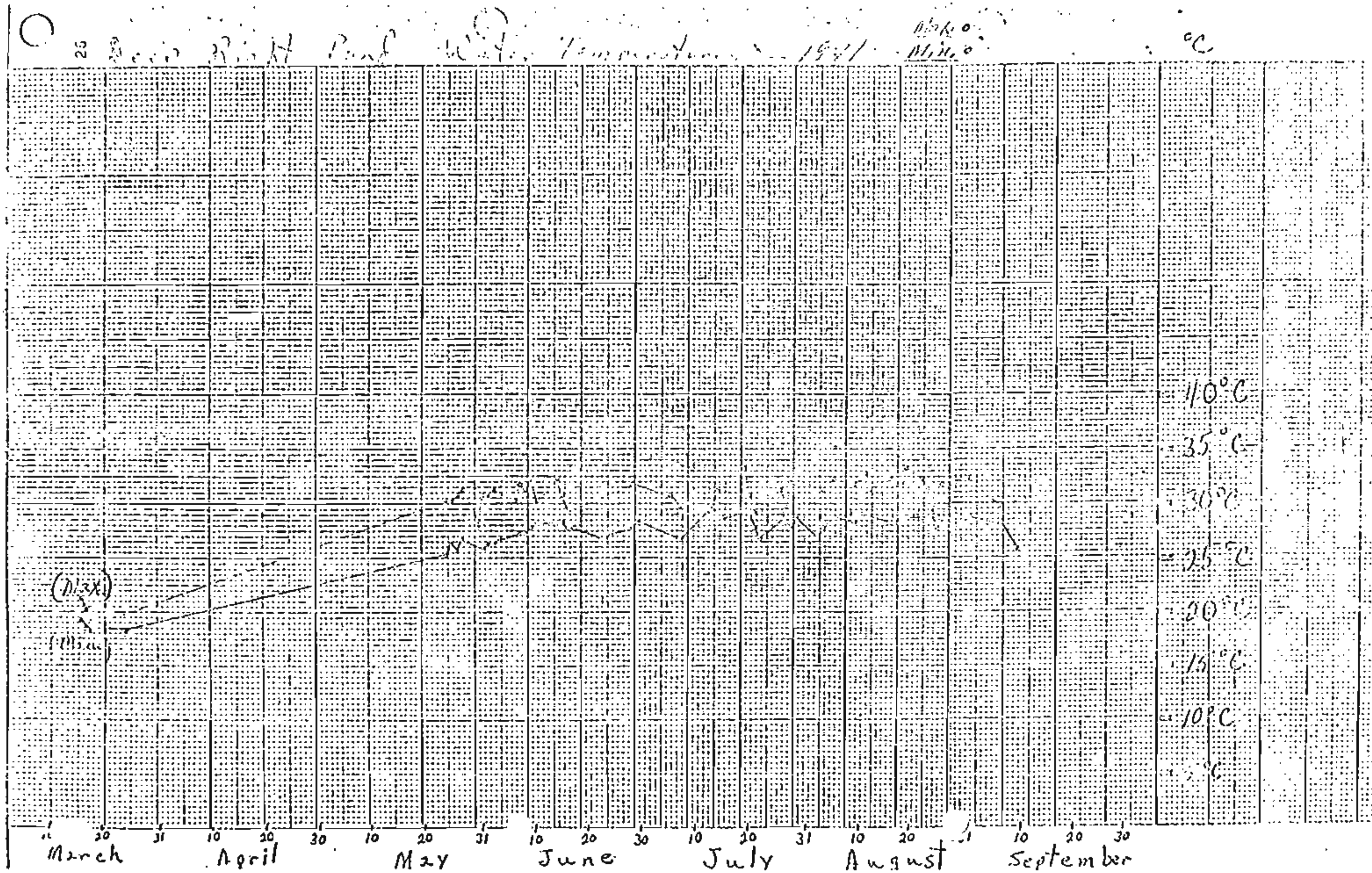
Deep Pool Water Temperature – 1990 Max. Min.




40°C
10°C
5°C

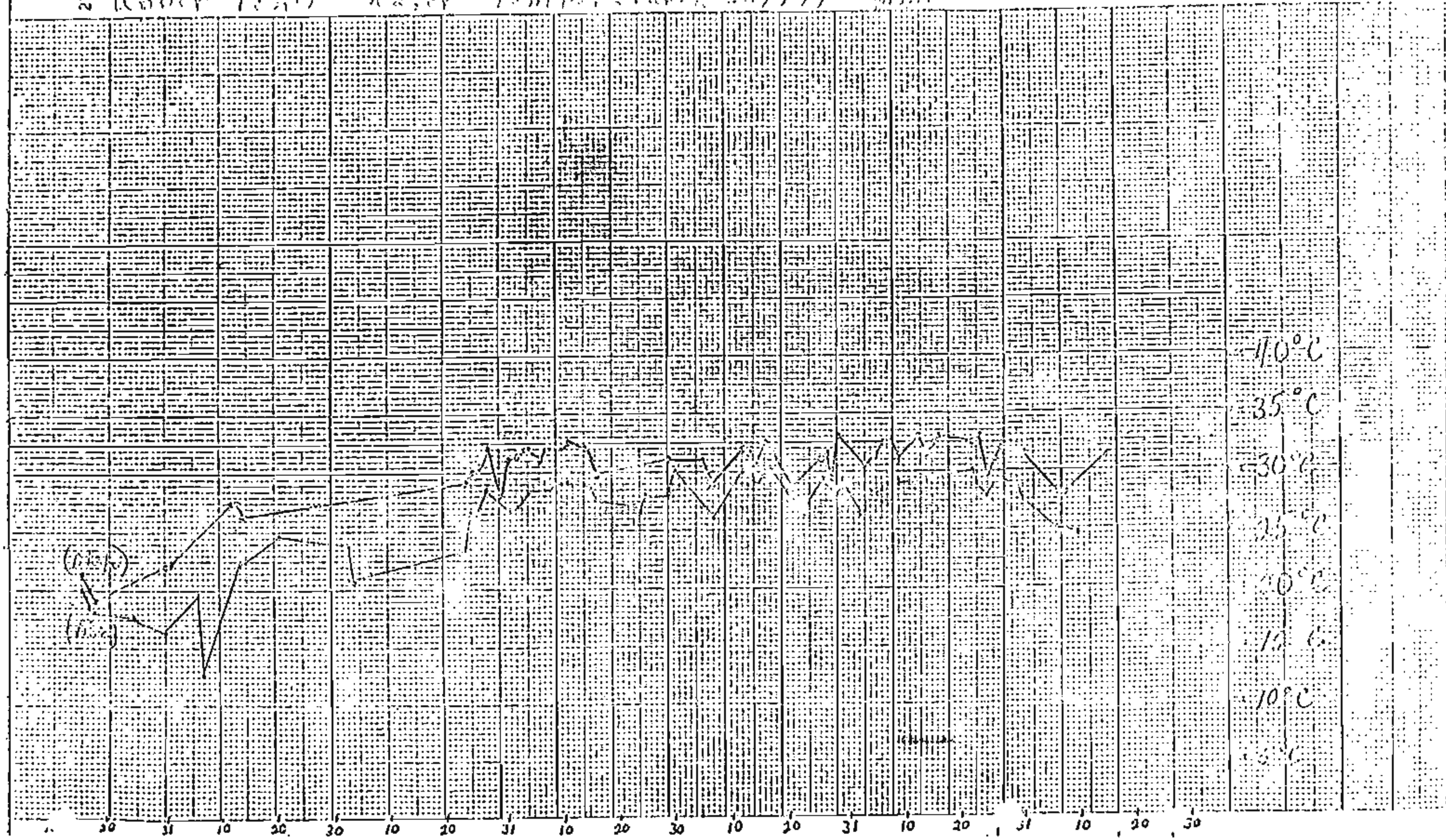





°C
(Max)
(Min)
40°C
35°C
30°C
25°C
20°C
15°C
10°C
March
April
May
June
July
August
September

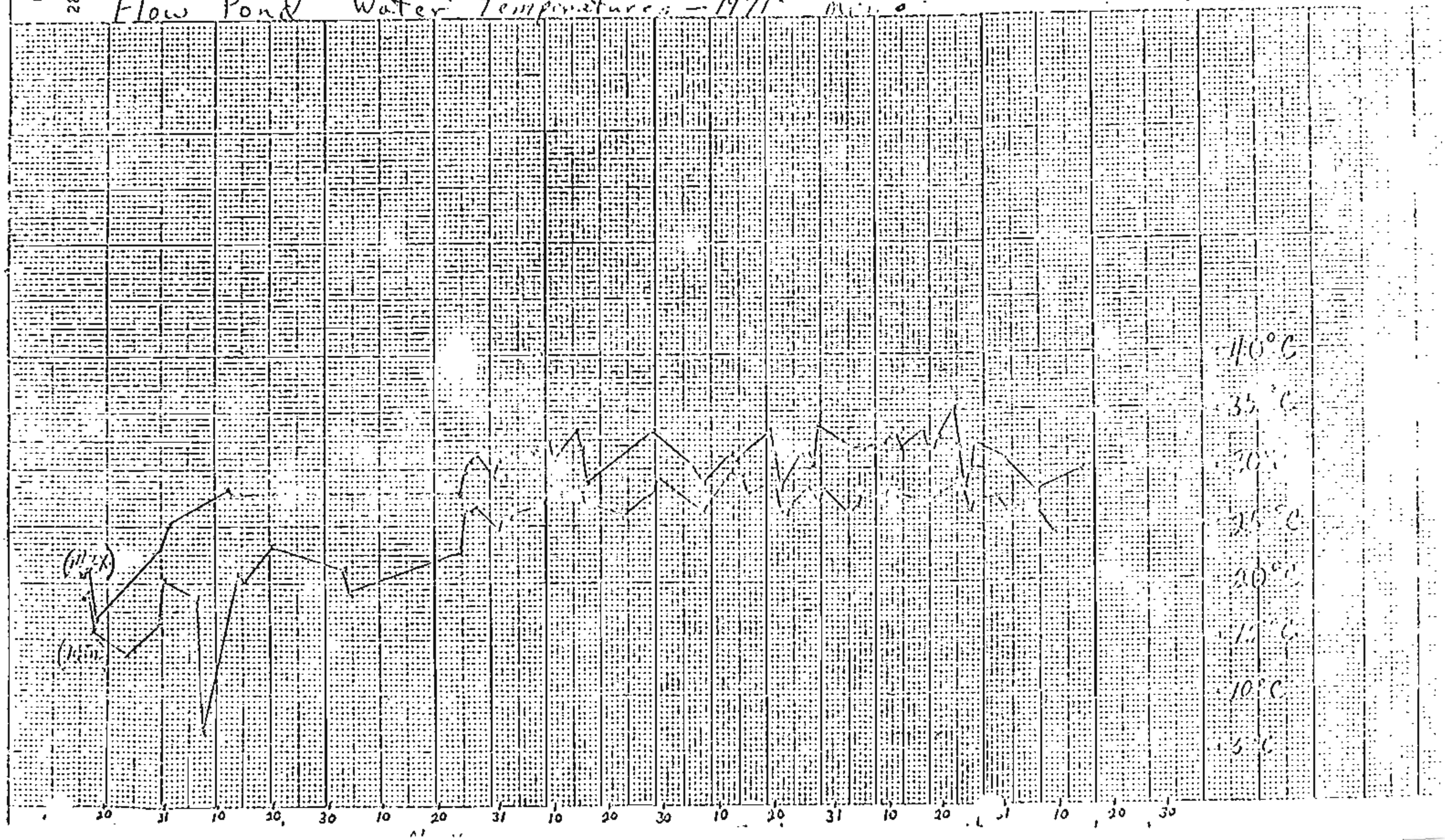
27

Upper Pond Water Temperature 1971 Max/Min °C

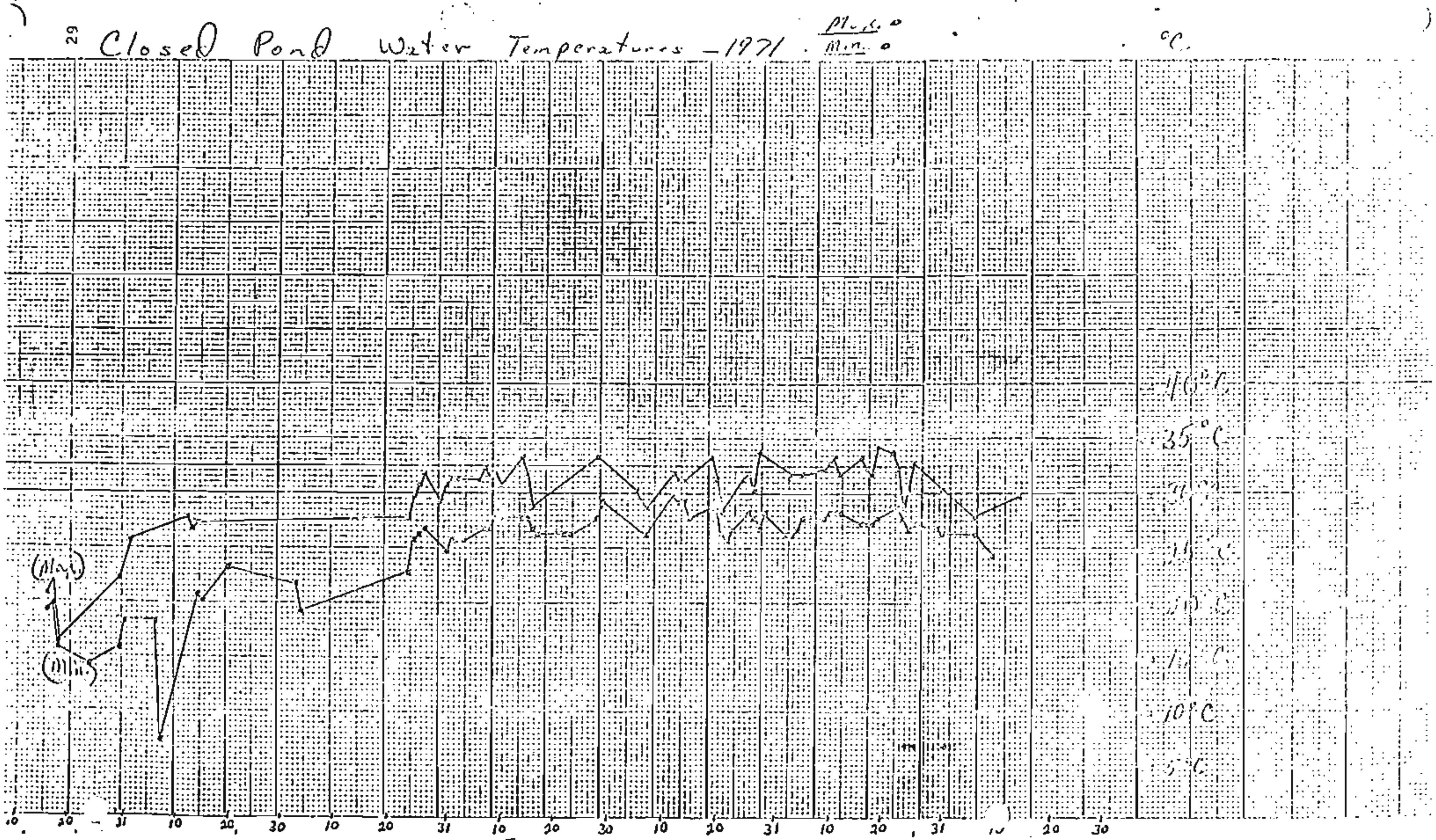


28

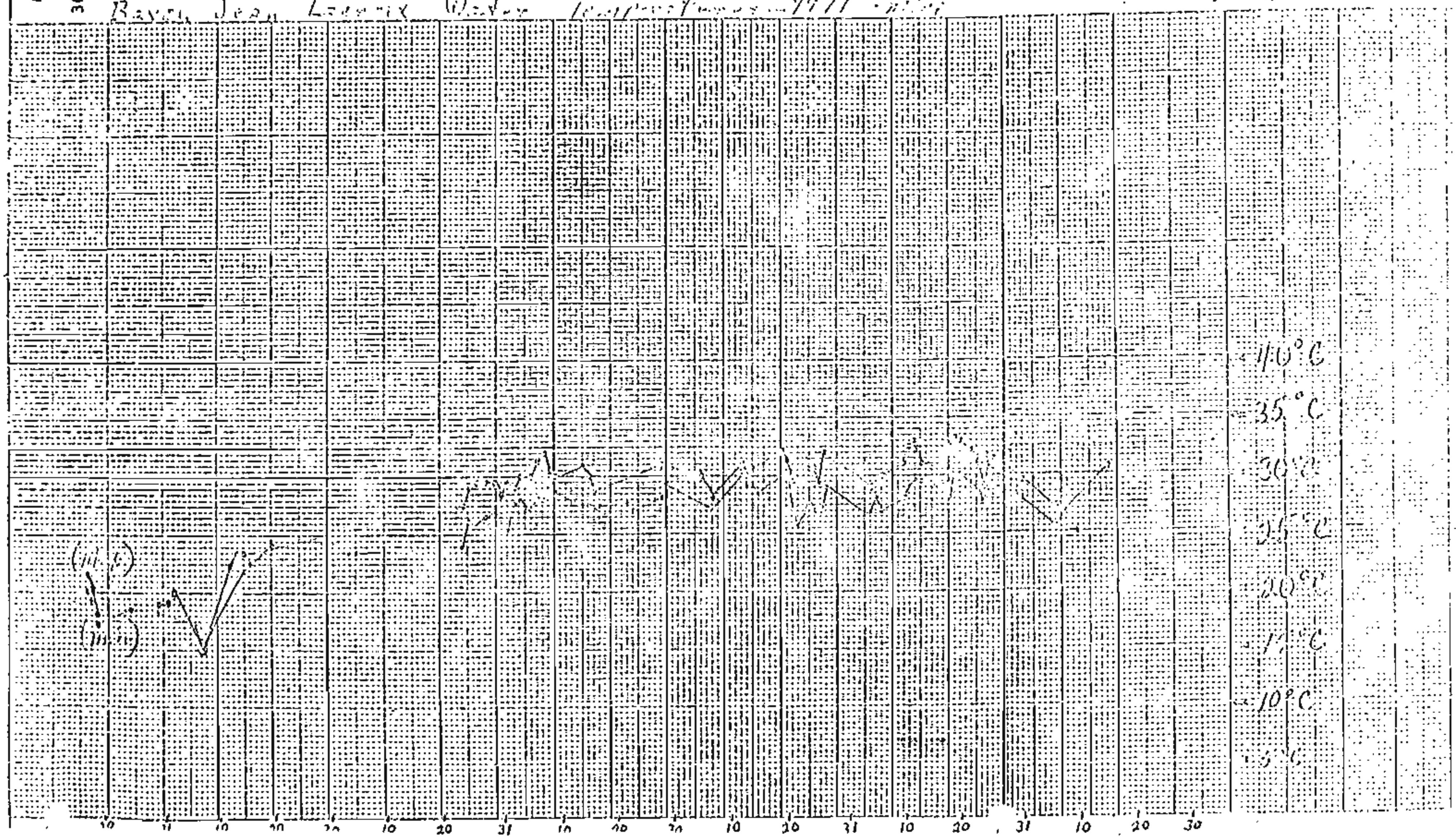
Flow Pond Water Temperatures — 1971 Max./Min. °C



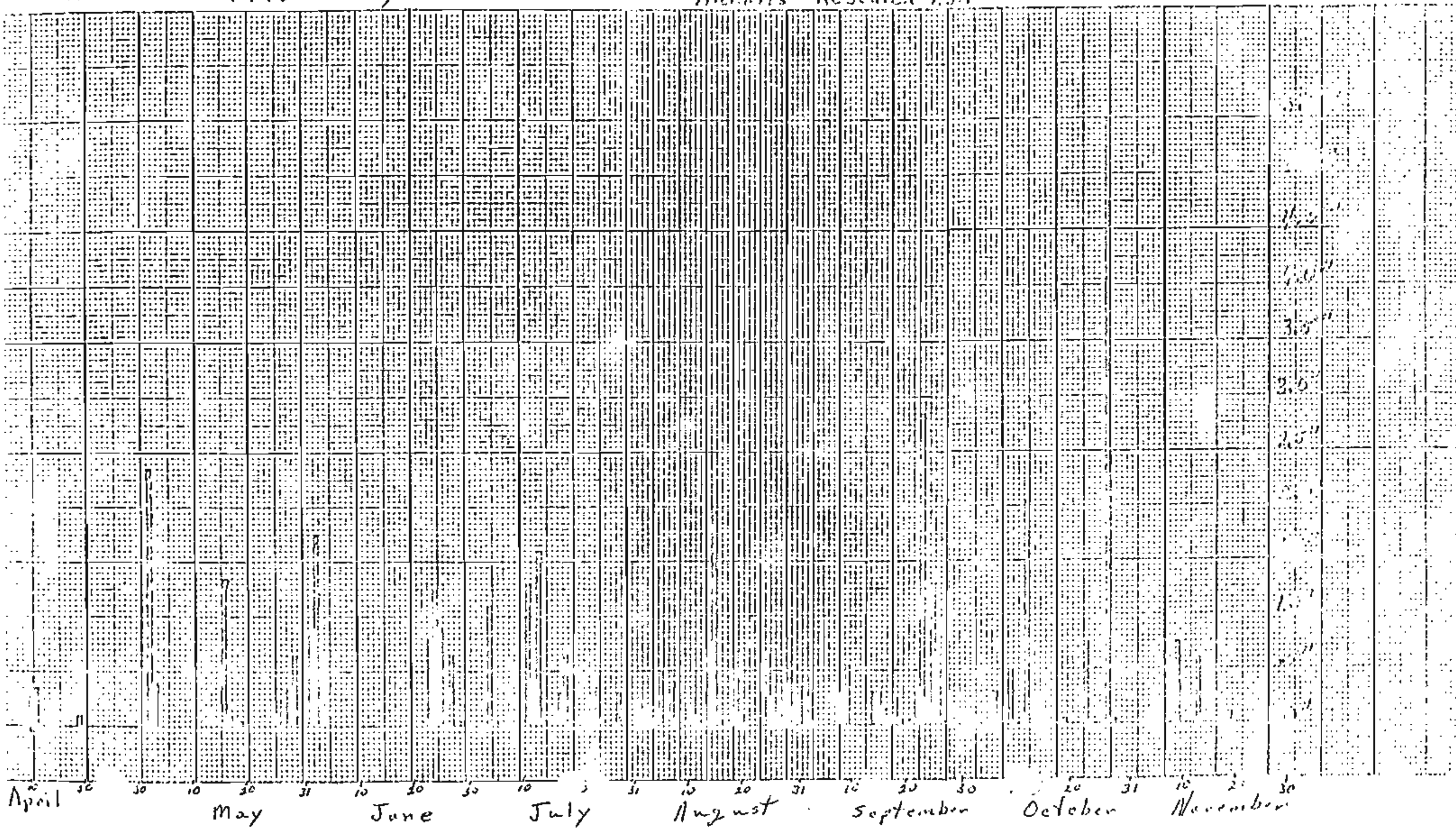
Closed Pond Water Temperatures – 1971

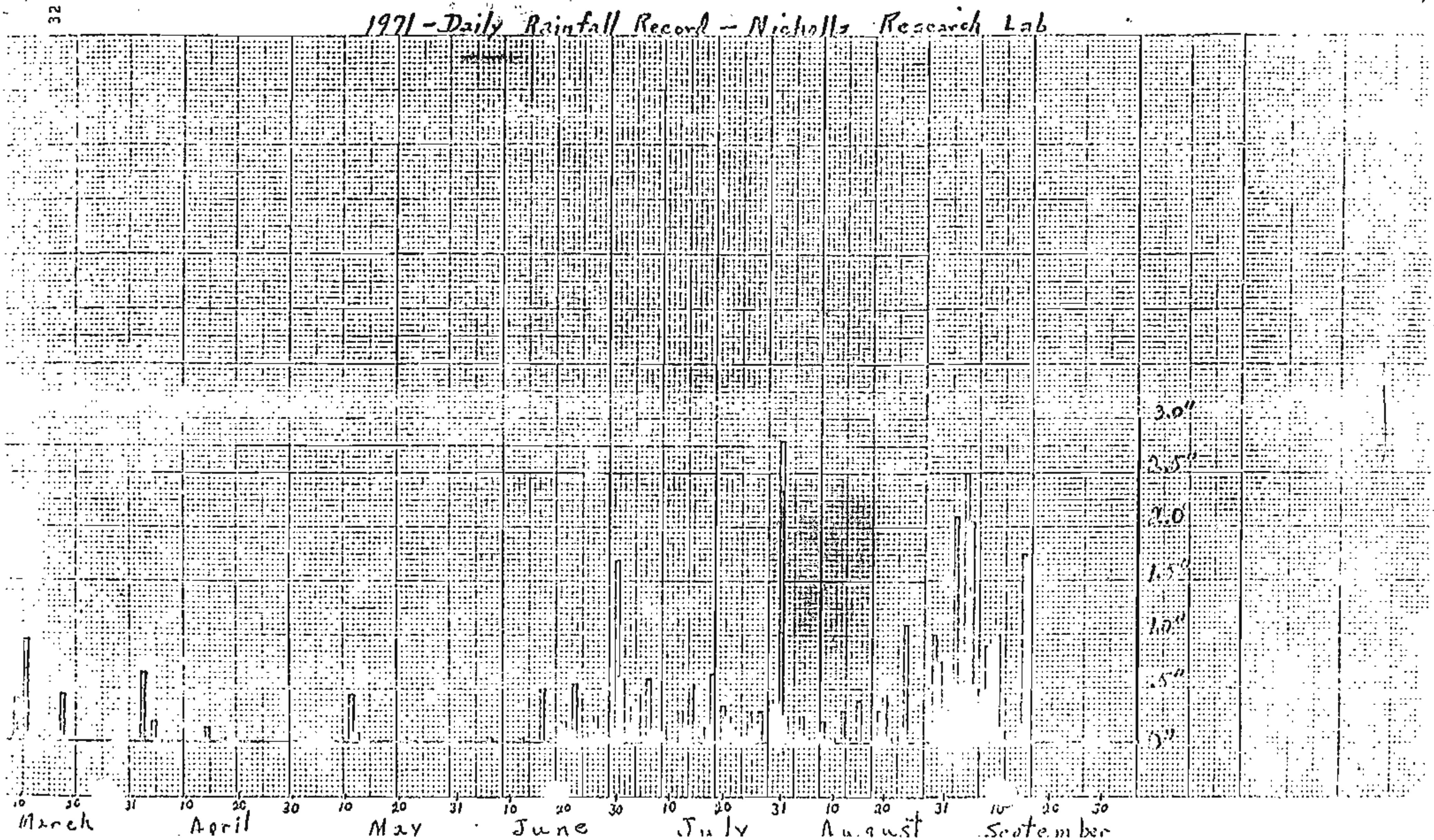


Bayou Jean Lacroix Water Temperatures 1971 Max. °C



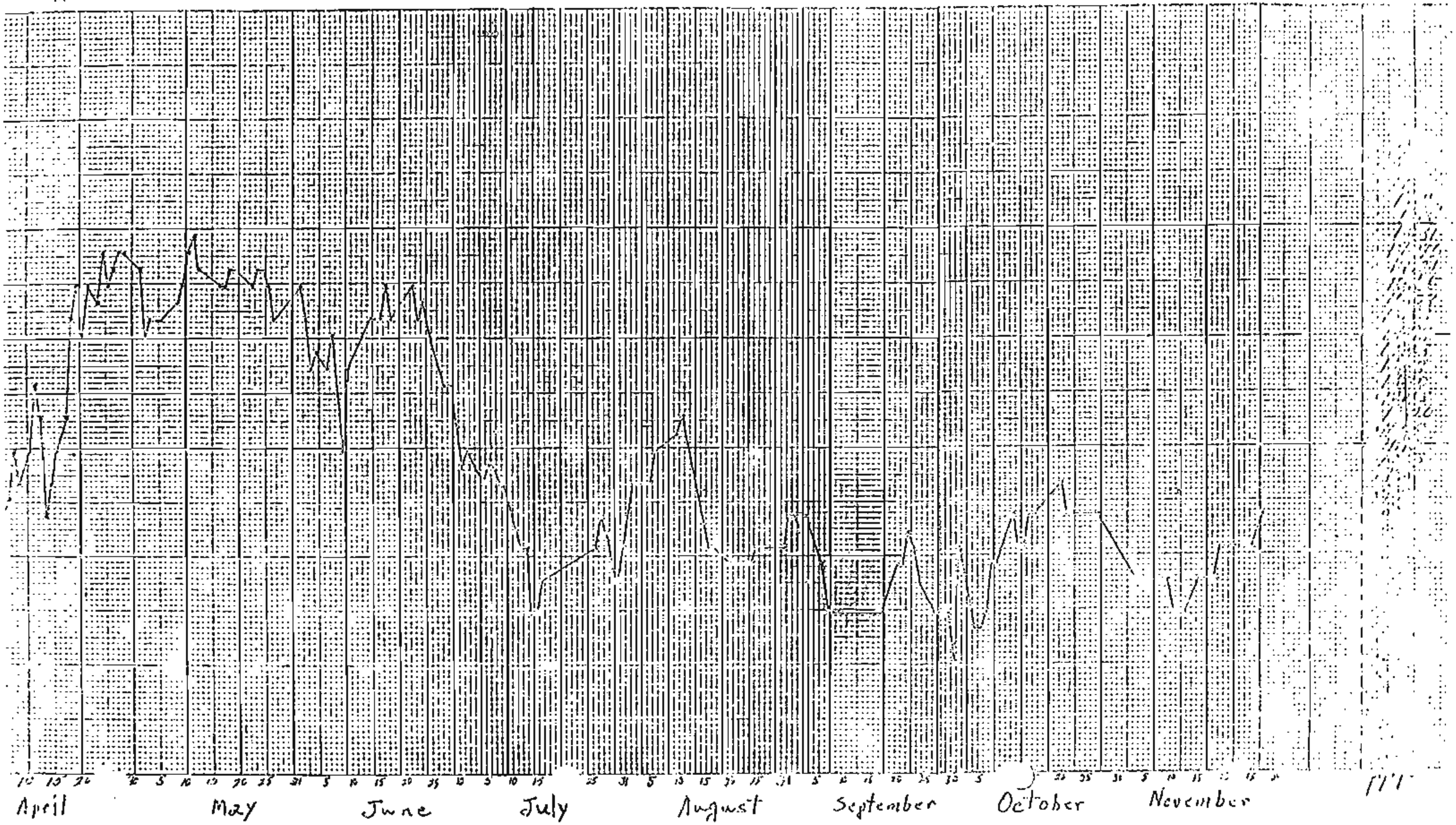
1970 - Daily Rainfall Record - Nicholls Research Lab



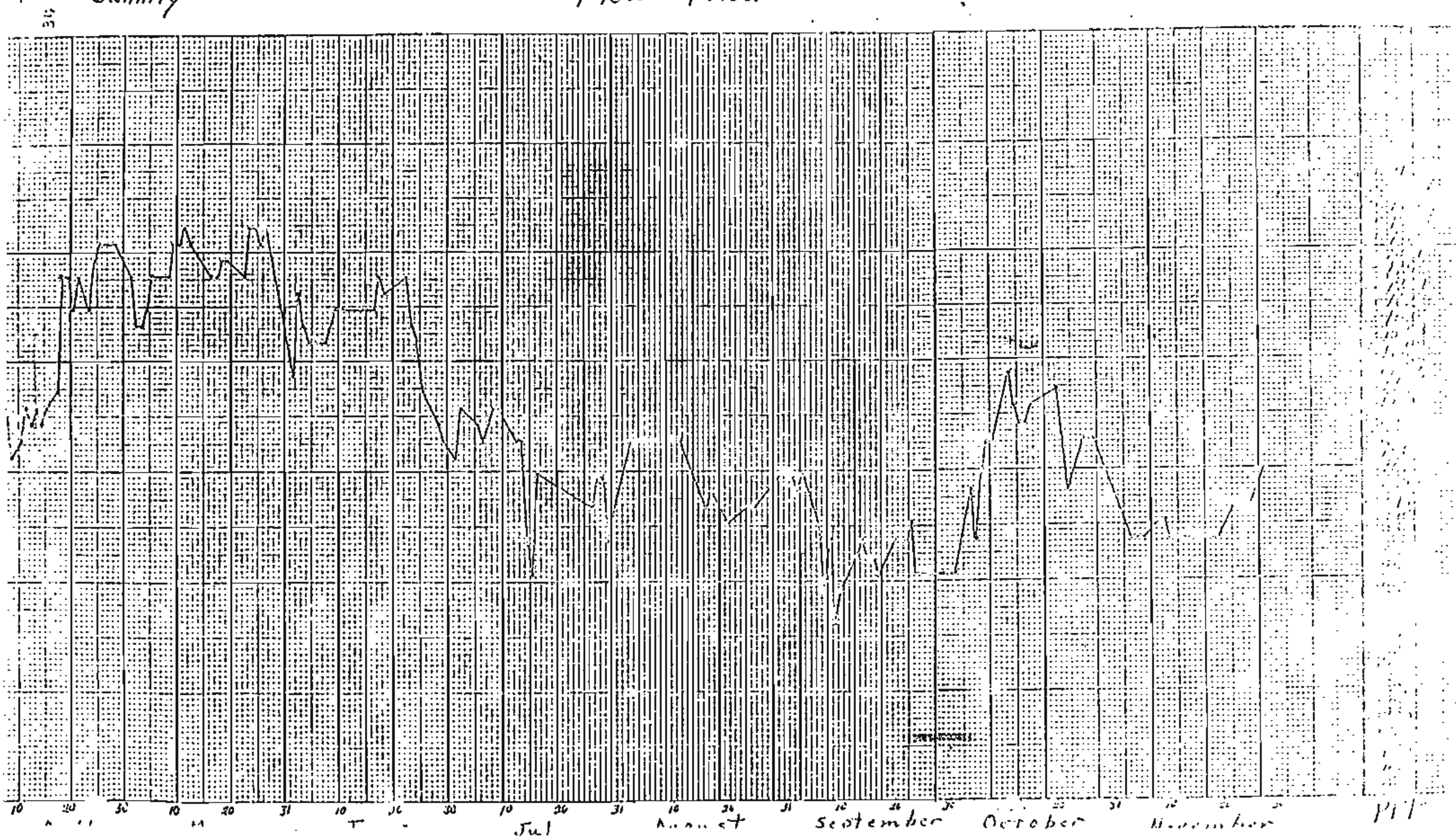


1971 - Daily Rainfall Record - Nicholls Research Lab
3.0"
2.5"
2.0
1.5"
1.0"
.5"
0"
10 20 31 10 20 30 10 20 31 10 20 30 10 20 31 10 20 31 10 20 30
March
April
May
June
July
August
September

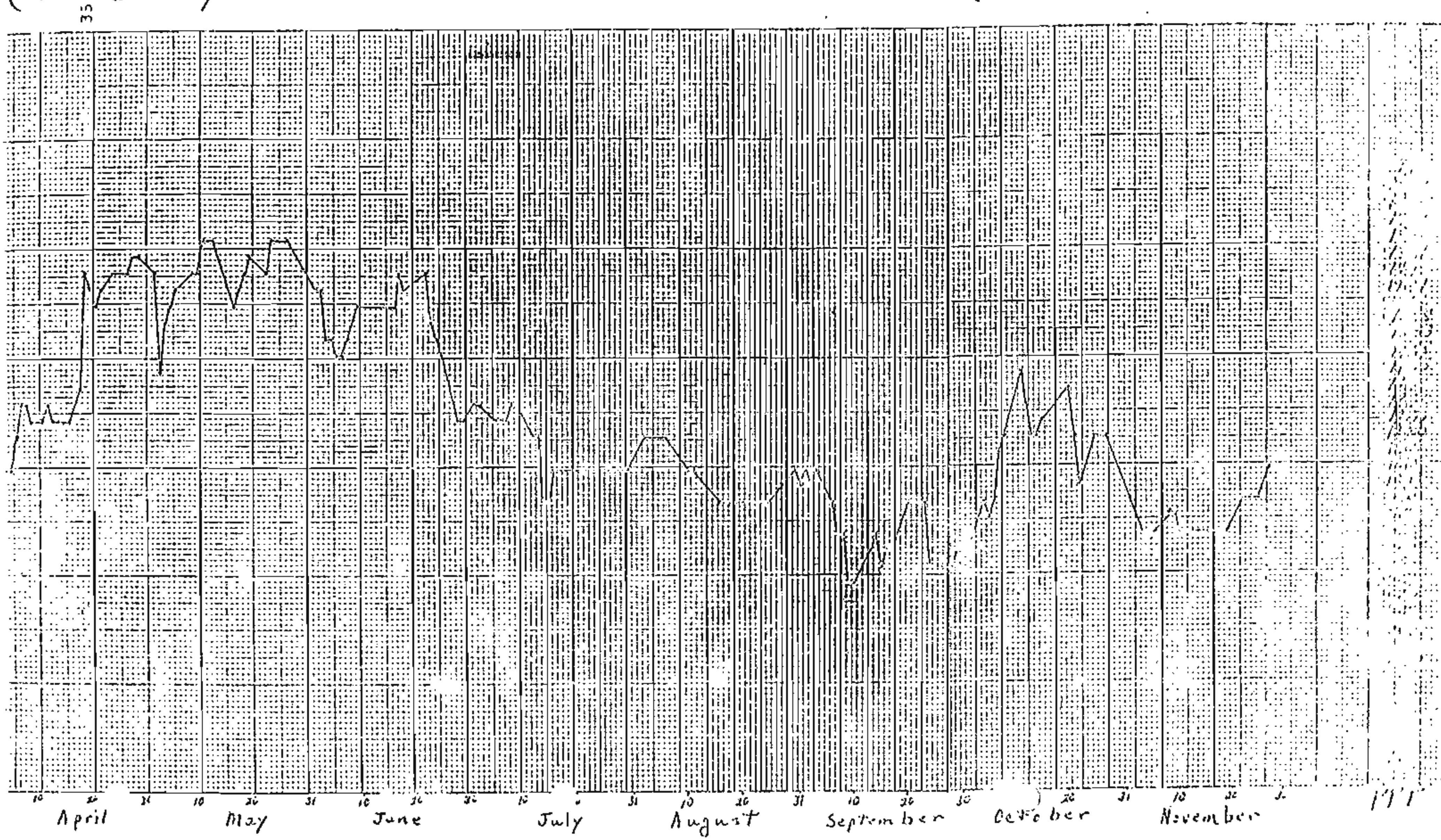
Salinity — 1970 Upper Pond



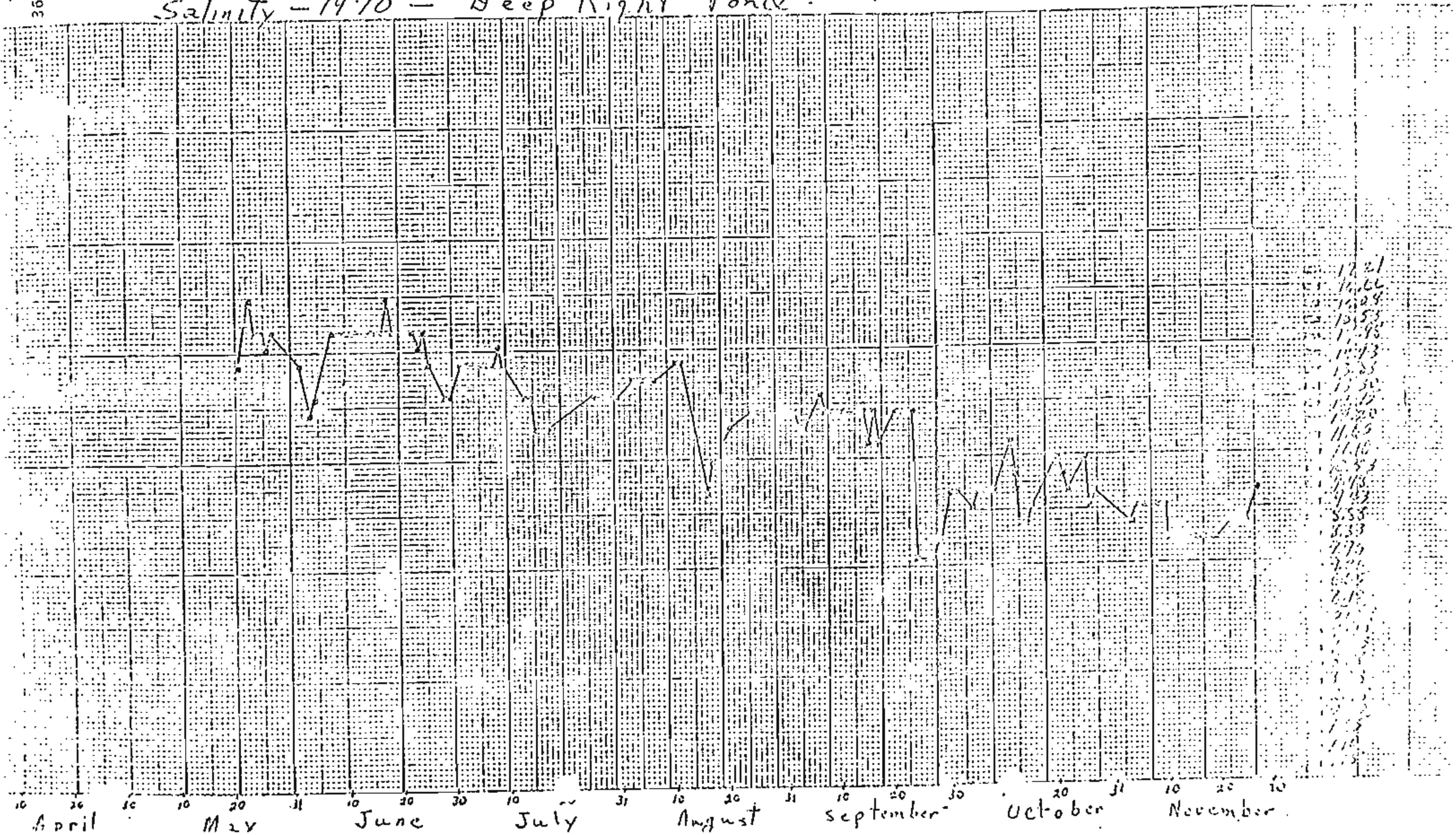
Salinity - 1970 Flow Pond

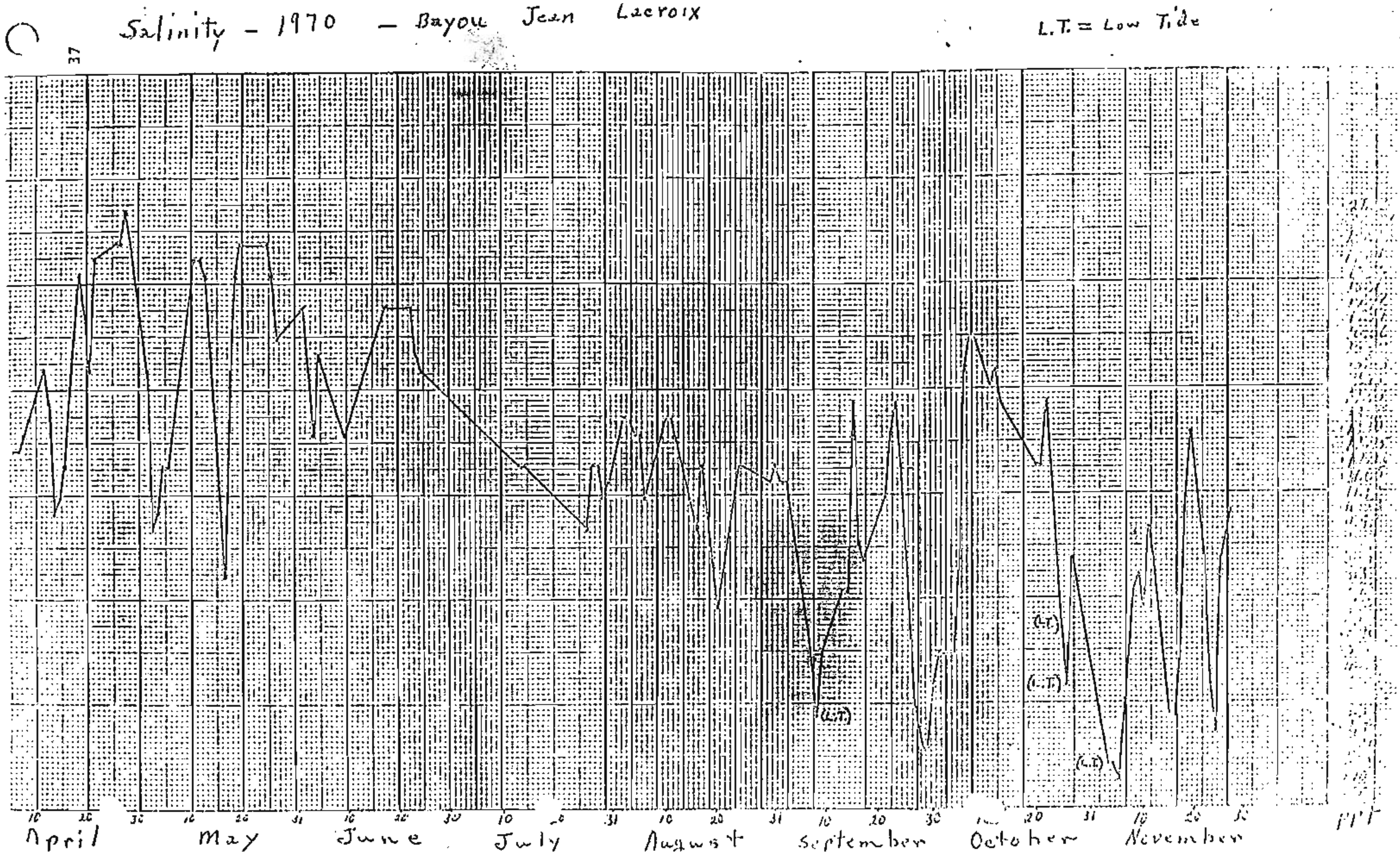


Salinity - 1970 Closed Pond



Salinity – 1970 – Deep Right Pond

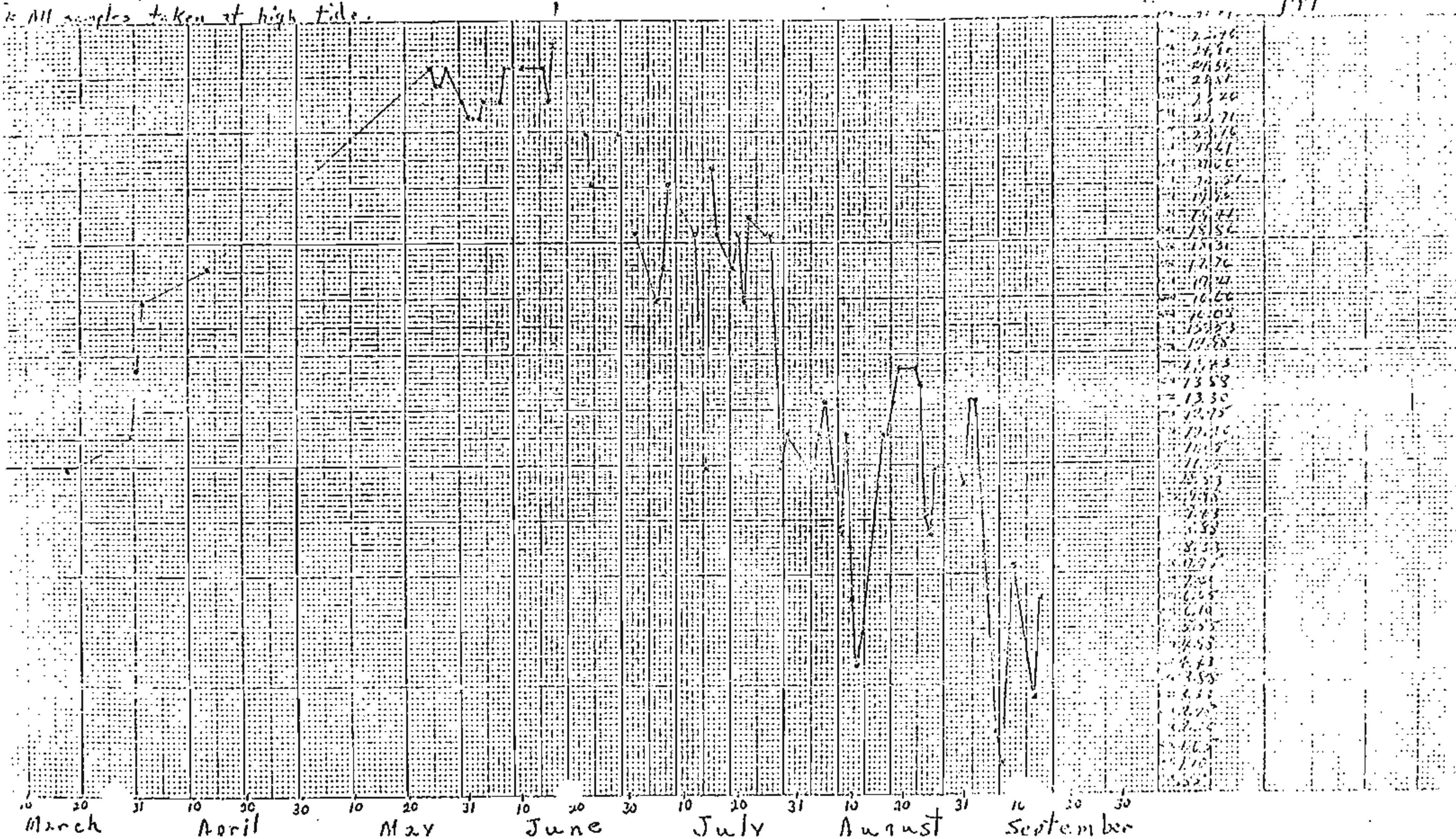




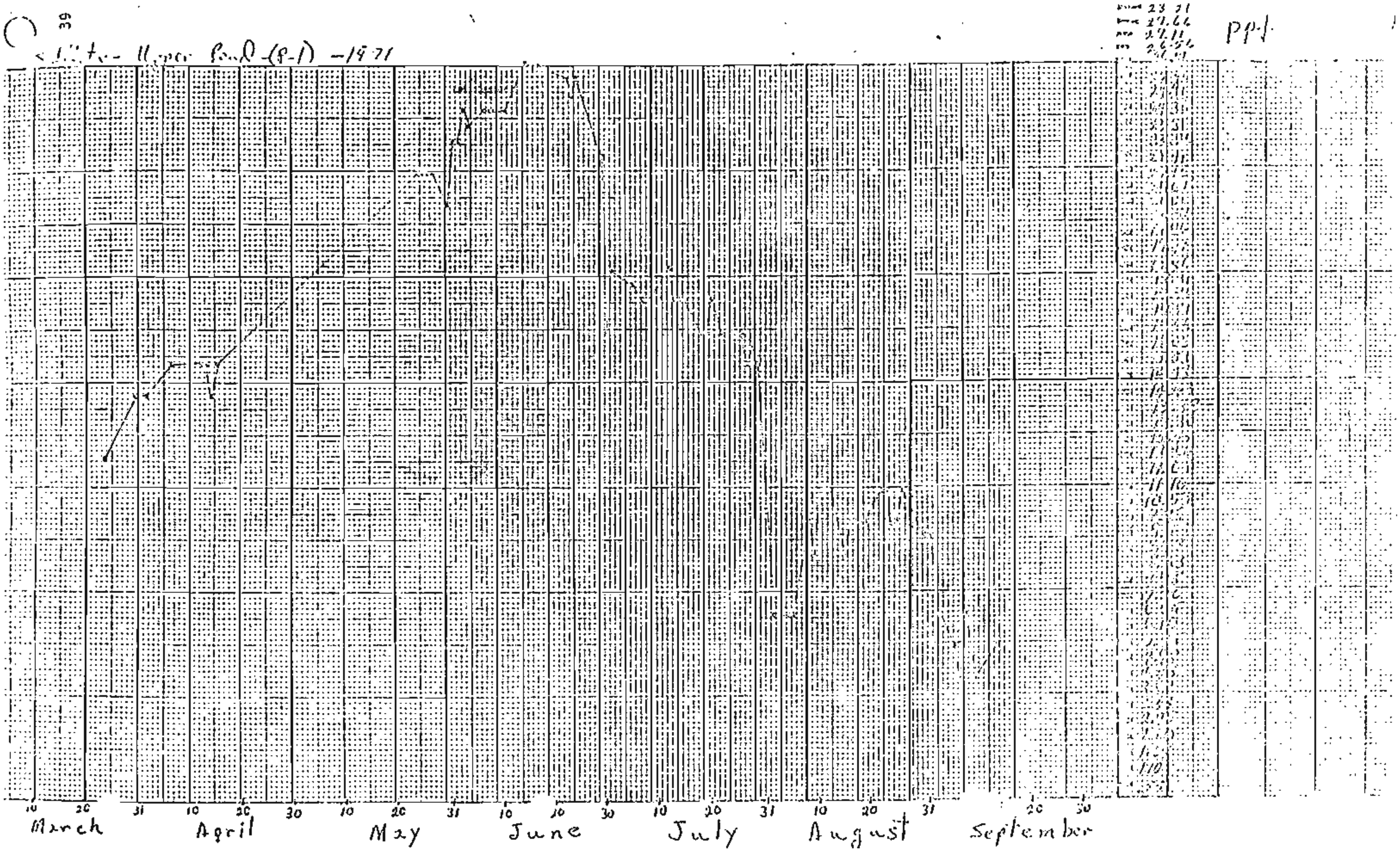
Salinity - 1970 - Bayou Jean Lacroix
L.T. = Low Tide
37
(L.T.)
(L.T.)
(L.T.)
(L.T.)
April
May
June
July
August
September
October
November

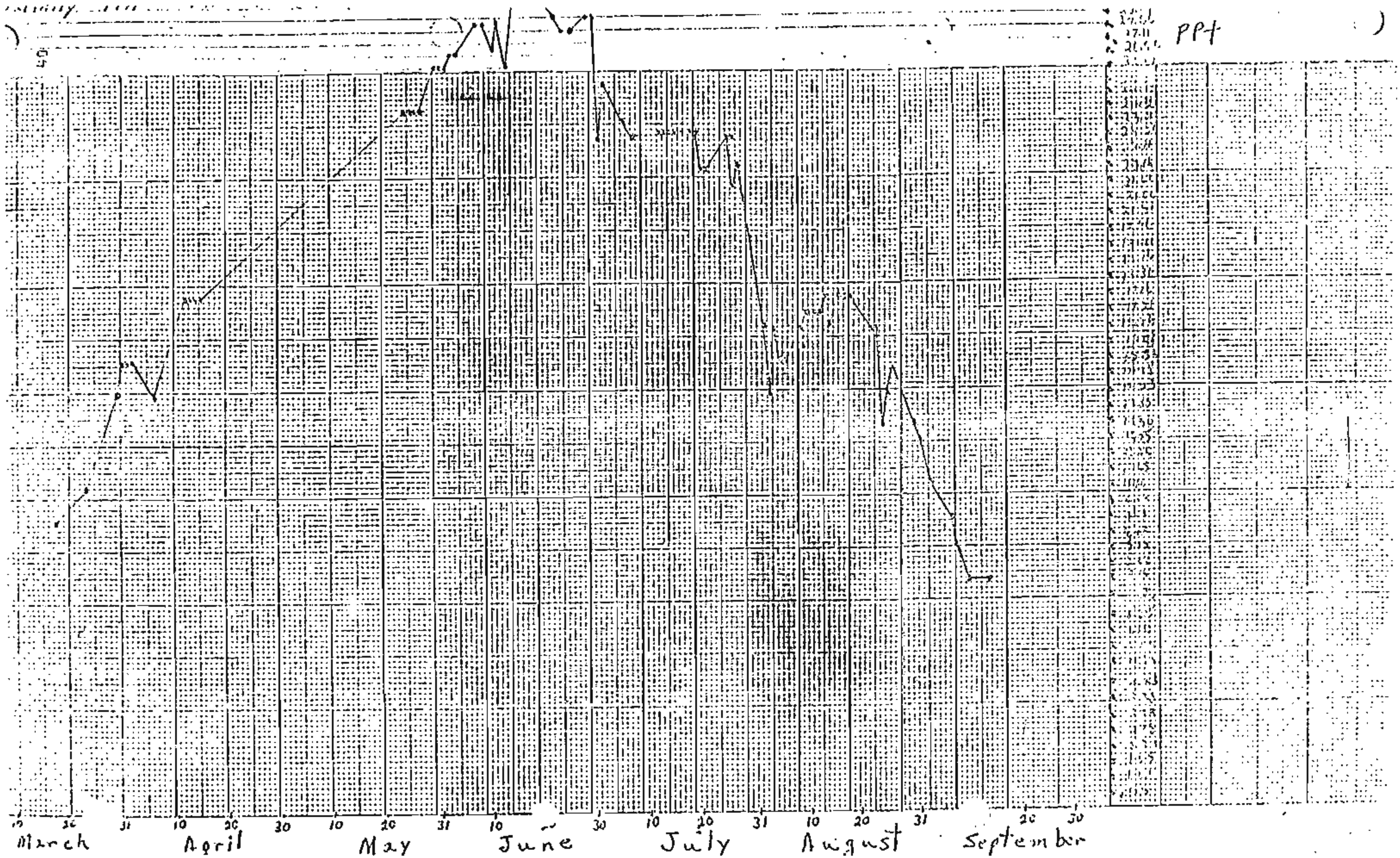
Salinity — 1971 — Bayou

* All samples taken at high tide.



Little Upper Pond (P-1) – 1971




PPt
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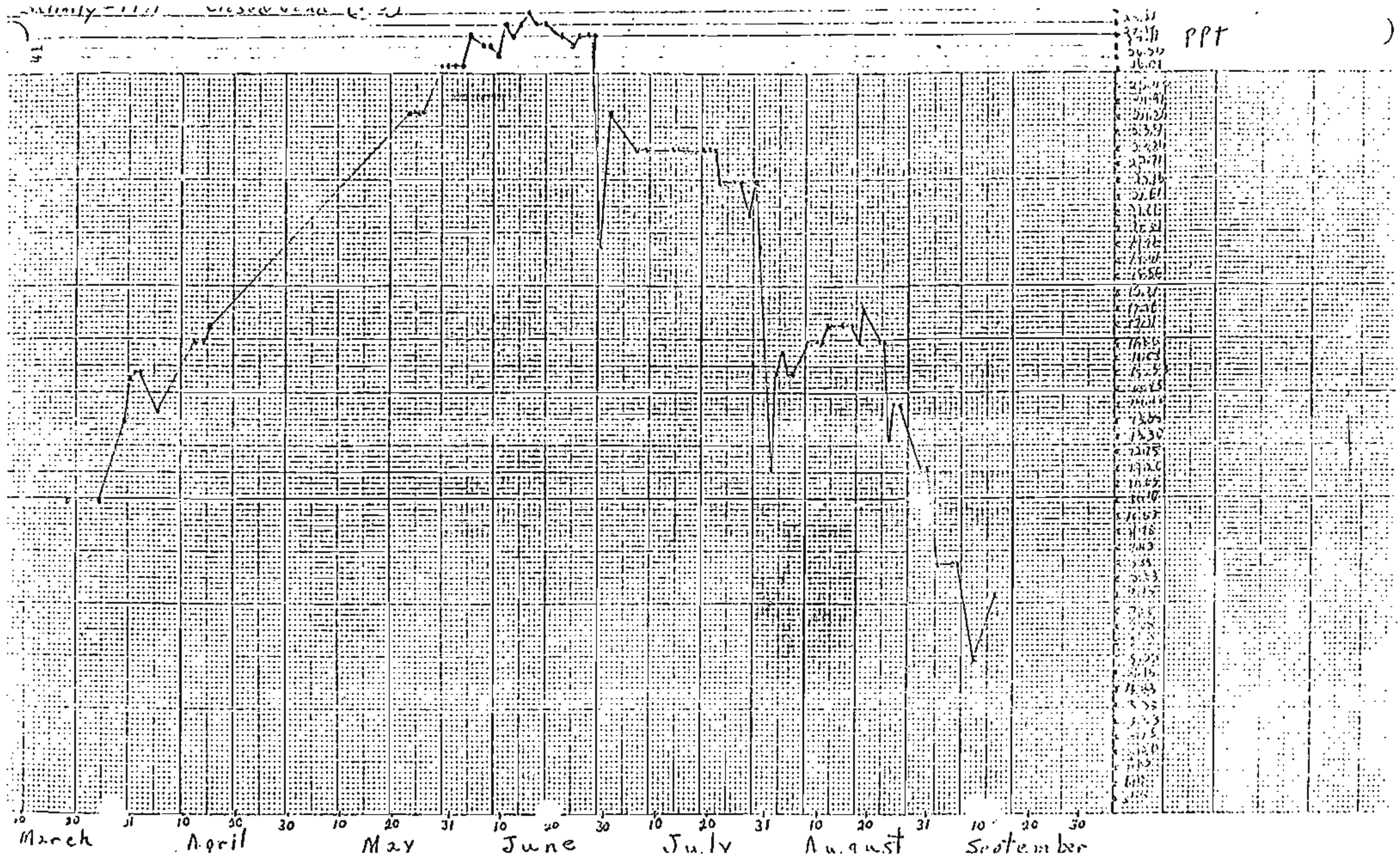
PPT
March
April
May
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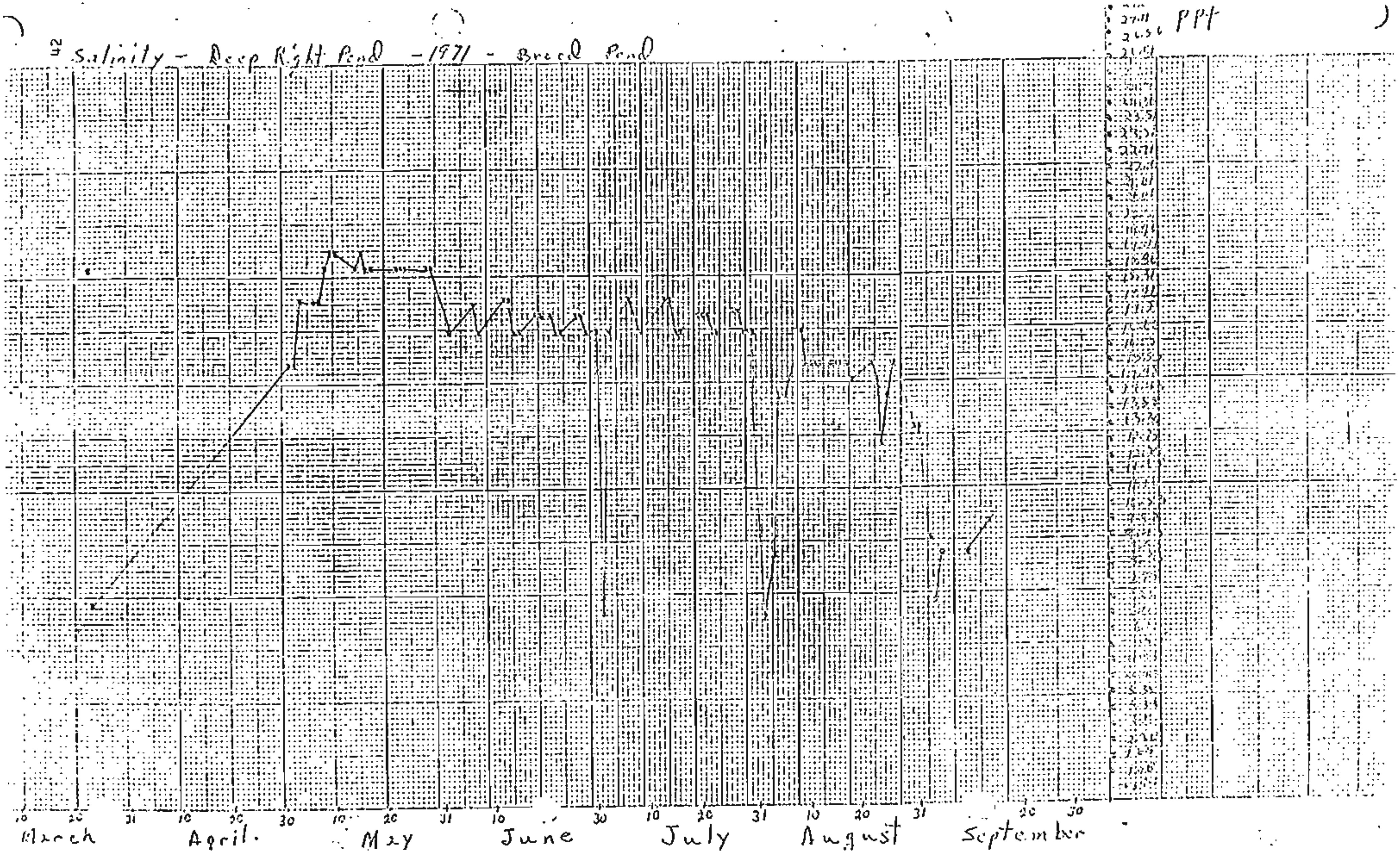
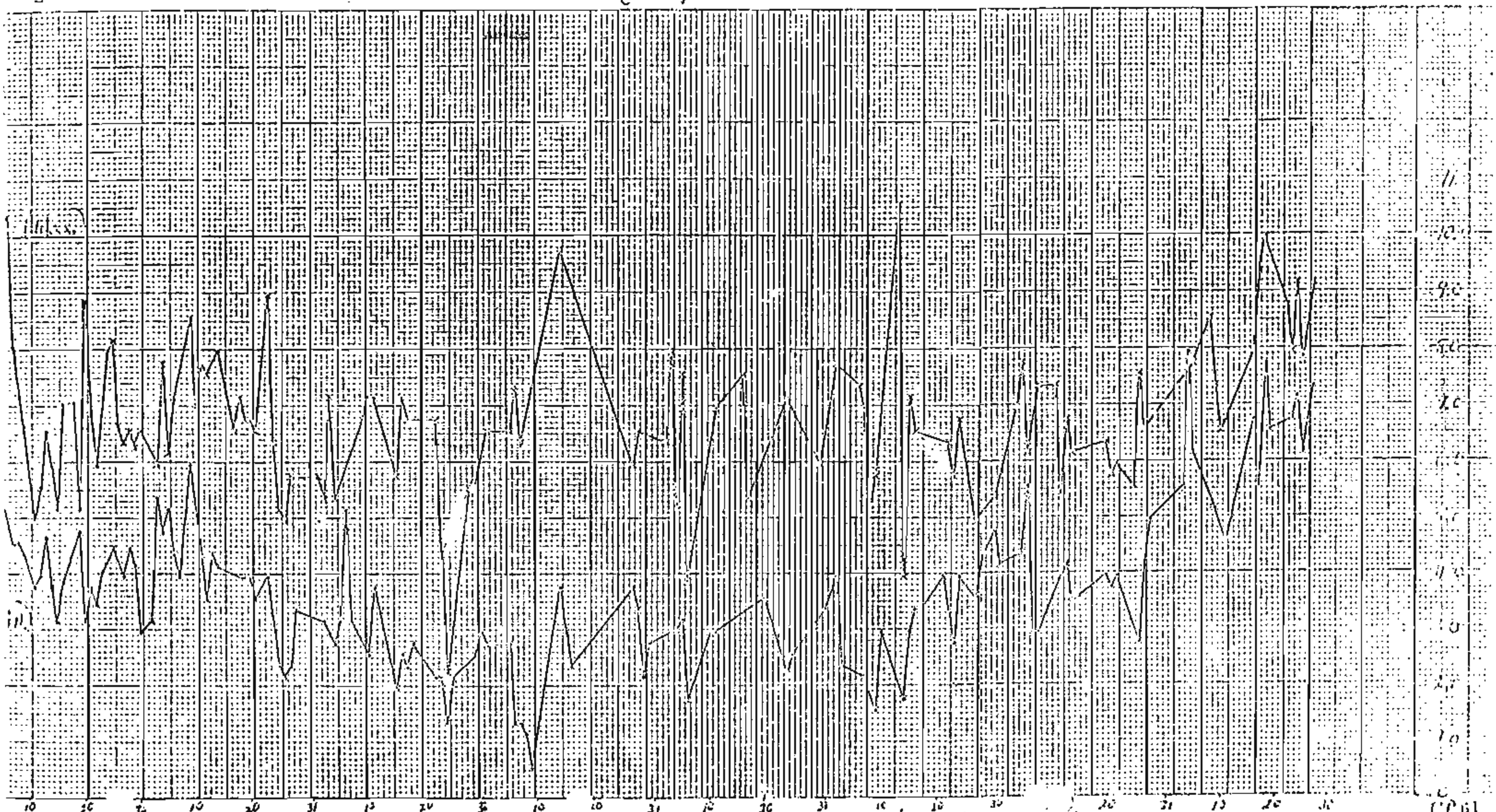
September

42 Salinity - Deep Right Pond - 1971 - Breed Pond

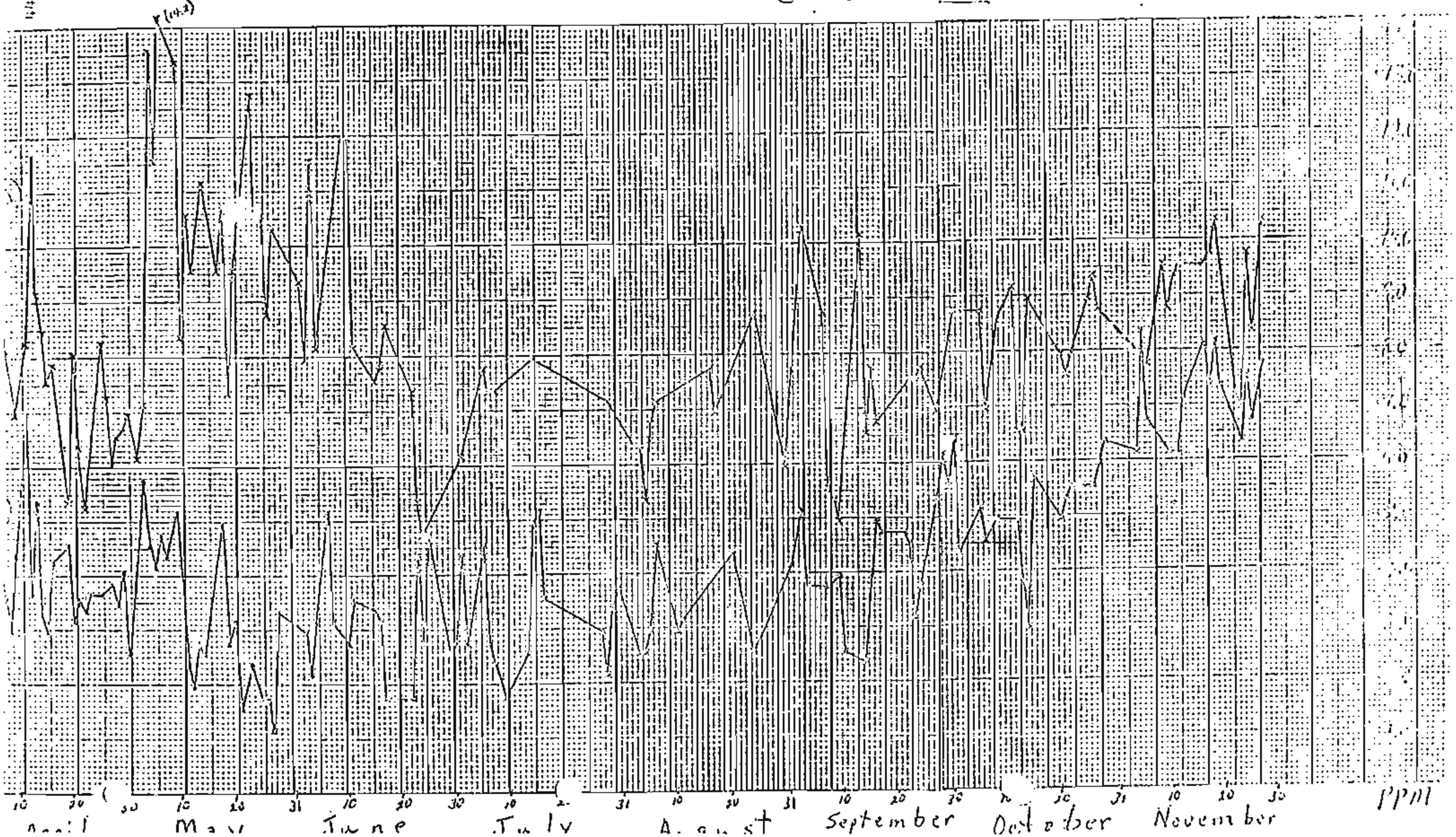


O_2 - Readings - 1970 ( ) Upper Pond (P-1) - Min. .)

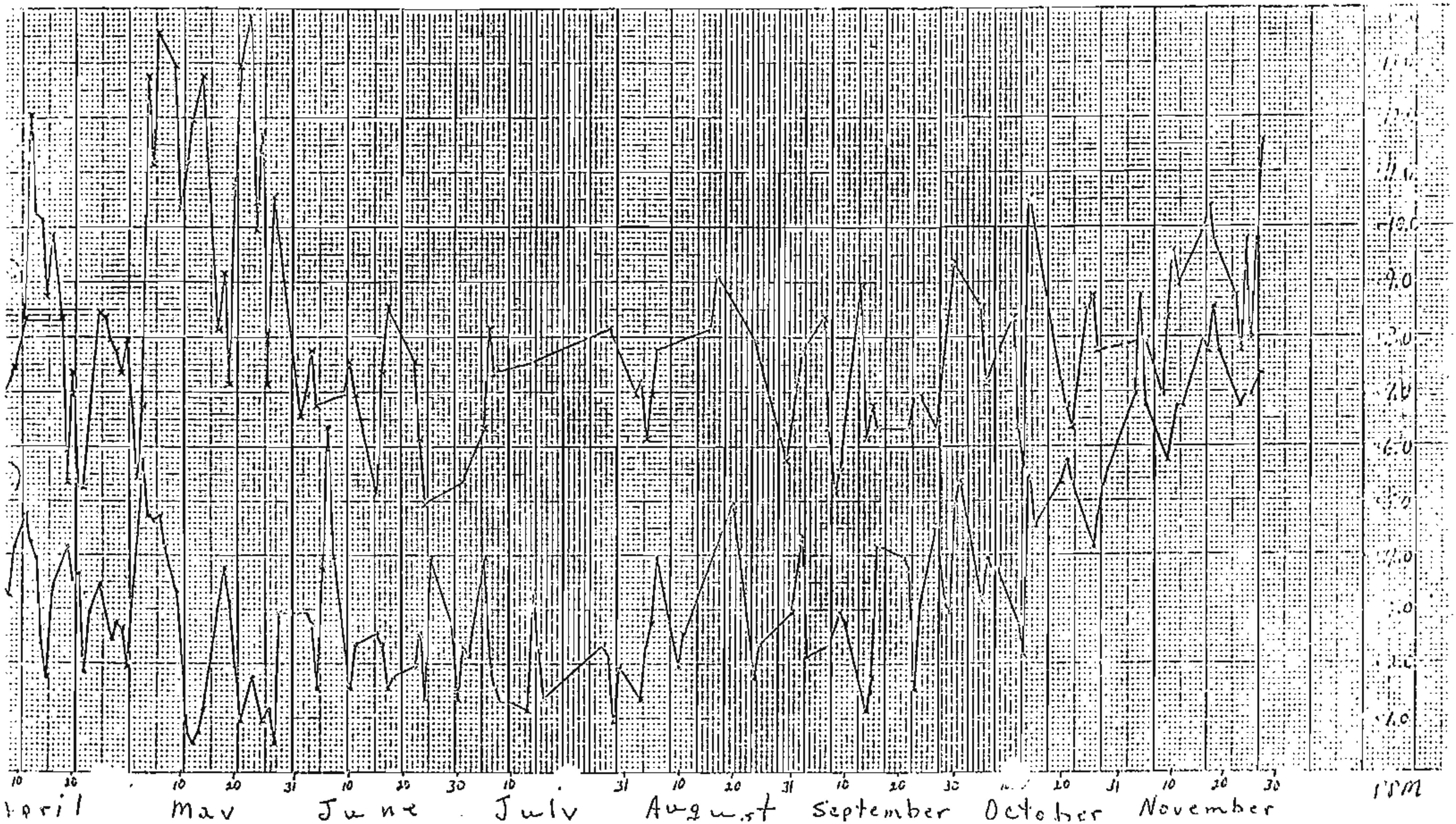


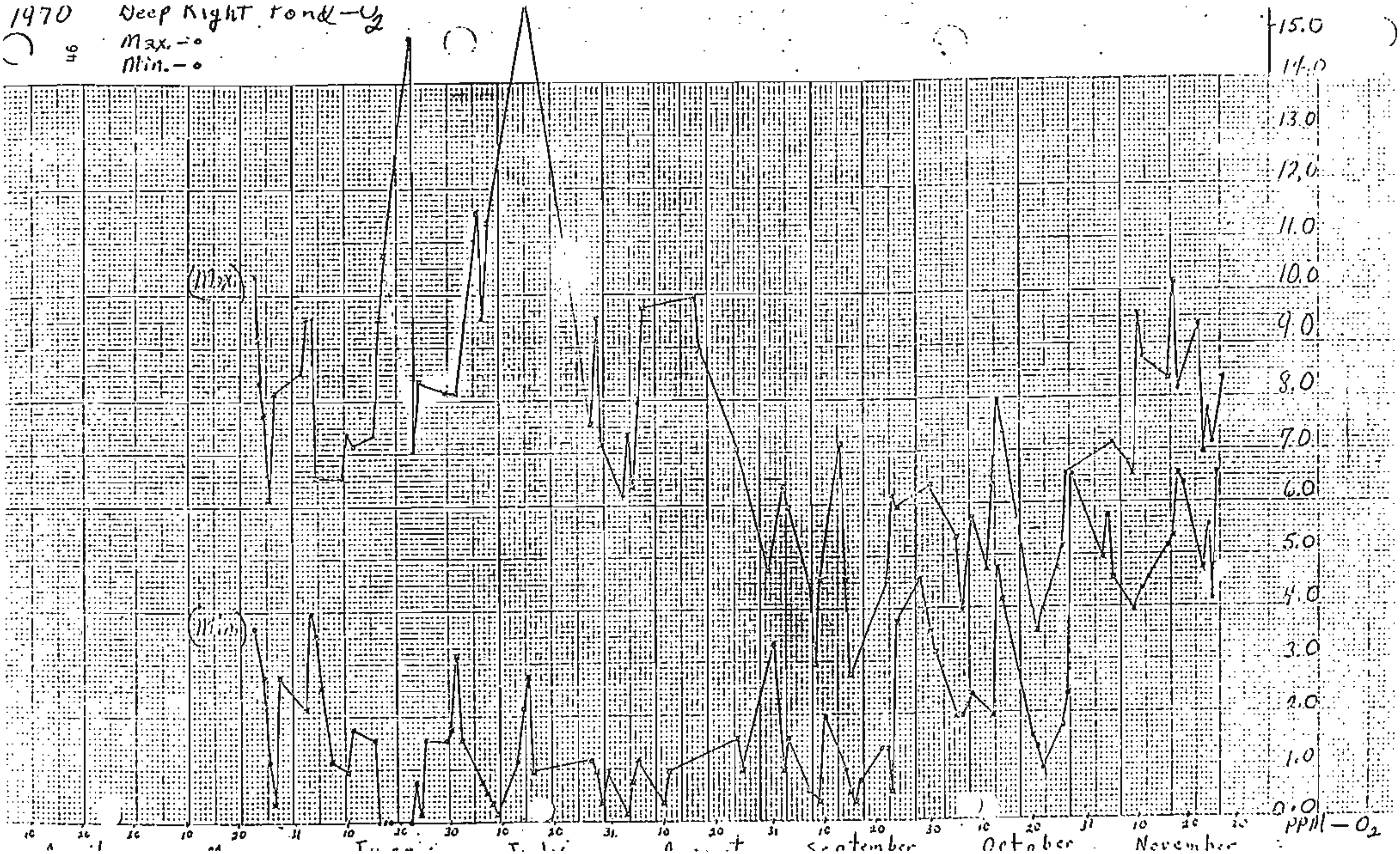
April May June July August September October November

O_2 — Readings — 1970 Flow Pond (P-2) — Max./Min.



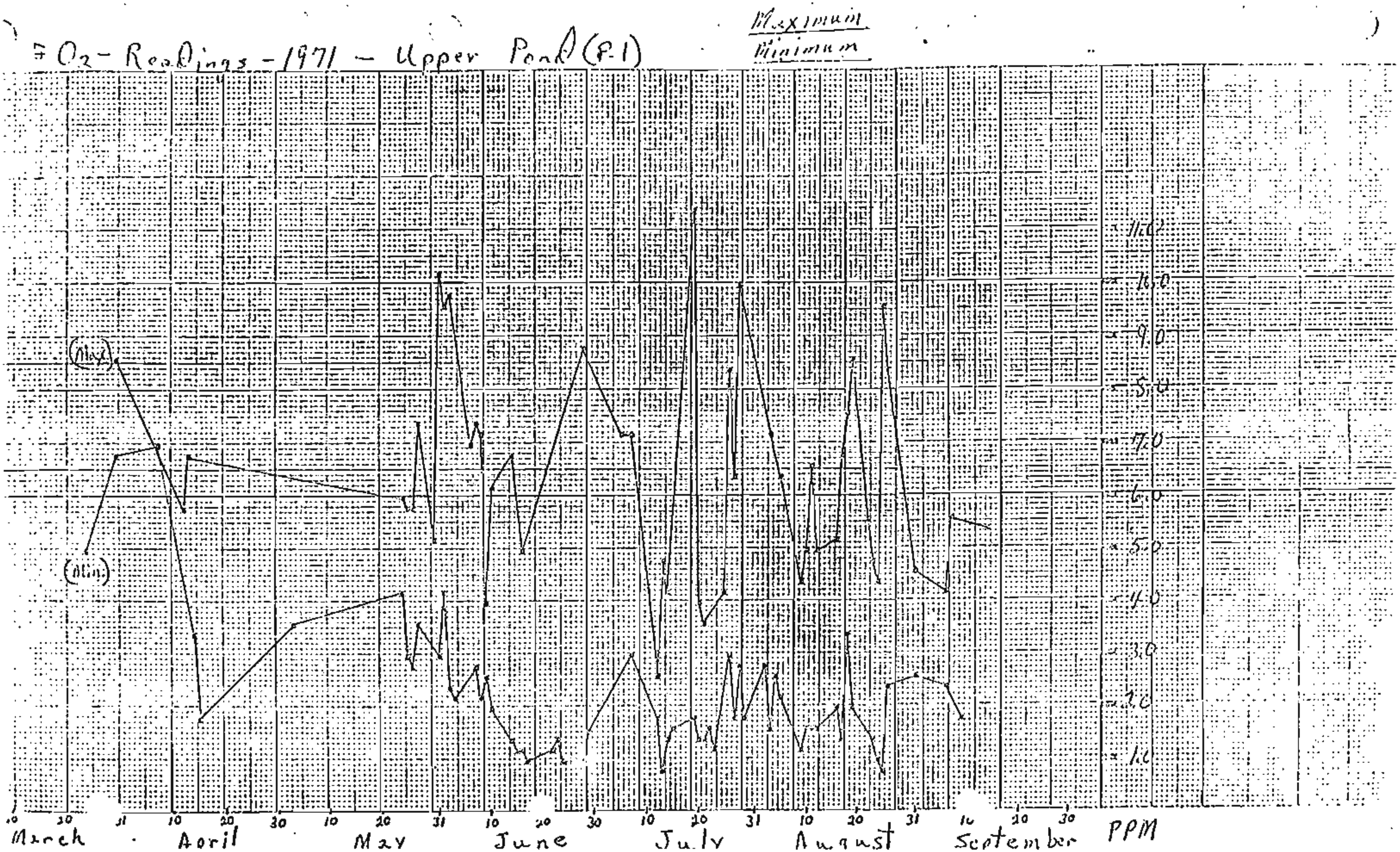
O_2 - Readings - 1970 , Closed Pond (1-3) — Max. / Min.





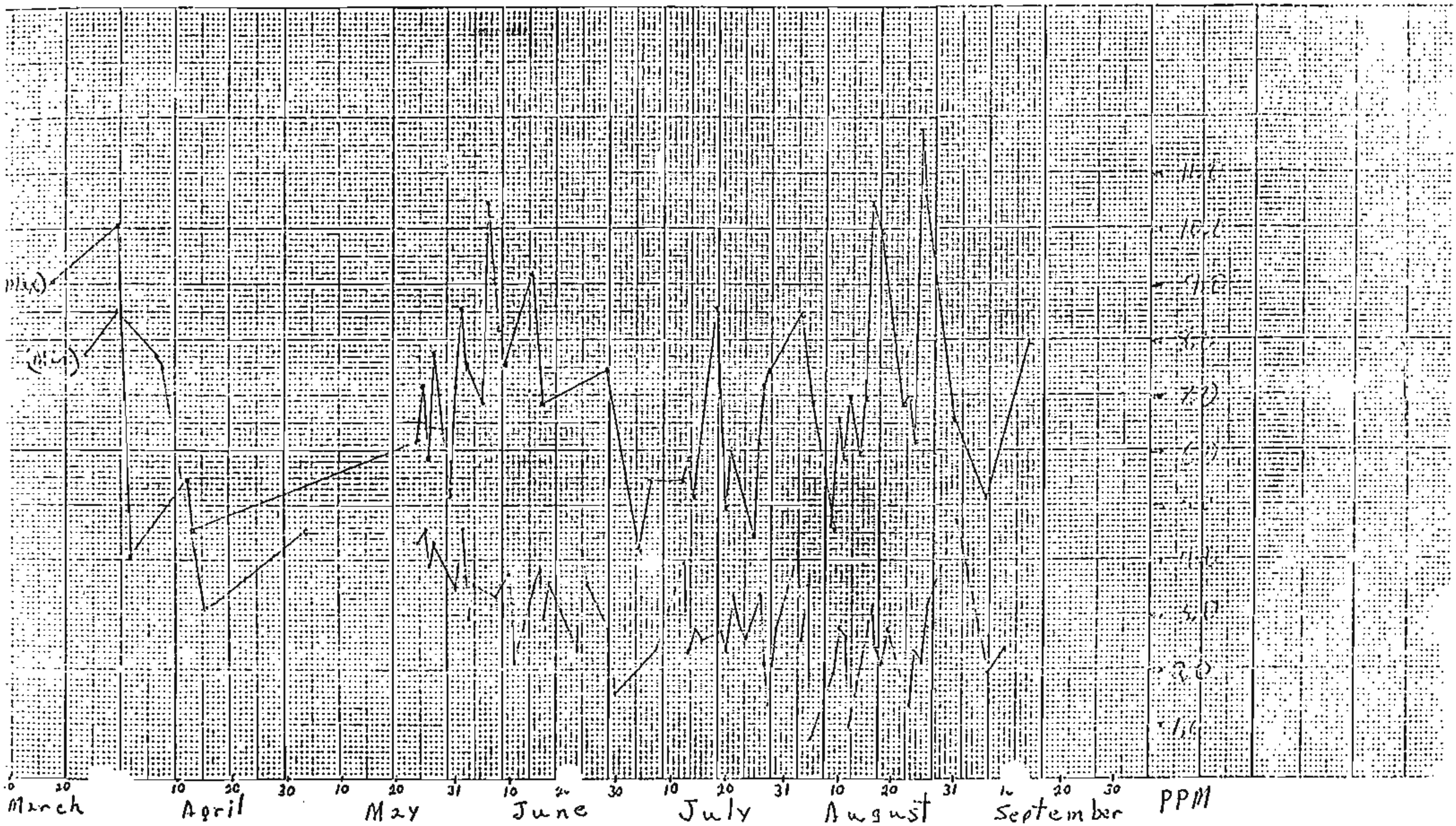
1970 Deep Right Pond—O2
Max.—o
Min.—•
Max
Min
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm — O2
September
October
November

O_2 - Readings - 1971 - Upper Pond (F-1)



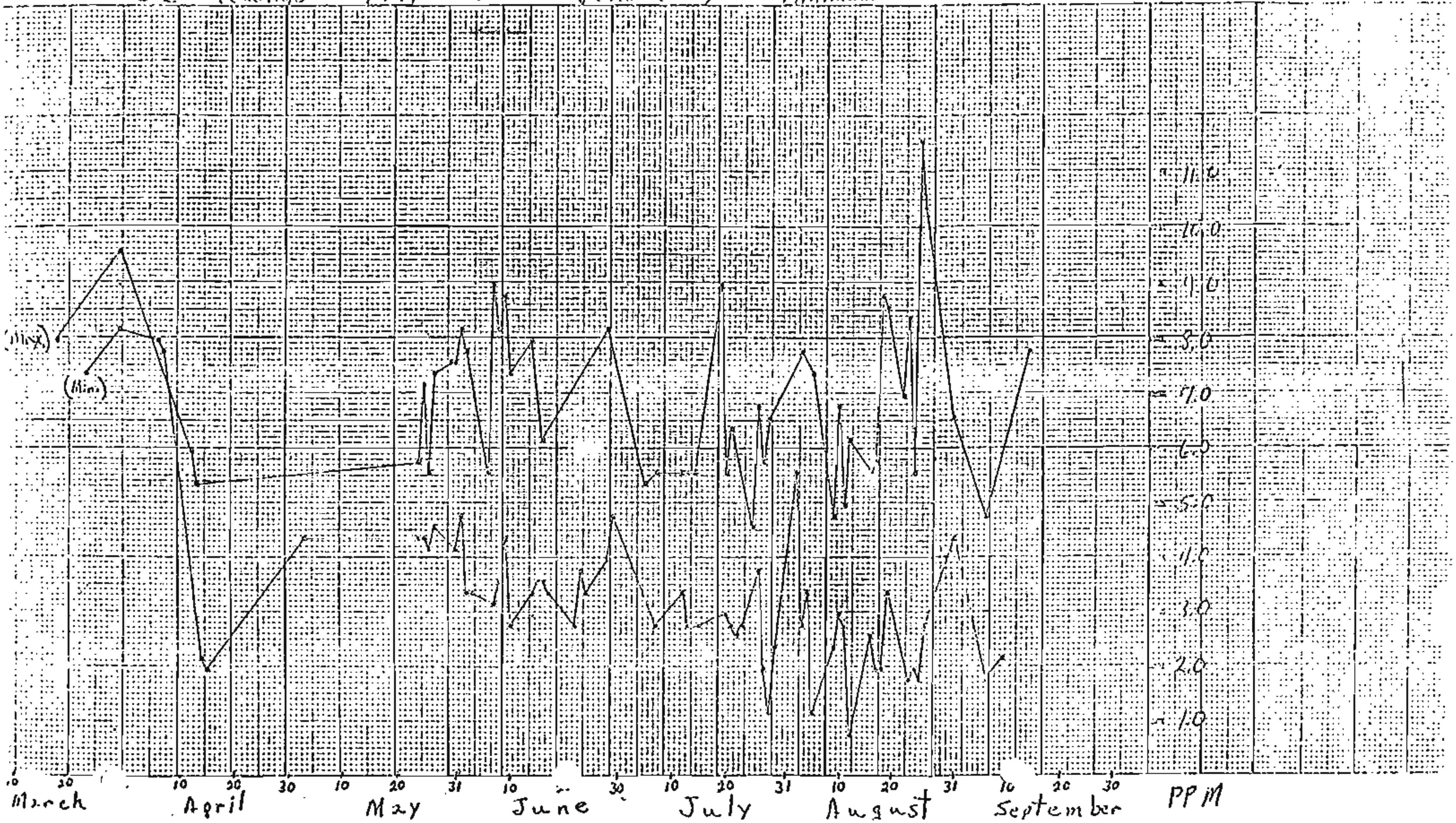
O_2 Readings – 1971 – Flow Pond (P-2)

Maximum
Minimum



O_2 – Readings – 1971 – Closed Pond (P-3)

Maximum
Minimum



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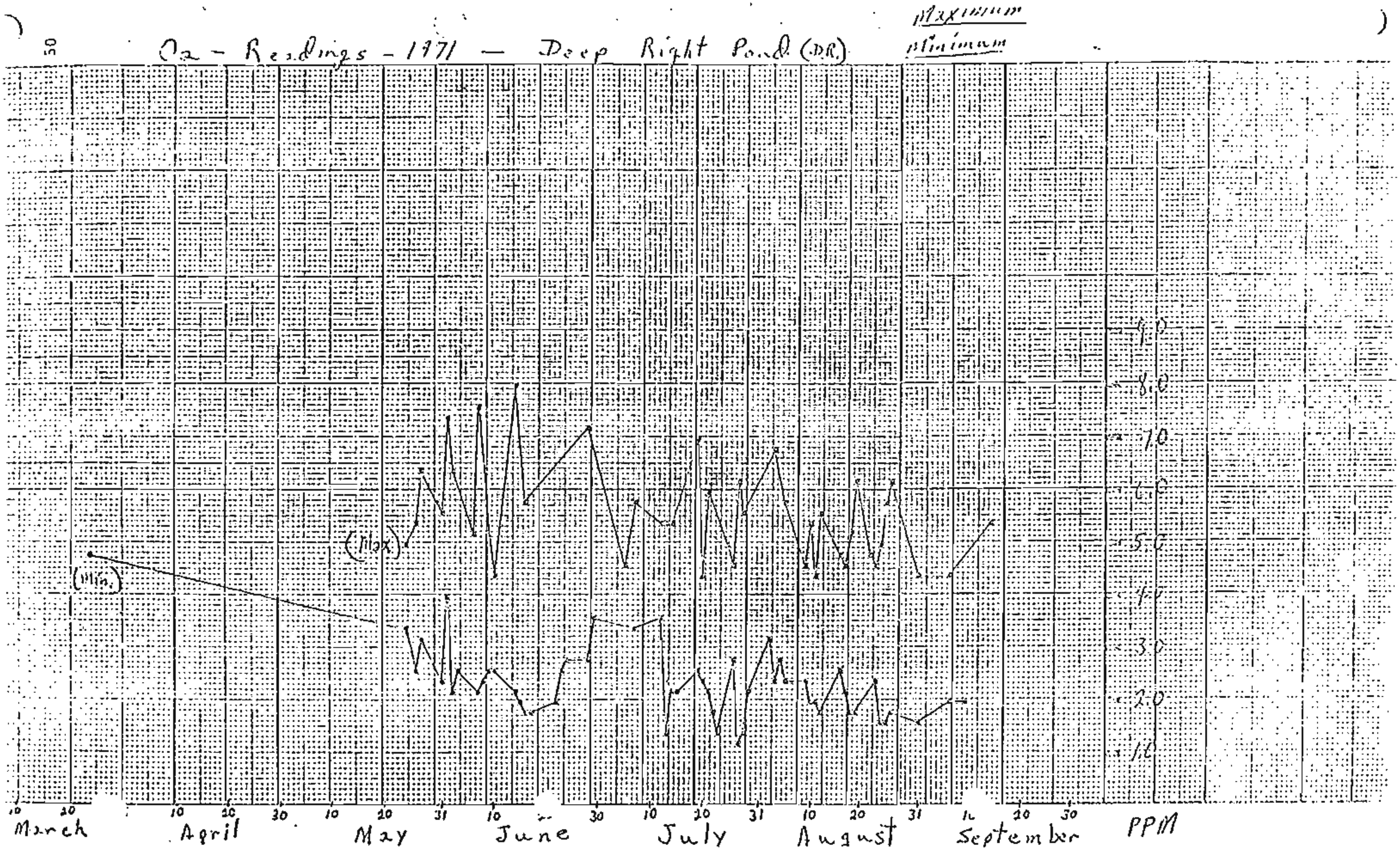
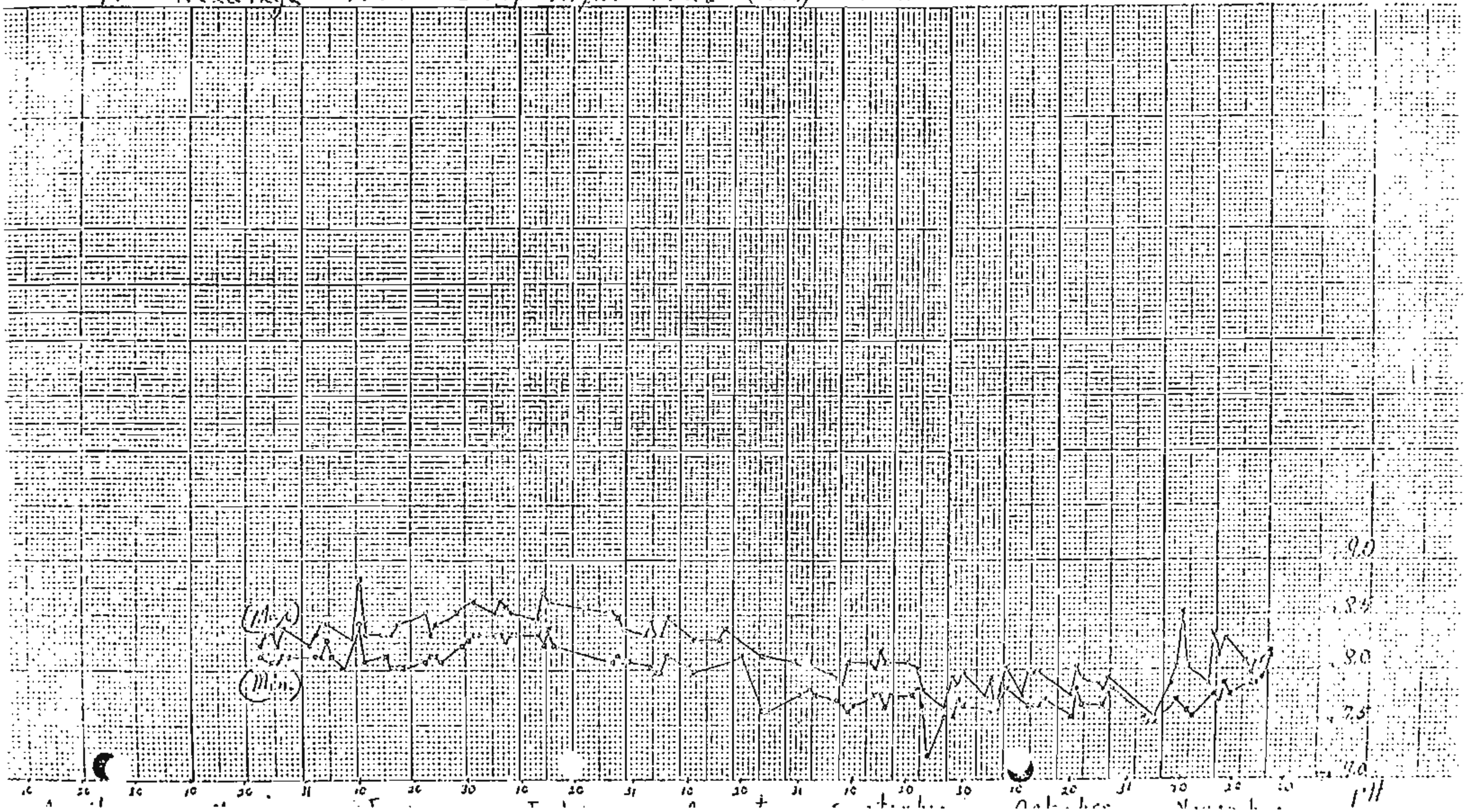
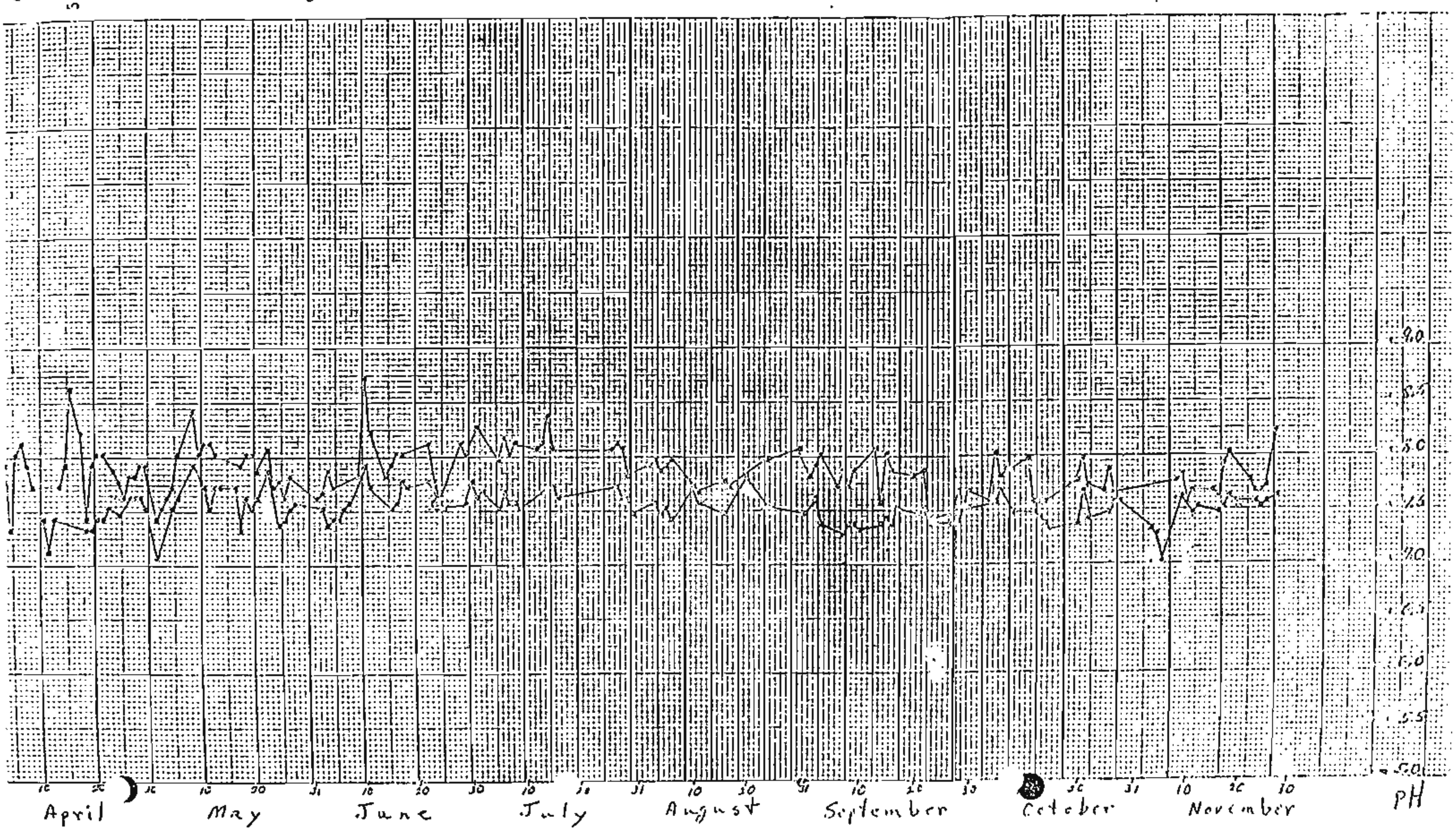
O_2 - Readings - 1971 — Deep Right Pond (DR)



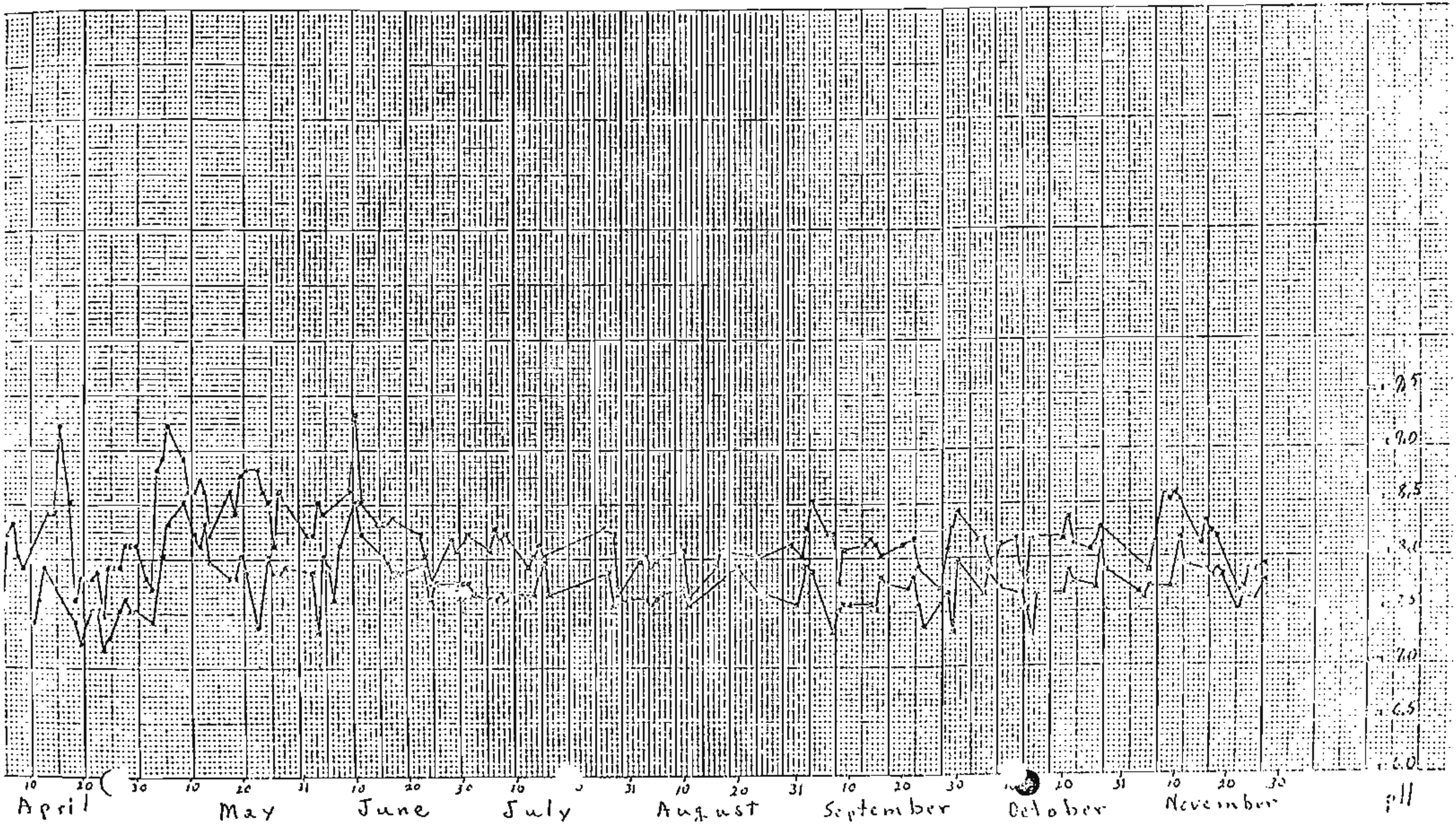
pH - Readings - 1970 - Deep Right Pond (D.R.) · Max.· Min.·



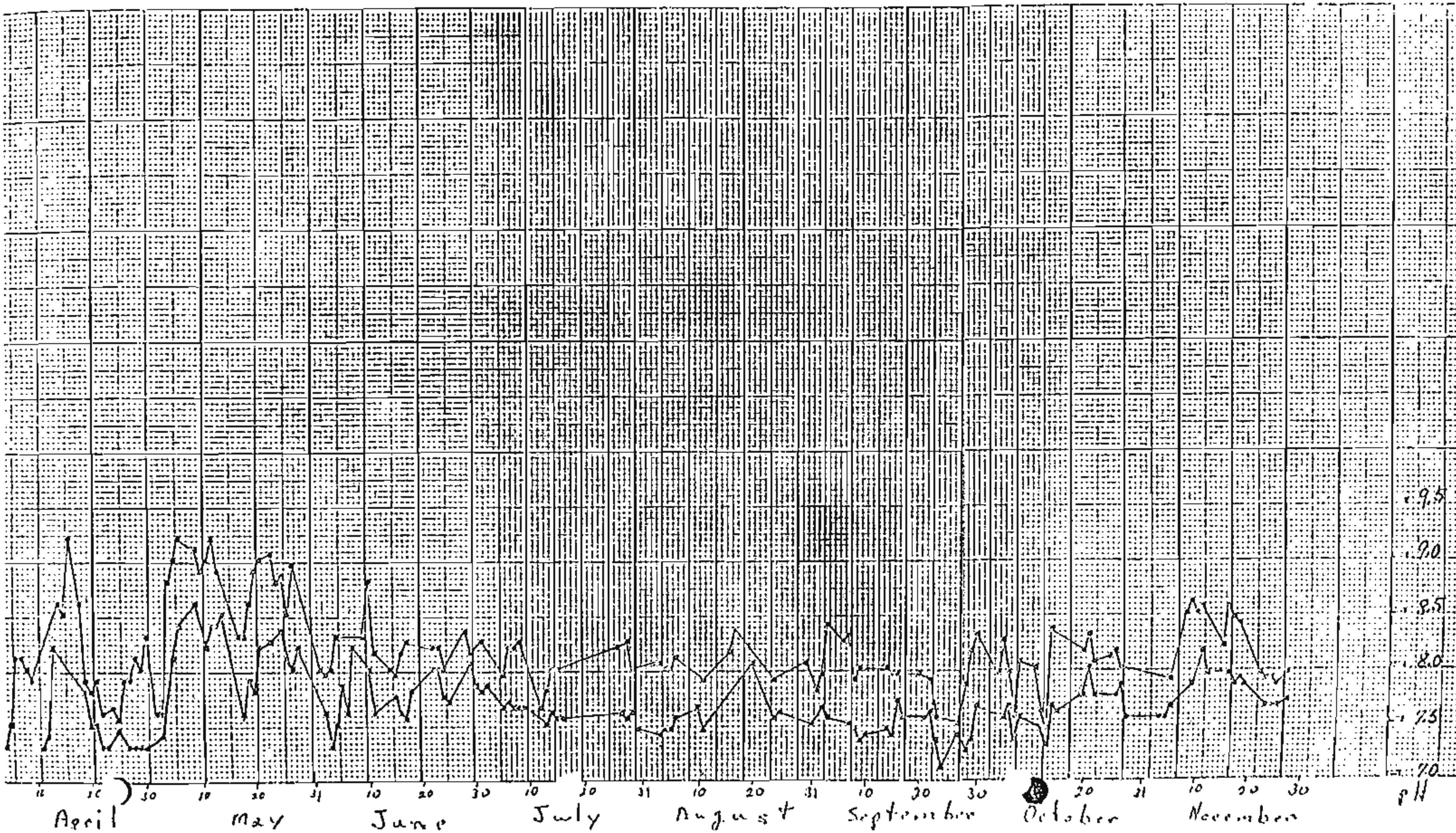
pH – Readings – 1970 – Upper Pond (P-1) – max. • min. •



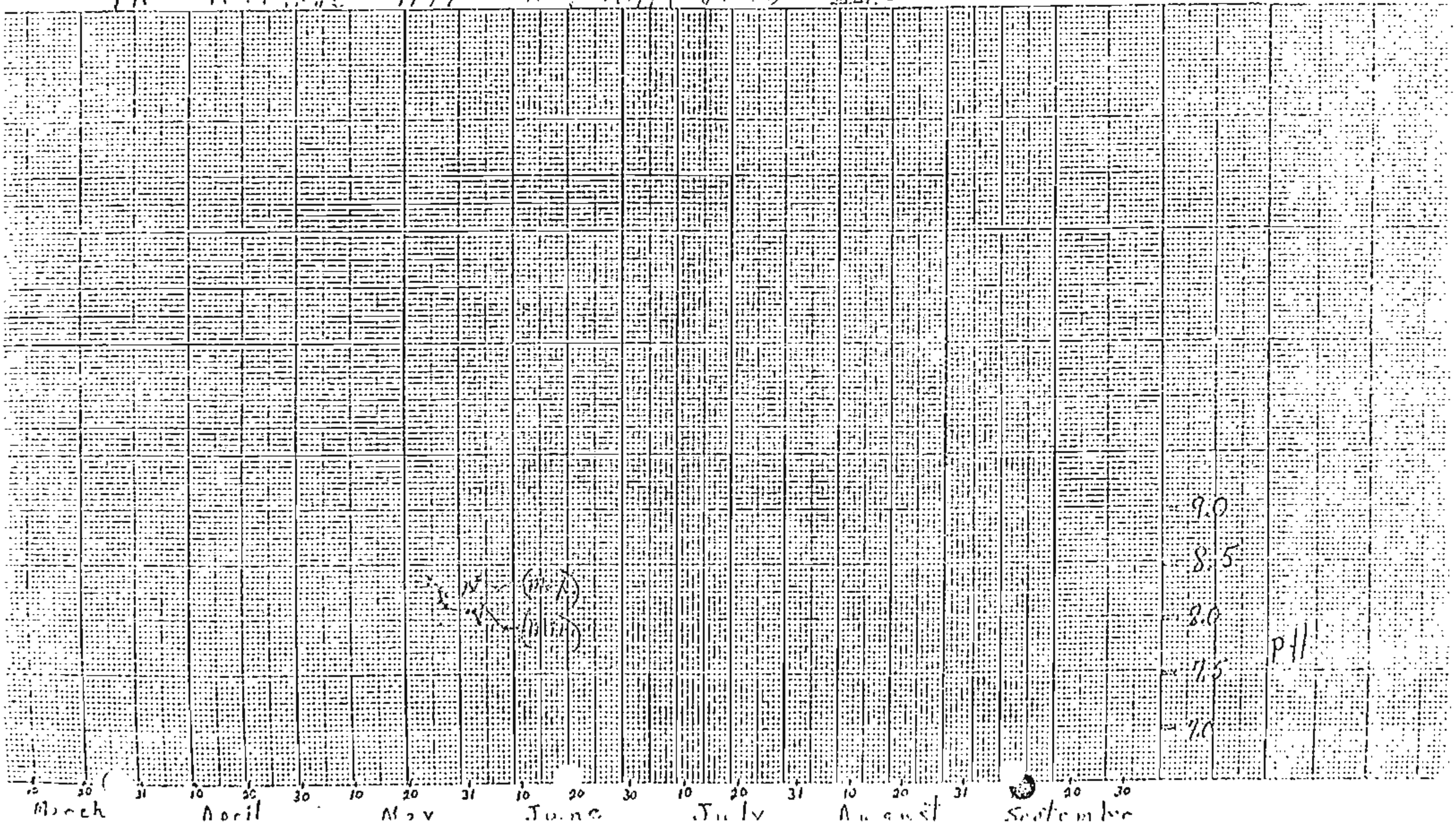
pH — Readings — 1970 — Flow Pond (P-2) — Max. — • Min. — •



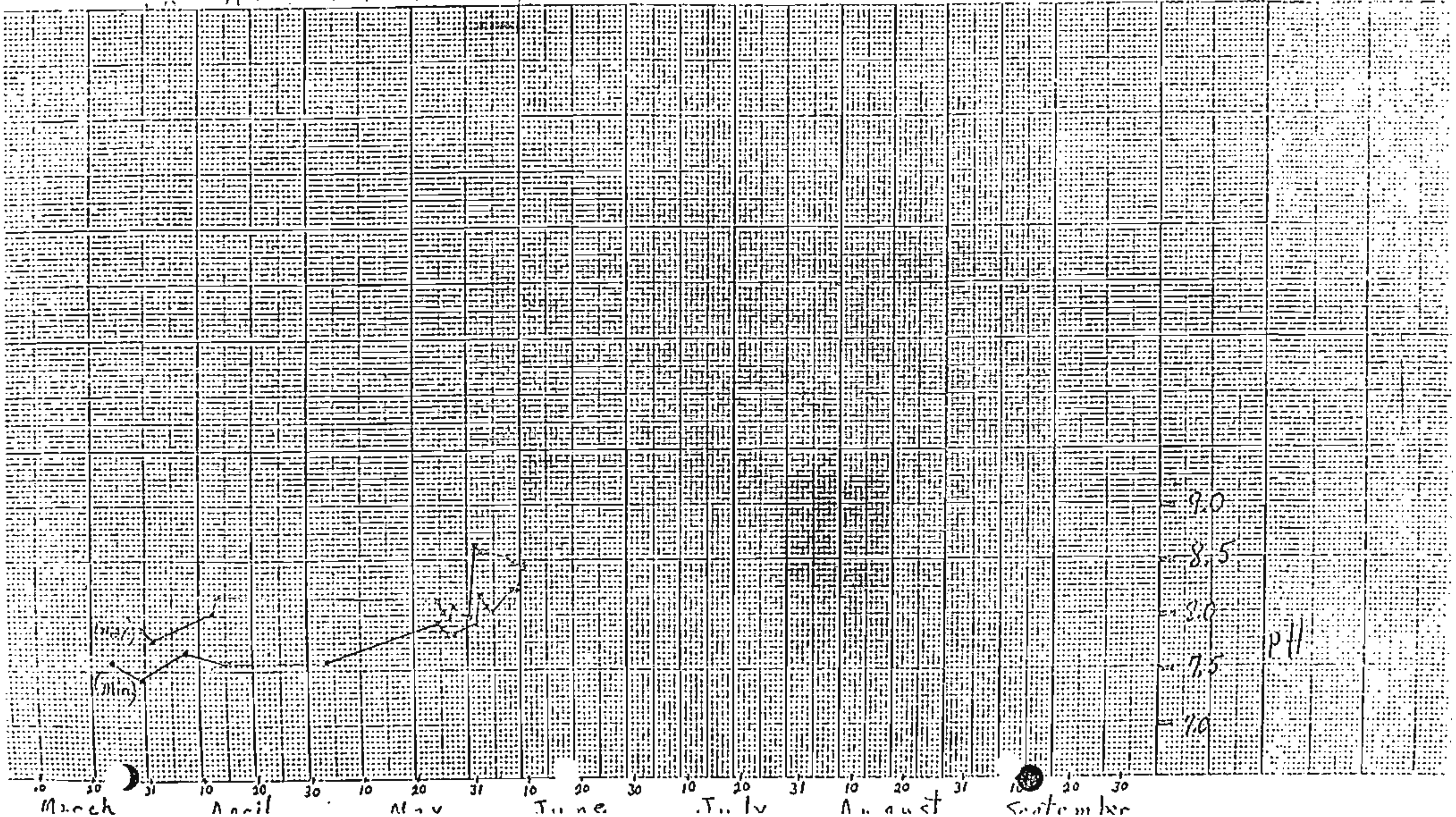
pH - Readings - 1970 — Closed Pond (P-3) -- max. • min. •



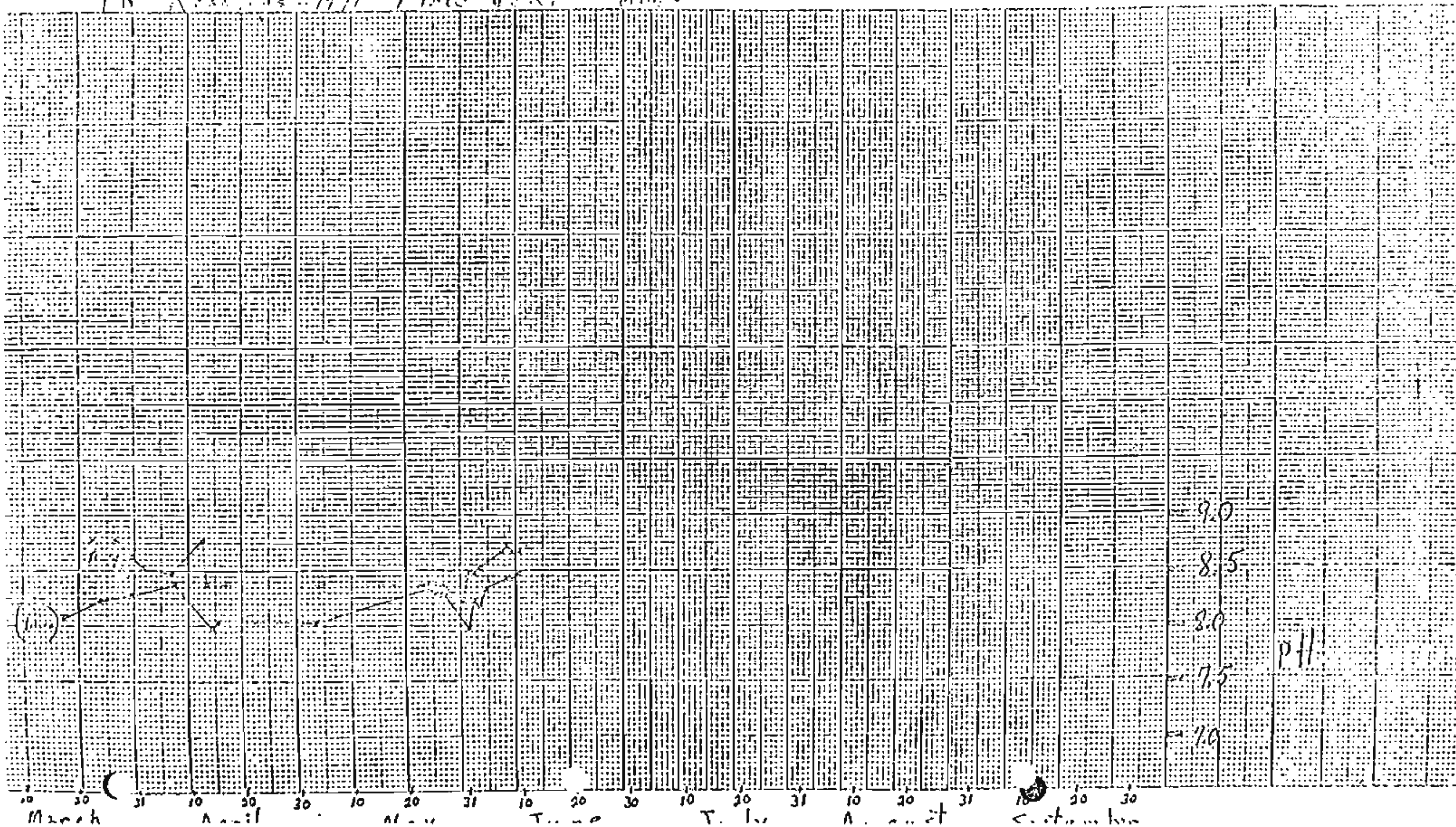
pH - Readings 1971 [illegible]



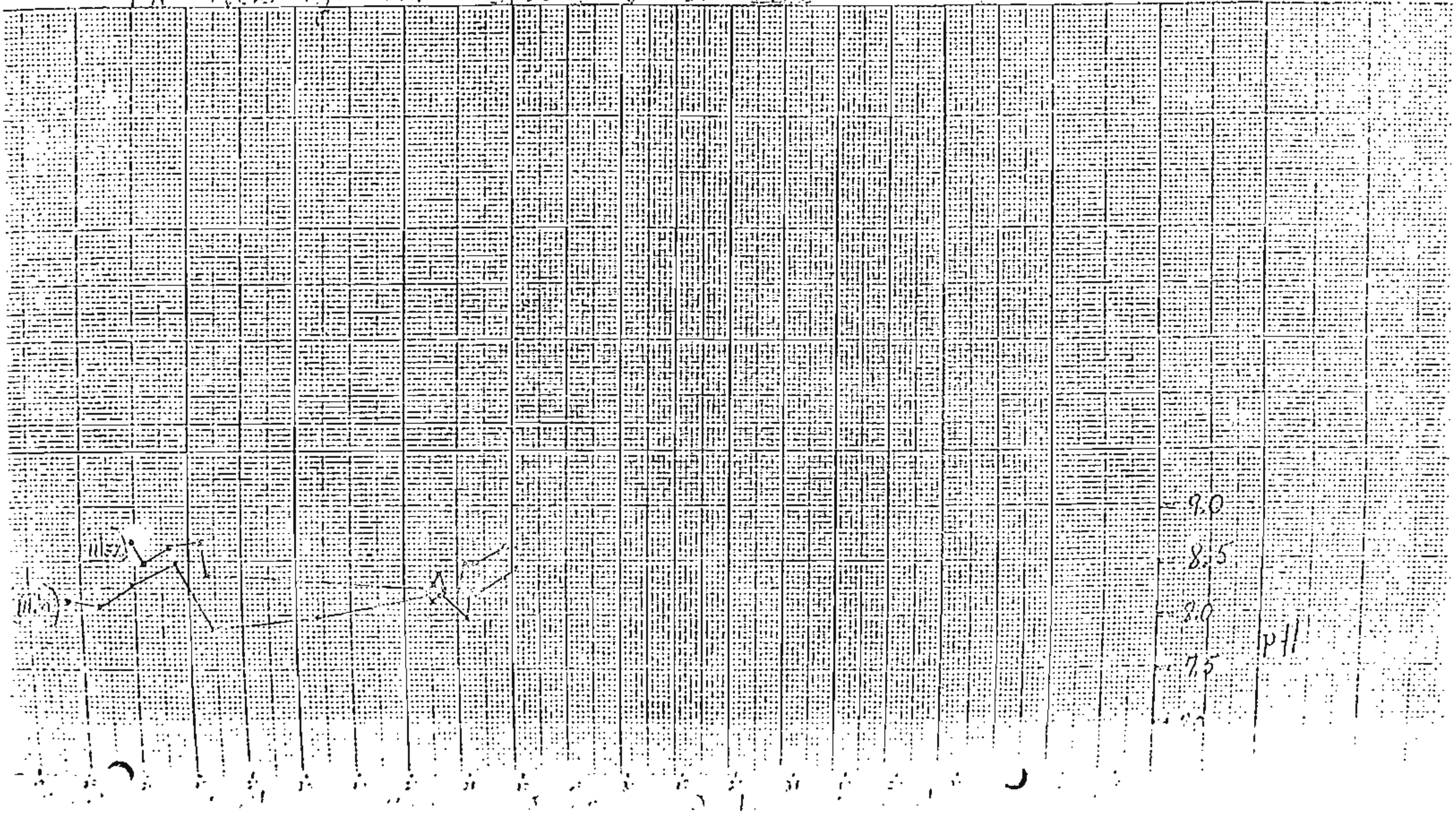
pH - Rock ... -1971 - Upper Pool Max / Min



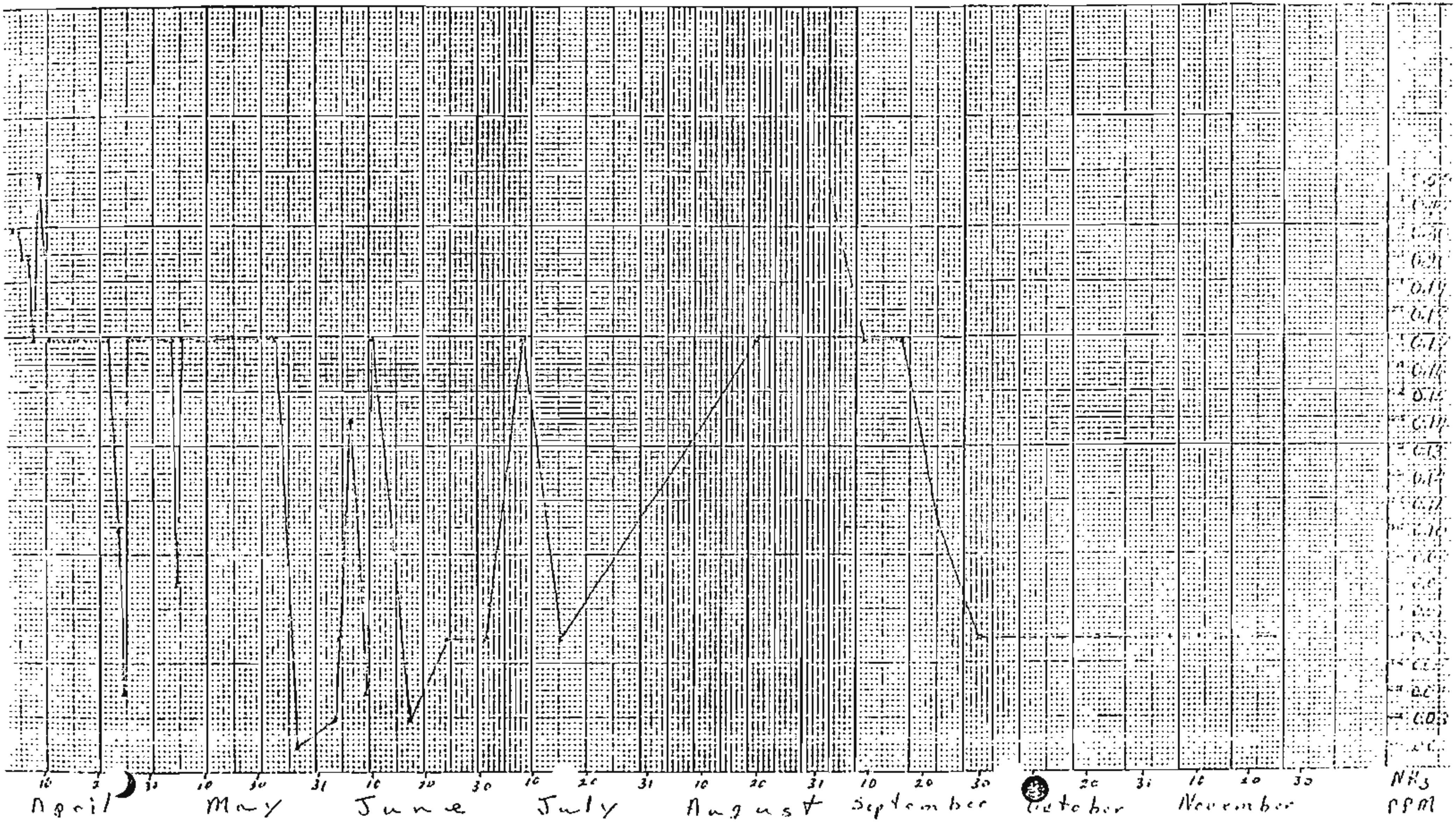
pH - Readings - 1971 - Flow ...



pH - Readings - 1971 - Closed Pond Max. / Min.

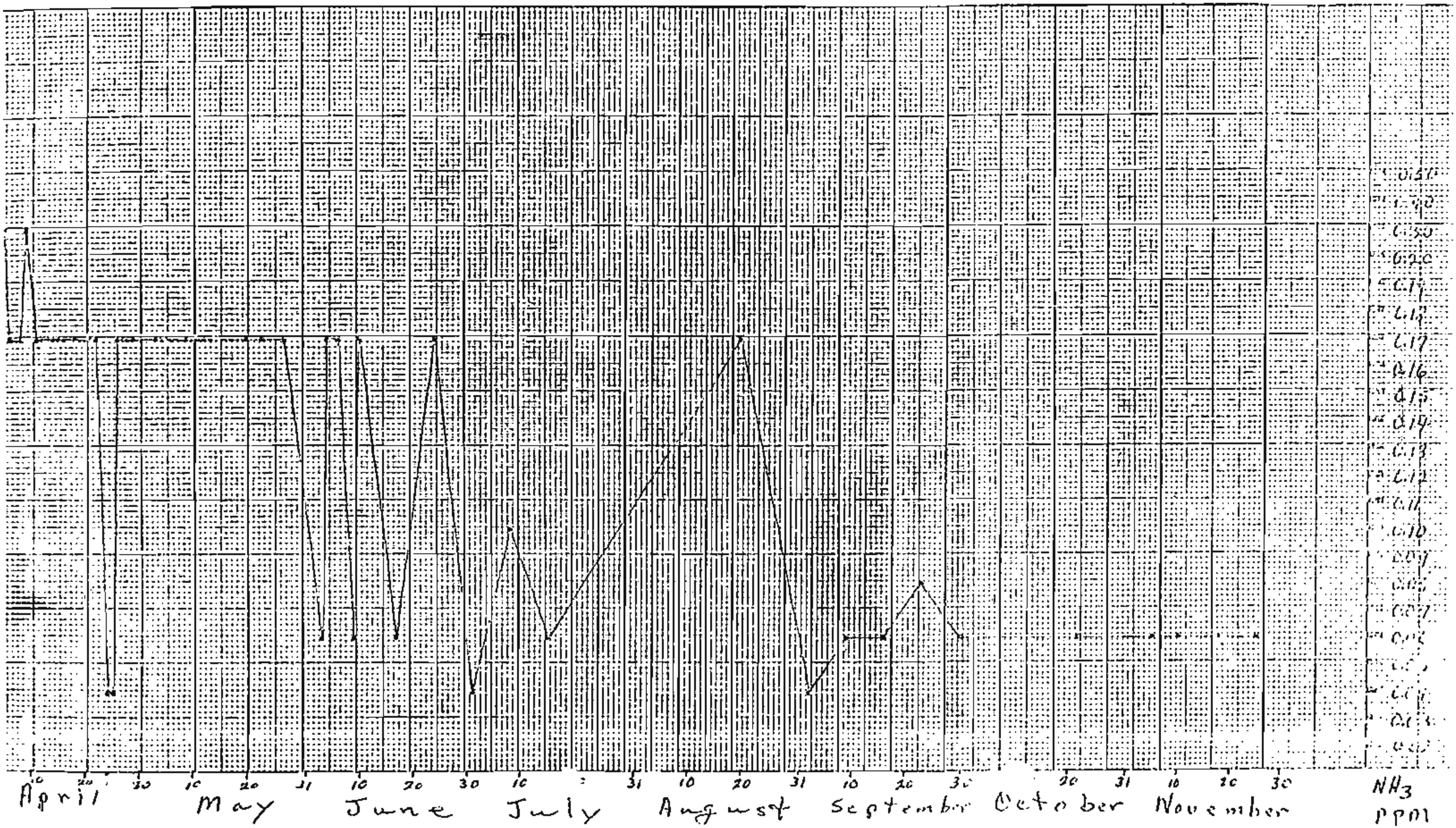


Ammonia Nitrogen - ppm — 1970 — Upper Pond (P-1)



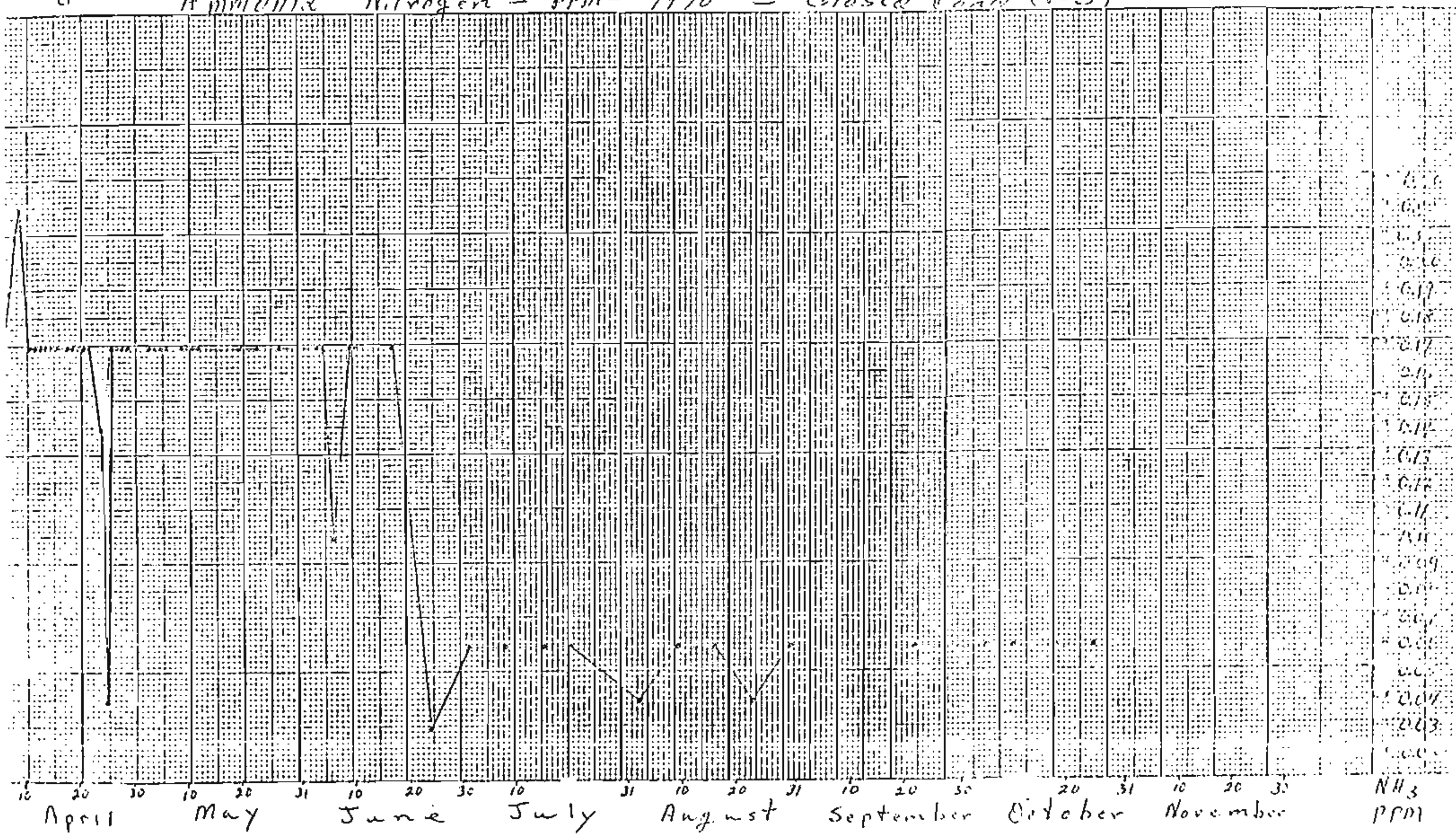
60

Ammonia Nitrogen - PPM - 1970 - Flow Pond (P-2)

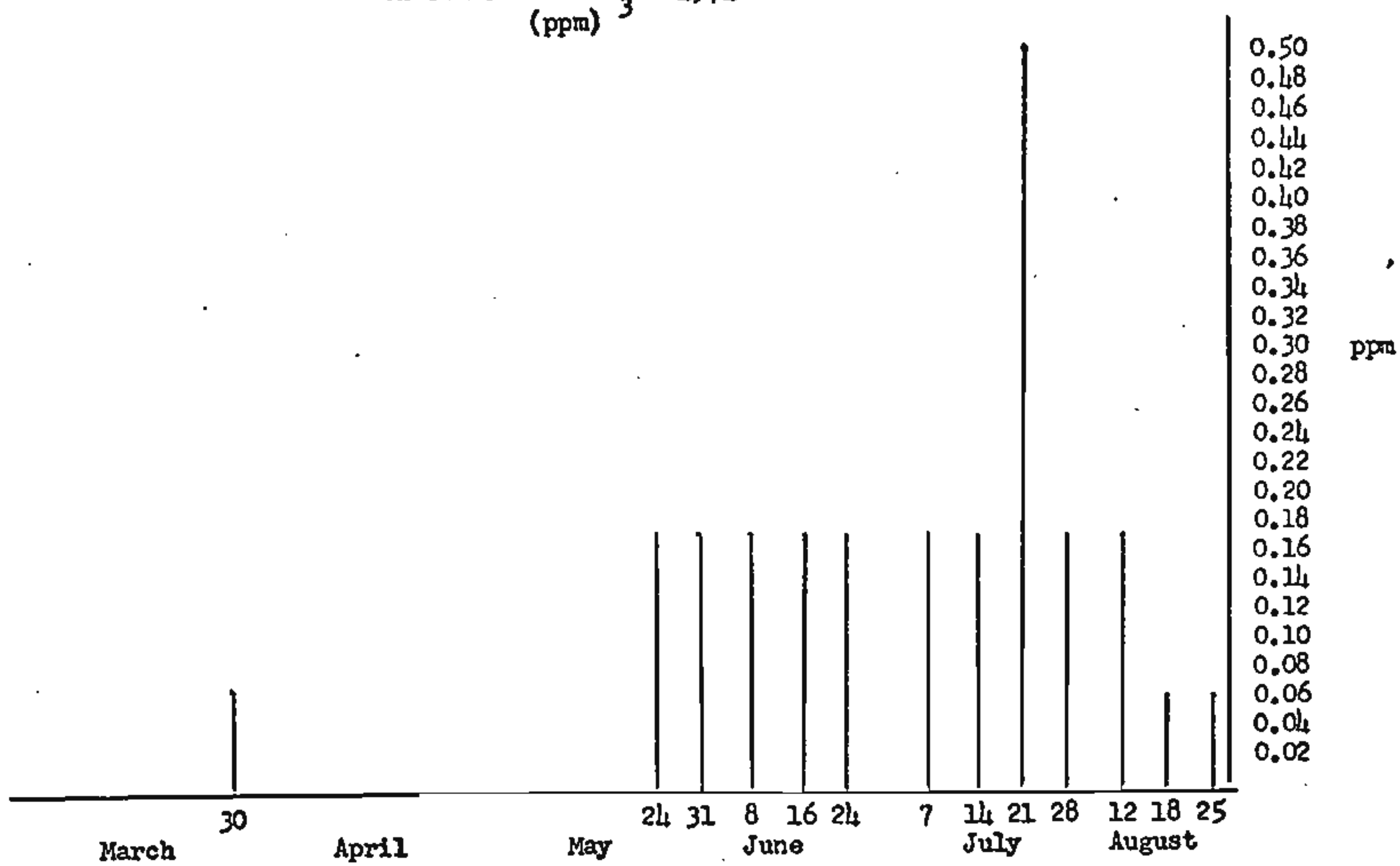


51

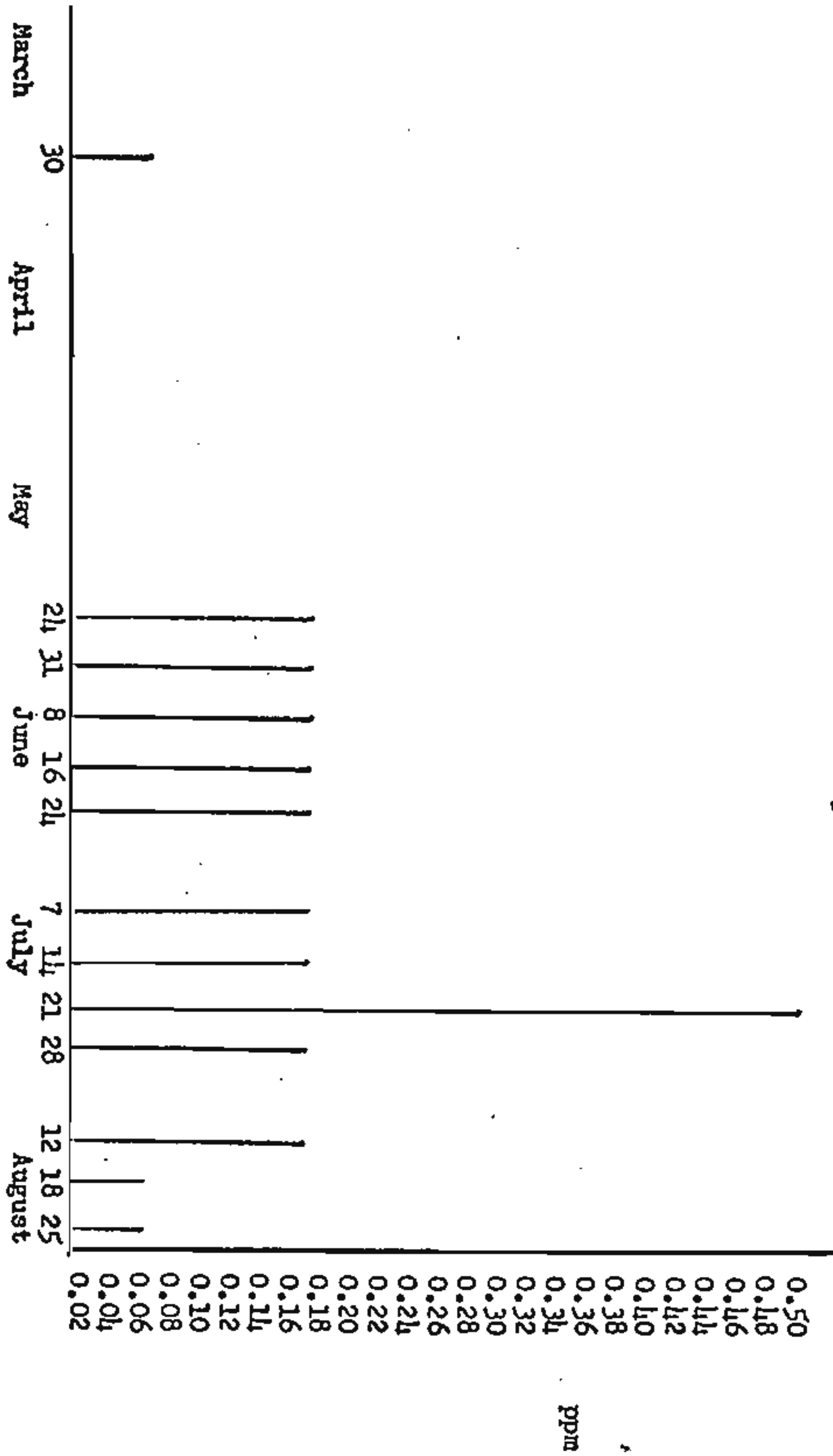
Ammonia Nitrogen - ppm - 1970 - Closed Pond (P-3)



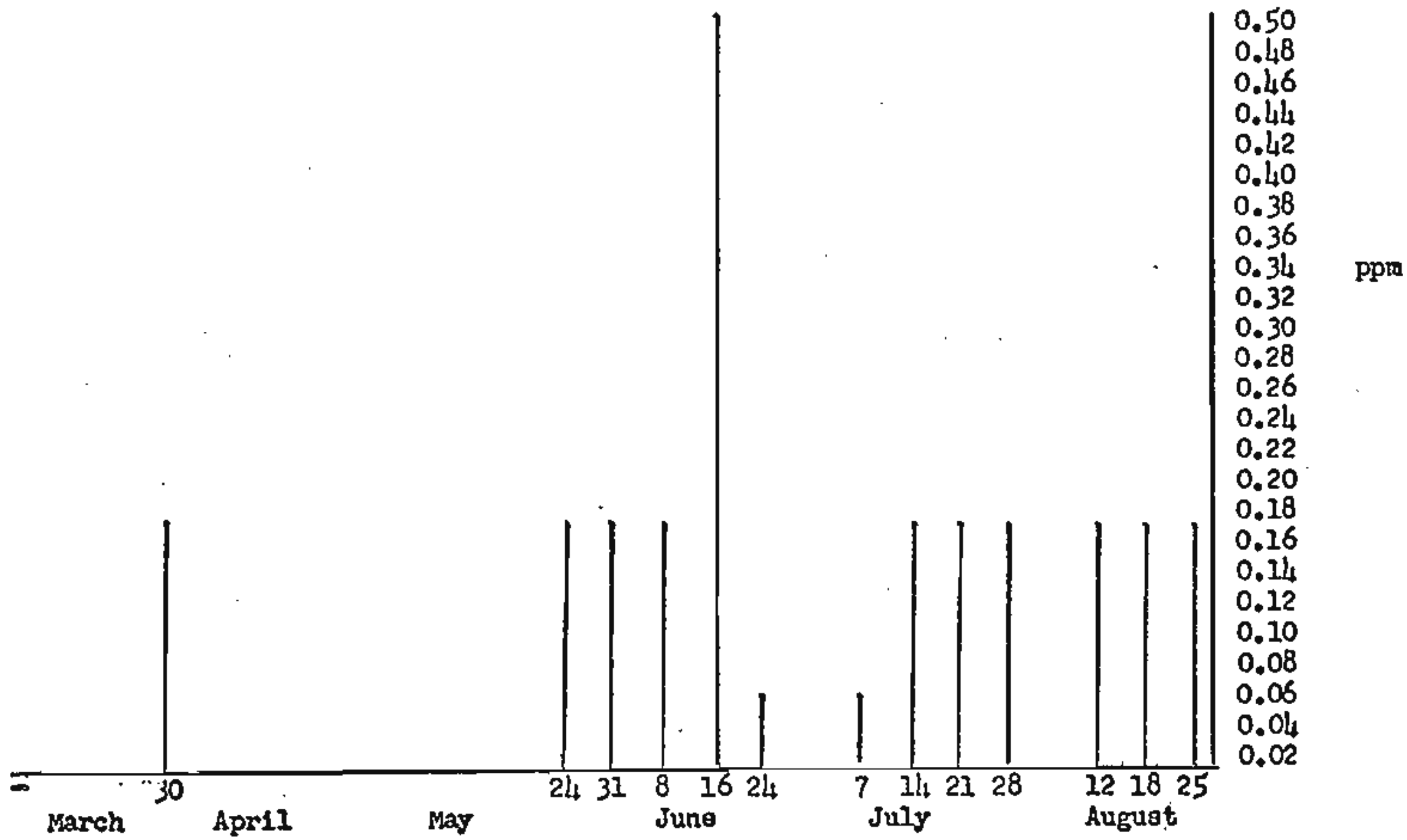
Closed Pond - NH_3 - 1971
(ppm)



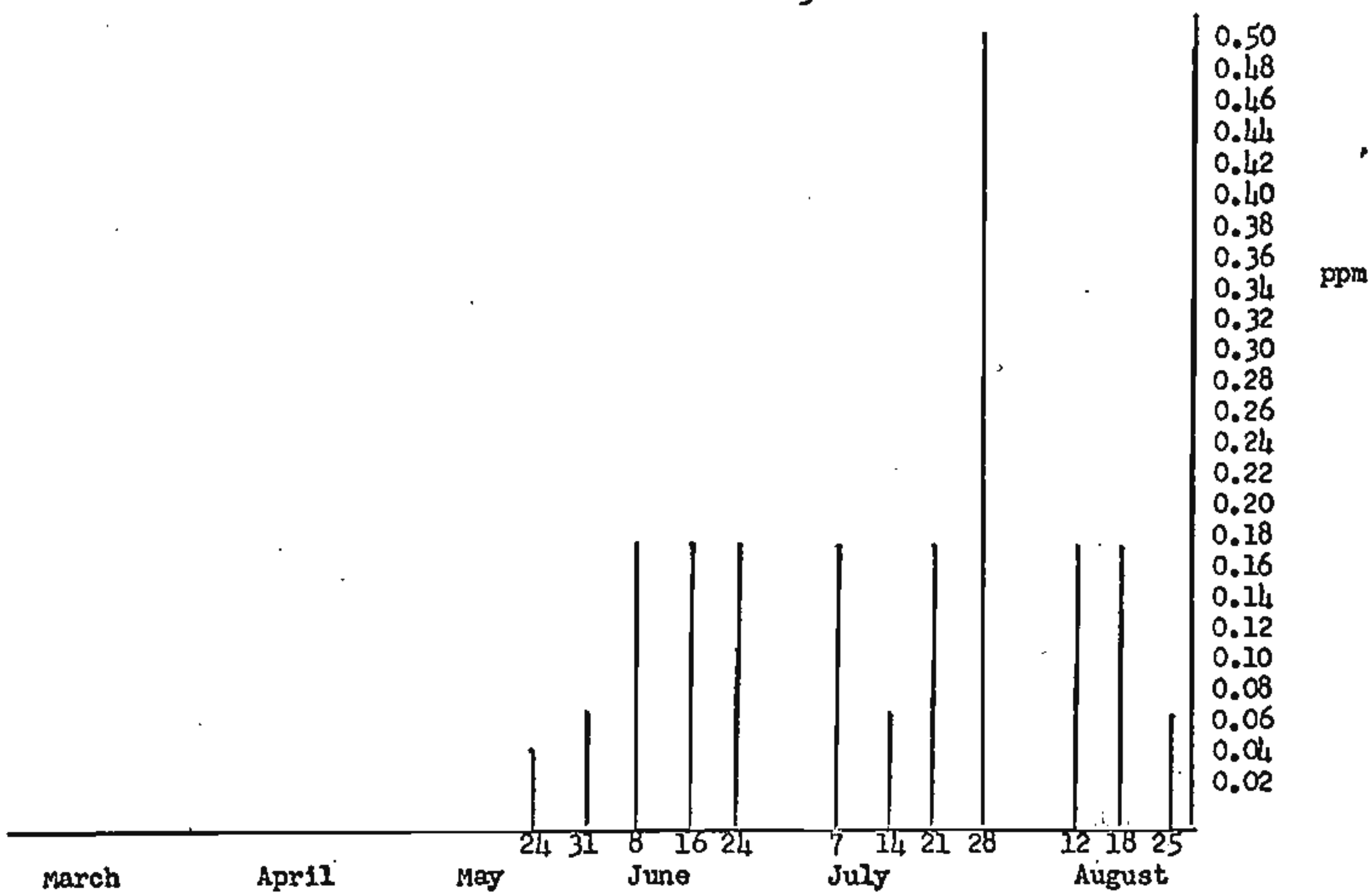
Flow Pond - NH_3 - 1971



Upper Pond - NH_3 - 1971



Deep Right Pond - NH_3 - 1971



C02

p. 66-74

NITRATES, NITRITES AND PHOSPHATES OBSERVED IN THE ESTUARIES OF THE LOUISIANA GULF COAST

Burt Wilson

Introduction

The phytoplankton and the zooplankton as well as the marsh grasses require certain nutrients for proper growth. These organisms are placed near the bottom of the food chain as for as the larger animals are concerned. It is therefore necessary to understand the metabolism and growth of these forms in order that one might appreciate maintenance of the larger animal species.

Two nutrients of critical important to any growth and development of aquatic forms is phosphorus and nitrogen. Phosphorus is an element required in the energy transfer systems of cells and as such is intimately associated with metabolic rates. Nitrogen on the other hand is an essential component of proteins and would therefore be a limiting factor on growth.

Phosphorus may be found in water in one of any number of forms, most of which are subject to the influence of the pH of the medium. In those environment which exhibit an alkaline pH this element is usually suspended as a calcium phosphate or a sodium phosphate. Normally marine and estuarine environments are alkaline. Ground or flowing surface water are richer in inorganic phosphates, where as open bodies of water have dilute quantities of this substance due to greater biological productivity. Finally the amount of dissolved oxygen in a given body of water apparently influences the amount of available phosphorus; evidence suggest an inverse relationship between dissolved oxygen and soluble phosphate compounds. Much of the phosphorus found in the estuarine waters today is due to surface runoff carrying waste of humans and industry. A considerable quantity of these phosphates become attached to particulate matter and settle to the bottoms. These bottoms therefore act as reservoirs of phosphorus, but are often reluctant to release this element to the water.

The bacteria and plankton on the other hand rapidly assimilate inorganic phosphorus and therefore represent an extremely valuable source of this substance. This phosphate utilization is observed in the diurnal and seasonal cycle of available dissolved phosphorus, consequently a reflection of certain types of biological productivity.

Nitrogen found in water was originally derived from the atmosphere and subsequently found its way into the nitrogen cycle. The nitrogenous compounds in water may come from surface runoff (pollutants), nitrogen fixation or biological decomposition. Biologically utilizable nitrogen takes the form of amonia, nitrite and nitrate compounds. The ammonia and nitrite are utilized by certain bacteria as a source of energy, resulting in their transformation into nitrates. As a consequence of these assimilation and conversion, nitrate-nitrogen is frequently the most abundant form of this element in water.

It has been known for some time that the nitrogen to phosphorus (N/P) ratio represented a useful tool for some biological productivity studies. There have been numerous studies made on the N/P ratio over a wide variety of aquatic environment, both marine and freshwater. These give data as to inorganic N/P ratio and ratios of organic or total nitrogen and phosphorus. The one poin t of agreement among these investigations would seem to be that the total organic N/P ratio fluctuate according to the requirement of endogenous plankton and is not necessarily a function of dissolved inorganic elements.

More recently culture studies of marine algae have demonstrated greater utilization of inorganic nitrogen than would have been expected from the mean N/P ratio (Ryther, 1971). In fact the conclusion drawn from these investigations suggest that nitrogen is the limiting factor in algal growth, and that the addition of phosphate played only a minor role.

Methods

The nitrates, nitrites and inorganic phosphates of surface water were determined for the cultivation ponds and adjacent bayou as a part of the Nicholls State University Shrimp Research Project conducted at Point-au-Chein, Louisiana. Nitrates and nitrites were determined by the "Cadmum-Copper reduction" method of E. D. Woods (1967). The phosphate were determined by the ammonium molyhdate technique as described by Strickland (1968). All samples were frozen as soon as possible following their collection. Prior to analysis the samples were thawed in a water bath and filtered through 0.45 micron millipore filter.

Results

The results of the nutrient analysis of the estuarine waters are illustrated in Figures 1, 2, and 3. In Figure 1, it is observed that NO_3-N ug at/liter varies from a low of 0.7 to a high of 11.4. In 1962, Robert Waldron surveyed Timbalier Bay, Louisiana and found a seasonal variation of NO_3-N of 0.3 - 4.7 ug at/L.. S, Z, Qasim (1969), on the other hand observed that in the tropical estuary of India the surface water NO_2-N ug at/L. seasonally varied between 0.31 - 40. The extremely high levels of nitrates were obtained during the monsoon season, a period when a great deal of surface runoff entered the estuaries. In Figure 1, it might be noted that the sample collected during the latter half of September were above average, apparently the result of high tides caused by hurricane Edith.

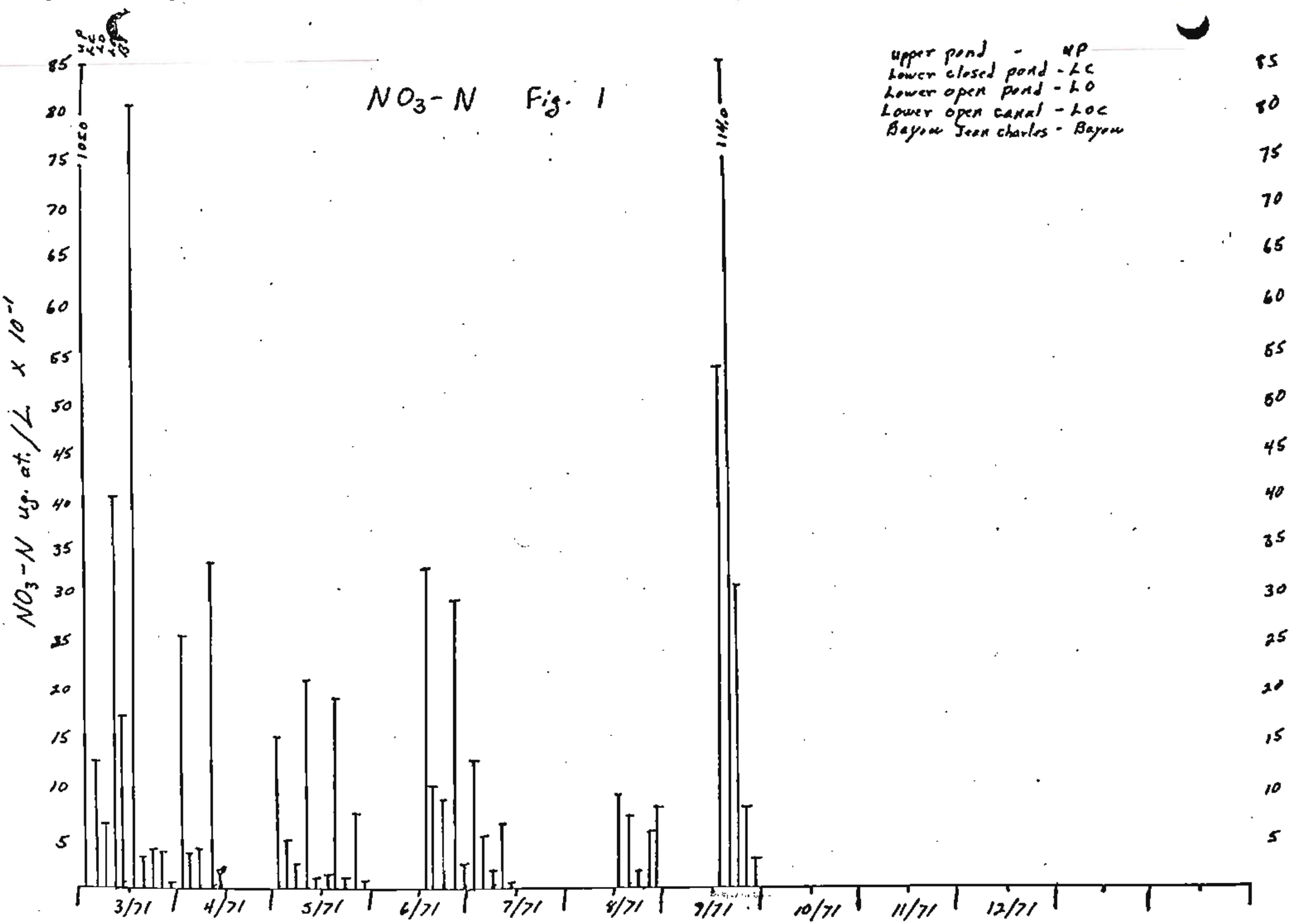
In Figure 2, it is observed that the PO_4-P ug at/L. varied from 0.3 to 2.4. Again the mean seasonal values appear to be higher than those observed by Waldon (1963), in Timbalier Bay, which varied from 0.12 - 0.87 ug at/L..Qasim (1969) in his studies found PO_4-P in the order of 0.36 - 1.0 ug at/L. with no appreciable influence by monsoons, which is in agreement with our findings. During the winter months there has been an elevation of nitrates and nitrites in the cultivation pond. These extremely high values are thought to be due in part to the excrement deposited in the water by large numbers of birds that inhabit the ponds during these months, in addition to reduced productivity.

The normally acceptable N/P ratio for sea water is 15:1, however, this is apparently not representative of estuarine waters. In Qasim's (1969) studies he found that the N/P ratio varied from a high of 40:1 during the monsoon month to a low of 0.53:1 for pre-monsoon periods. The N/P extremes observed in one of the culture in the Nicholls Project was 28:1 and a low of 0:0.85. However, it should be pointed out that the current feeling among research is that the N/P ratio does not necessarily reflect true productivity, (Ryther 1971). There appears to be a close correlation between the cycles of phosphorus and organic production in estuarine waters, whereas the nitrogen cycle is completely unconnected with the productivity rhythm. In fact, Currie (1953) found no significant increase in the rate of photosynthesis when the water samples were enriched with inorganic nitrogen and phosphorus. Rythus (1959) observed that the instantaneous concentration of nutrients is not as important in affecting productivity as the rate with which these elements are regenerated and absorbed in forms other than the inorganic salts. This observation might well explain the variations revealed in Figures 1 and 2.

It should be further noted that the levels of phosphates in the impoundments as well as the bayou is fairly consistant in comparison to the nitrates. There appeals to be abundance phosphorus in the marshes for proper nutrition and growth. The data for NO_3-N does suggest considerable fluctuation in the available of this nutrient in these ponds, but as stated previously nitrogen is incorporated more significantly by plankton than phosphorus.

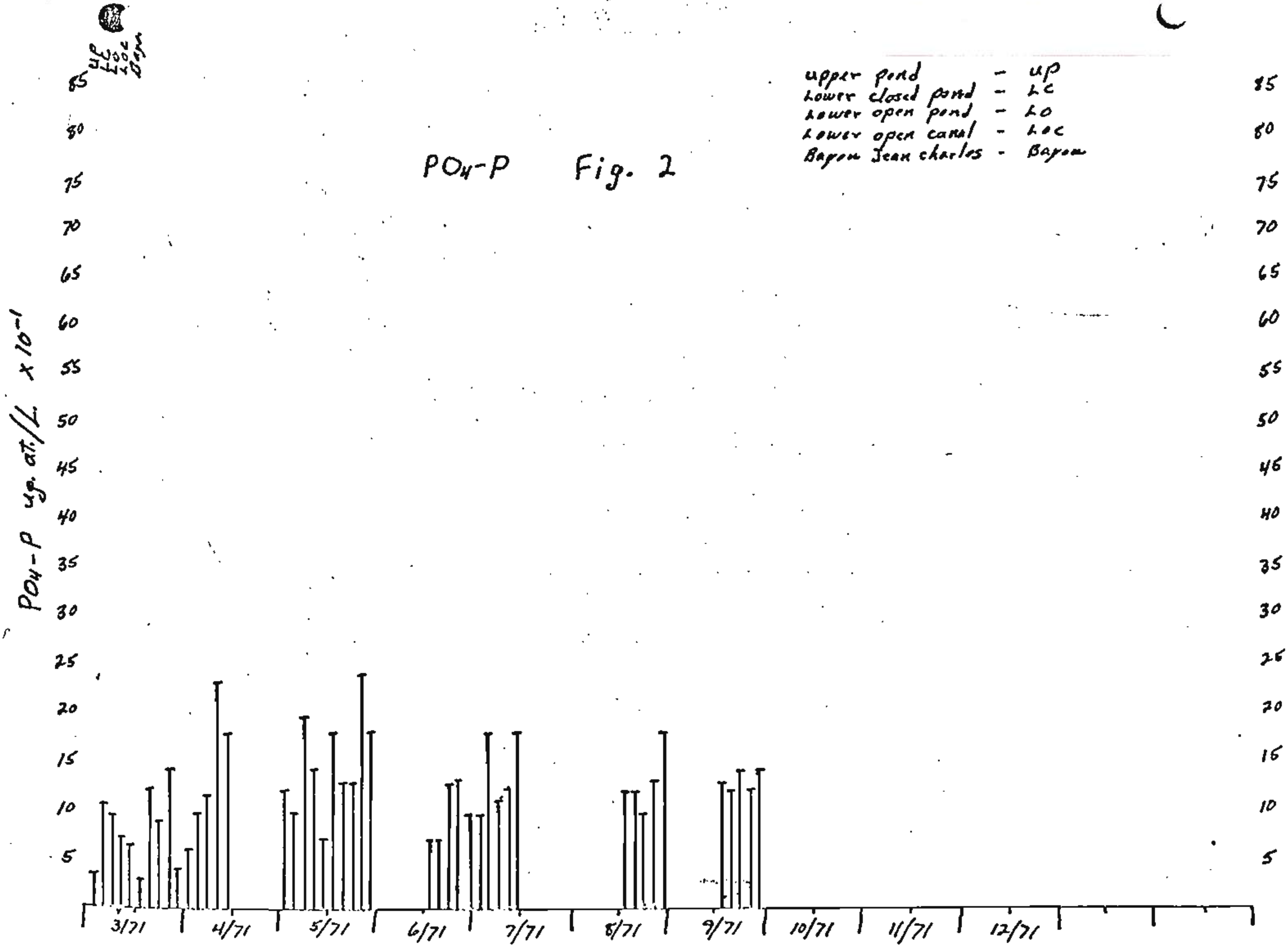
In a pond culture study, More (1969) found that even with the addition of fertilizer the NO_3-N fail to increase.

It therefore seems apparent that these marsh ponds do contain sufficient nitrogen and phosphorus to maintain abundant biological productivity. This productivity is evidently limited only by the available sunlight, oxygen and types of organism that might inhabit these environments.

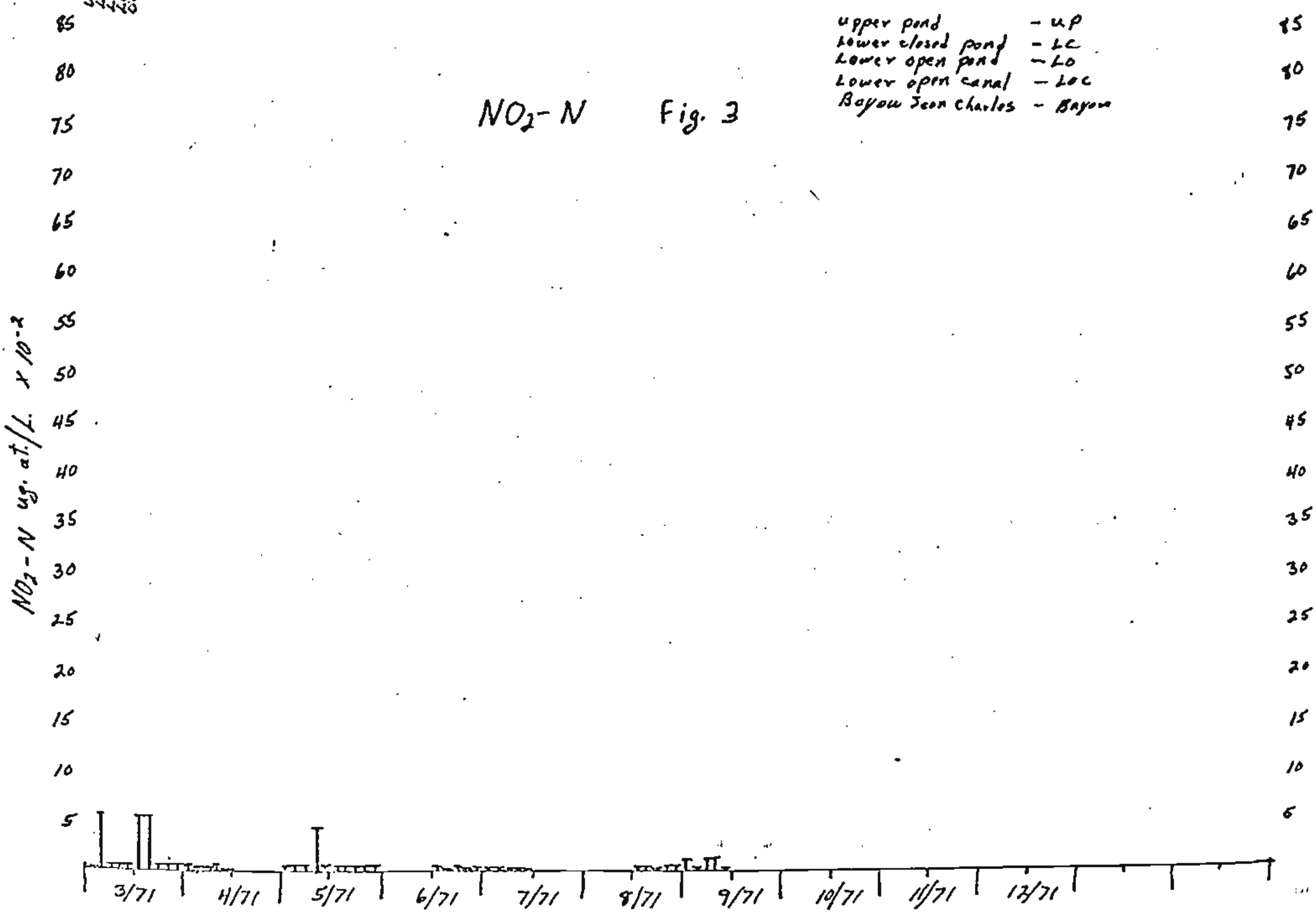

upper pond - UP
Lower closed pond - LC
Lower open pond - LO
Lower open canal - LOC
Bayou Jean charles - Bayou
UP LC LO LOC B
105.0
114.0
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
3/71
4/71
5/71
6/71
7/71
8/71
9/71
10/71
11/71
12/71
NO_3-N ug. at./L x 10^{-1}

NO_3-N Fig. 1

PO4-P Fig. 2



upper pond - UP
Lower closed pond - LC
Lower open pond - LO
Lower open canal - LOC
Bayou Jean charles - Bayou
PO4-P ug. at./L x 10^-1
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
3/71
4/71
5/71
6/71
7/71
8/71
9/71
10/71
11/71
12/71


upper pond - UP
Lower closed pond - LC
Lower open pond - LO
Lower open canal - LOC
Bayou Jean Charles - Bayou
NO_2-N ug. at./L. x 10^{-2}
85
80
75
70
65
60
55
50
45
40
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30
25
20
15
10
5
3/71
4/71
5/71
6/71
7/71
8/71
9/71
10/71
11/71
12/71

NO_2-N Fig. 3

References and Notes

Currie, R. I. 1958. Some observations on organic production in the Northeast Atlantic. Rapp. P.-v. Reun. perm. int. Explor. Mer, 144 pp-96-102.

More, William. 1969. Saltwater pond research progress report. Coastal Fisheries, Texas Park & Wildlife Dept. No. 1 p-4.

Qasim, S. Z. and et. al. 1969. Organic production in a tropical estuary. Proceed. Indian Acad. Sci. Vol LXIX No. 2, p51-94.

Reid, George K. 1961. Ecology of Inland Waters and Estuaries. Reinhold Publ. Corp. N. Y. p. 183-193.

Ryther, John, H. & Dunstun, W. M. 1971. Nitrogen, phosphorus, and eutrophication in the coastal marine environment. Science Vol. 171 pp 1008-1013.

Strickland, J. D. H. & Parsons, T. R. 1968. A Practical Handbook of Seawater Analysis. Bull. Fish. Res. Bd. Can., No. 167, p 63-64.

Waldron, Robert P. 1963. A seasonal ecological study of foraminefera from Timbalier Bay Louisiana. Gulf Res. Report Vol. 1, No. 4, p. 185.

Wood, E. D. & et. al. 1967. Determination of nitrate in sea water by Cadmium-Copper Reducation to Nitrite. J. Mar. Biol. Ass. Uk. Vol. 47, p 23-31.

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PP. 75-151

SEA GRANT RESEARCH PROJECT
SOIL ANALYSES OF POND BOTTOMS

The primary objective of this phase of the Sea Grant Studey was to analyze the pond bottoms for the following: Ortho-Phosphates, Nitrates, Nitrites, Ammonium Nitrogen, Organic Matter Content and pH. These analyses were made at bi-weekly intervals except organic matter which was determined at 90-day intervals.

The purpose of these analyses was to determine whether these soils were deficient in the above nutrients and to try to detect any changes in these nutrients that could be related to the water sample changes as well as variances in shrimp production.

Any differences in production due to the primary treatments might be ascertained as such, if no differences in the pond bottoms could be detected.

The soil samples were taken at bi-weekly intervals from the upper pond, the lower open and closed ponds and a sample from the bayou adjacent to the lower ponds during the first year. Beginning the second year, sampling was done at approximately 60-day intervals to substantiate the results of the previous year.

pH determinations were done with a Beckman pH meter, while the other analyses were done with extraction of the desired element with acid extraction solutions. After filtration, and proper dilutions for each procedure, reagents were added to bring out the colors and these color changes were then read on the Spectrophotometer to determine the amount of the desired element in parts per million.

Organic Matter Content determinations were made via the Sulfuric Acid digestion method. After digestion, the solution is clearified and a color indicator dye is added. The solution is then titrated with a basic solution and the organic matter percent could be computed.

A determination of the soil type at the beginning of tho project was made and the results showed that the pond bottoms fell into the textural class of a Silt Loam. Soils from the three ponds showed an analyses of 12% clay, 15% very fine sand and 73% silt.

The results are as follows:

Ortho Phosphates - 100 + parts per million in all ponds and throughout the year.

Nitrates - Less than 10 ppm in all ponds and throughout the year.

Nitrites - No trace in all ponds and throughout the year.

Ammonium Nitrogen - More variation here than any other determinations. It ranged from 0 - 10 parts per million. There seemed to be no particular pattern. One week one pond was higher while the next week the same pond was low. In all cases the results show that NH_4 Nitrogen was low even though there were some fluctuations.

pH - These determinations also were consistent, ranging from approximately 7.0 to 8.0. No trend or pattern showing one pond being consistently different from any other.

Organic Matter - Organic matter percent was fairly high in all cases ranging from 8 - 11% in the three ponds while the bayou samples were consistently 2 to 3% lower than the pond samples.

Ca - Determinations were made early in year. All ponds showed high with regards to this element.

These results show that there was no obvious differences between the three ponds in question with regards to soil nutrients. All of the ponds reacted similarly. Any small change in one usually occurred in all, indicating either an experimental error in technique or in fact all ponds very similar in nature and reaction.

The deficiency of the elements in question is difficult to ascertain, since norms for the quantity of the elements are not known. Compared to agricultural soils, the Organic Matter Content is very high and should provide an ample supply of some of the elements. All forms of nitrogen were low and this was difficult to understand since Organic Matter is the principal source of nitrogen in soils. However, since nitrogen is very soluble, it is possible that the nitrogen went into solution as soon as it was released by the organic matter.

The pH levels were consistent and a little higher than agricultural soils. The presence of sodium in the salt water probably accounted for the higher pH levels and would be normal for these soils. However these values were not high enough to interfere with normal reactions and interchanges in the soil. Phosphorous levels were high throughout the year and no problem exists here.

No differences between the three ponds were detected during the study as far as the soil was concerned. Neither was there any variation from season to season.

Apparently any mineral depletion from the soil was counteracted by a similar addition from dying animal and plant life. There seems to exist a closed and complete cycle in regards to soil fertility with natural production.

The purpose of the analyses was to determine or detect any differences if any and to try to correlate this to the variances in water changes or shrimp production. Since there was no change in the soil in this study, no association or correlations can be made. However some of the nutrients are utilized in the food chain of shrimp. Either the phytoplankton are getting their nutrients from the water and not affecting the soil or the minerals being used are replenished as rapidly as they are being used, therefore, showing no change in a soil analysis at periodic intervals.

TABLE I

Soil analysis of the Research Ponds (Upper Pond) of the N.S.F. Sea Grant Research at Point-au-Chein for 1970-71 (Results expressed in Parts Per Million)

	Nitrites	Nitrates	Ammonium N.	Phosphorous	pH	% Organic Matter
March	0	-	-	100+	7.0	9.8
April	0	5	-	100+	-	10.9
May	0	5	-	100+	7.1	10.4
June	0	20	-	100+	-	-
July	0	10	2	100+	7.0	9.7
July	0	10	5	100+	6.8	-
Aug.	0	10	2	100+	8.3	-
Aug.	0	8	8	100+	8.0	-
Sept.	0	1	5	100+	7.6	-
Sept.	0	1	6	100+	7.5	-
Oct.	0	0	10	100+	8.0	11.8
Oct.	0	0	6	100+	7.5	-
Oct.	0	0	10	100+	7.2	-
Nov.	0	0	6	100+	8.0	-
Nov.	0	0	3	100+	7.7	-
Dec.	0	0	6	100+	7.9	-
Jan.	0	0	1	100+	-	-
Feb.	0	0	2	100+	8.1	-
March	0	0	2	100+	8.2	-
April	0	0	0	100+	8.3	10.5
June	0	0	0	100+	7.8	9.0
August	0	7	11	100+	7.7	10.8
S	0	0	4	100+	6.8	10.8

TABLE II

Soil analysis of the Research Ponds (Lower Pond-Open) of the N.S.F. Sea Grant Research at Point-au-Chein for 1970-72 (Results expressed in Parts Per Million)

70	Nitrites	Nitrates	Ammonium N.	Phosphorous	pH	% Organic Matter
March	0	-	-	100+	7.2	8.6
April	0	5	-	100+	-	10.1
May	0	5	-	100+	7.1	10.2
June	0	10	-	100+	-	-
July	0	10	5	100+	6.9	8.0
July	0	10	0	100+	7.1	-
Aug.	0	10	2	100+	8.0	-
Aug.	0	7	5	100+	7.7	-
Sept.	0	1	12	100+	7.4	-
Sept.	0	1	5	100+	7.4	-
t.	0	0	5	100+	7.9	11.3
Oct.	0	0	1	100+	7.6	-
Oct.	0	0	3	100+	7.5	-
Nov.	0	0	1	100+	7.6	-
Nov.	0	0	3	100+	7.7	-
Dec.	0	0	0	100+	7.9	-
71 Jan.	0	0	2	100+	-	-
Feb.	0	0	1	100+	8.1	-
March	0	0	11	100+	8.1	-
April	0	Tr.	2	100+	8.2	8.8
June	0	0	6	100+	8.2	8.4
August	0	0	11	100+	7.7	9.7
Sept.	0	0	0	100+	11.0	10.2

TABLE III

Soil analysis of the Research Ponds (Lower Pond-Closed) of the N.S. F. Sea Grant Research at Point-au-Chein for 1970-71 (Results expressed in Parts Per Million)

'70	Nitrites	Nitrates	Ammonium N.	Phosphorous	pH	% Organic Matter in soil
March	0	-	-	100+	7.3	8.8
April	0	5	-	100+	-	10.2
May	0	5	-	100+	7.2	10.0
June	0	10	-	100+	-	-
July	0	10	5	100+	6.9	8.1
July	0	10	0	100+	7.2	-
Aug.	0	10	1	100+	7.7	-
Aug.	0	8	5	100+	7.8	-
Sept.	0	1	6	100+	7.5	-
Sept.	0	1	5	100+	7.4	-
Oc	0	Tr.	4	100+	7.8	11.8
Oct.	0	0	1	100+	7.6	-
Oct.	0	0	3	100+	7.5	-
Nov.	0	0	3	100+	7.5	-
Nov.	0	0	2	100+	7.7	-
Dec.	0	0	2	100+	7.8	-
Jan.	0	0	0	100+	-	-
Feb.	0	0	3	100+	8.0	-
March	0	0	1	100+	8.1	-
April	0	0	1	100+	8.3	10.3
June	0	0	6	100+	8.3	10.8
August	0	0	8	100+	7.7	9.7
Sept.	0	0	2	100+	7.2	9.6

TABLE IV

Soil analysis of the Research Ponds (Bayou) of the N. S. F. Sea Grant Research at Point-au-Chein for 1970-71 (Results expressed in Parts Per Million)

	Nitrites	Nitrates	Ammonium N.	Phosphorous	pH	% Organic Matter wt.
1970						
March	-	-	-	-	-	-
April	÷	-	-	-	-	-
May	-	-	-	-	-	-
June	-	-	-	-	-	-
July	0	10	2	100+	7.5	7.5
July	0	10	5	100+	7.2	-
Aug.	0	10	5	100+	8.2	-
Aug.	0	7	1	100+	7.6	-
Sept.	0	1	7	100+	7.7	-
Sept.	0	Tr.	2	100+	7.6	-
Oct.	0	Tr.	4	100+	7.9	5.4
Oct.	0	Tr.	5	100+	7.5	-
Oct.	0	Tr.	0	100+	7.5	-
Nov.	0	Tr.	0	100+	8.0	-
Nov.	0	Tr.	6	100+	7.9	-
Dec.	0	Tr.	1	100+	7.8	-
1971						
Jan.	0	0	6	100+	-	-
Feb.	0	Tr.	0	100+	8.0	-
March	0	0	1	100+	8.0	-
April	0	0	0	100+	8.0	4.7
June	0	Tr.	6	100+	8.2	10.2
August	0	Tr.	3	100+	7.3	8.6
Sept.	0	Tr.	0	100+	11.0	2.3

Diurnal O^2 Method For Primary Productivity Method

1. Dissolved oxygen was determined by the Winkler Method at four (4) hour intervals beginning at midnight through the whole 24 hr. day, in each pond. Each dissolved oxygen determination was the average of 3 samples.

2. Temperature was recorded for each pond at each oxygen sampling period.

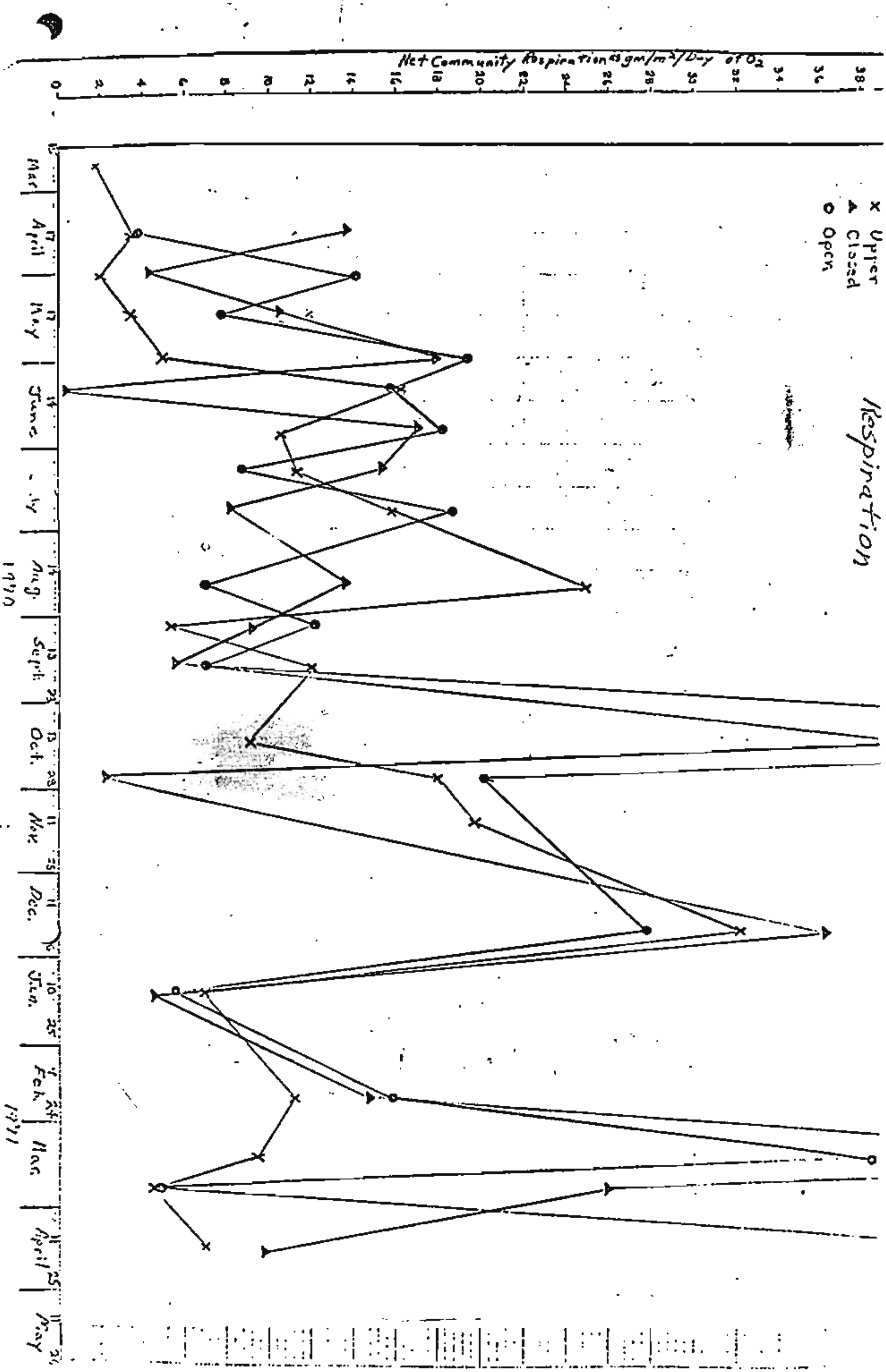
3. Primary productivity and respiration were then determined for each pond using the method given by Odum and Hoskin (Publ. Inst. Mar. Sci. 5:16-45. 1958) on page 18.

Diurnal O_2 Studies (p and r in gm./M^2/day) (k in gm./M^2/hr.)

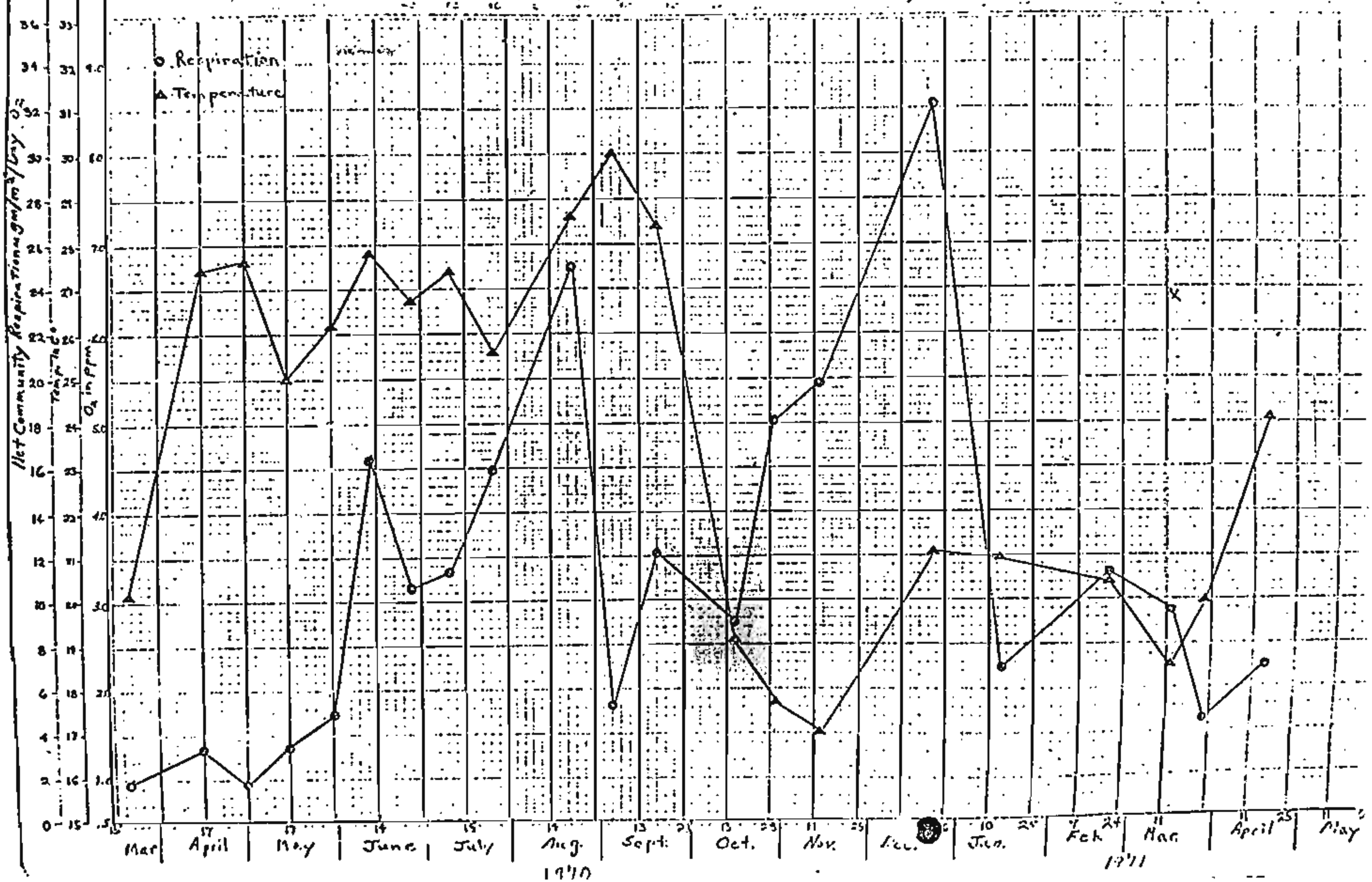
Date	Pond 1	Pond 2 (Open)	Pond 3 (Closed)	Bayou
Mar. 20, 70'	p= 0.30 r= 1.50 k= 0.10			
Apr. 3, 70'	p= 1.83 r= 28.75 k= 4.38	p= 1.33 r= 7.43 k= 1.08	p= 1.14 r= 13.64 k= 2.00	
Apr. 17, 70'	p= 2.46 r= 3.30 k= 0.105	p= 2.77 r= 3.76 k= 0.04	p= 7.79 r= 14.01 k= 0.72	
May 1, 70'	p= 1.86 r= 2.10 k= 0.165	p= 7.98 r= 14.34 k= 0.85	p= 5.95 r= 4.27 k= 0.11	
May 16, 70'	p= 1.78 r= 3.37 k= 0.14	p= 7.74 r= 7.74 k= 0.015	p= 6.90 r= 8.64 k= 0.315	
May 30, 70'	p= 4.97 r= 5.04 k= 0.08	p= 13.36 r= 19.12 k= 0.79	p= 13.12 r= 17.77 k= 0.72	
June 12, 70'	p= 8.02 r= 19.21 k= 1.60	p= 5.64 r= 16.49 k= 2.07	p= 2.24 r= 0.36 k= 0.00	
June 26, 70'	p= 5.83 r= 10.04 k= 0.495	p= 7.43 r= 19.41 k= 1.25	p= 10.57 r= 18.11 k= 1.11	
July 10, 70'	p= 5.08 r= 11.64 k= 0.64	p= 4.24 r= 8.82 k= 0.41	p= 6.33 r= 16.35 k= 0.81	p= 1.63 r= 3.20 k= 0.58
July 25, 70'	p= 4.95 r= 15.95 k= 1.36 chl= 20.29	p= 6.69 r= 19.88 k= 1.64 chl= 13.98	p= 4.43 r= 7.13 k= 0.30 chl= 10.16	p= 15.58 r= 90.00 k= 7.57 chl= ———
Aug. 8, 70'	p= r= k= chl= 25.71	chl= 27.21	chl= 29.99	chl= 27.52
Aug. 21, 70'	p= 7.64 r= 24.72 k= 1.65 chl= 29.45	p= 4.74 r= 6.49 k= 0.195 chl= 30.77	p= 7.09 r= 13.58 k= 0.660 chl= 24.97	p= 3.14 r= 61.40 k= 6.04 chl= 16.01
Sept. 4, 70'	p= 2.71 r= 4.38 k= 0.13 chl= 17.07	p= 7.12 r= 11.33 k= 0.80 chl= 31.24	p= 6.82 r= 8.82 k= 0.53 chl= 29.55	p= 0.70 r= 17.84 k= 1.69 chl= 15.43
Sept. 18, 70'	p= 5.33 r= 13.03 k= 0.72 chl= 16.08	p= 2.89 r= 6.38 k= 0.28 chl= 10.53	p= 2.81 r= 4.52 k= 0.145 chl= 19.75	chl= 9.06

Diurnal O_2 Studies

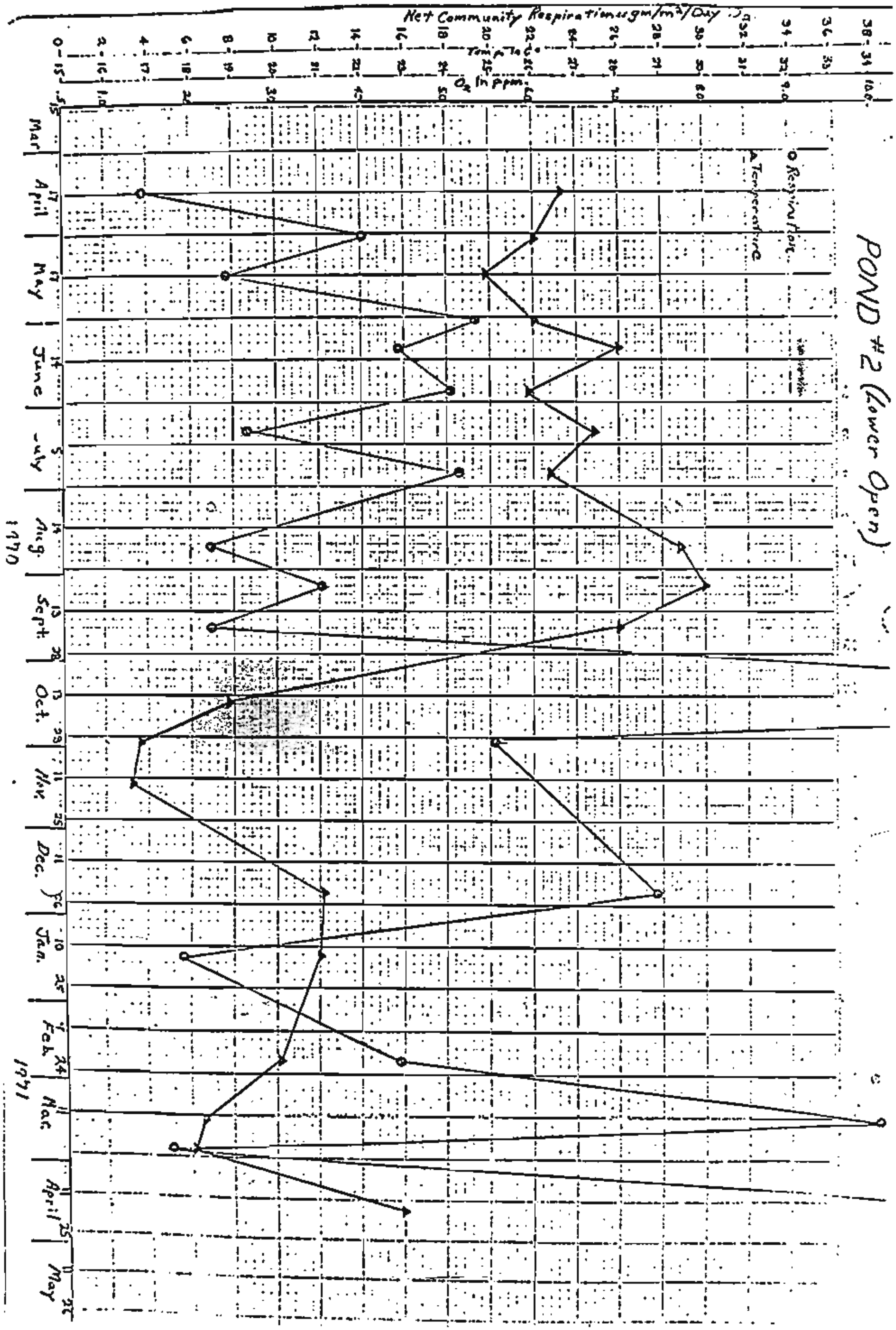
Date		Pond 1	Pond 2 (Open)	Pond 3 (Closed)	Bayou
Oct. 2, 70'	p=				
	r=				
	k=				
	chl=	15.19	16.33	15.33	13.14
Oct. 16, 70'	p=	0.72	3.50	2.05	0.20
	r=	8.81	67.89	40.28	20.43
	k=	0.41	3.31	1.97	2.01
	chl=	8.24	8.17	8.65	3.13
Oct. 29, 70'	p=	6.92	10.00	1.54	0.18
	r=	18.92	21.72	1.88	2.05
	k=	1.52	3.54	0.425	0.30
	chl=	3.49	8.91	9.78	1.04
Nov. 13, 70'	p=	7.55		2.65	0.44
	r=	19.37		5.61	5.08
	k=	2.20		1.30	0.60
	chl=	13.74	9.53	13.84	7.02
Dec, 22, 70'	p=	12.36	12.13	14.99	6.50
	r=	32.57	27.01	34.91	23.22
	k=	1.92	3.04	2.02	1.71
	chl=	18.51	43.58	59.23	13.10
Jan. 14, 71'	p=	3.33	3.40	3.92	1.02
	r=	6.46	5.85	3.87	4.12
	k=	0.325	0.94	0.195	0.377
	chl=	14.65	43.29	55.14	21.33
Feb. 19, 71'	p=	6.70	7.45	6.72	1.05
	r=	11.24	12.88	12.09	6.45
	k=	0.125	0.24	0.320	0.405
	chl=	9.05	49.38	66.44	13.59
Mar. 12, 71'	p=	1.96	13.11	23.44	
	r=	9.81	41.84	63.41	
	k=	0.79	3.98	5.42	
	chl=	4.90	48.88	81.80	9.97
Mar. 25, 71'	p=	3.11	2.51	10.07	14.95
	r=	4.66	5.21	25.02	5.18
	k=	0.20	0.41	2.66	0.015
Apr. 16, 71'	p=	5.74	11.25	1.18	1.22
	r=	6.94	60.51	8.61	3.04
	k=	0.125	3.82	0.49	0.105
	chl=	11.57	———	———	10.25

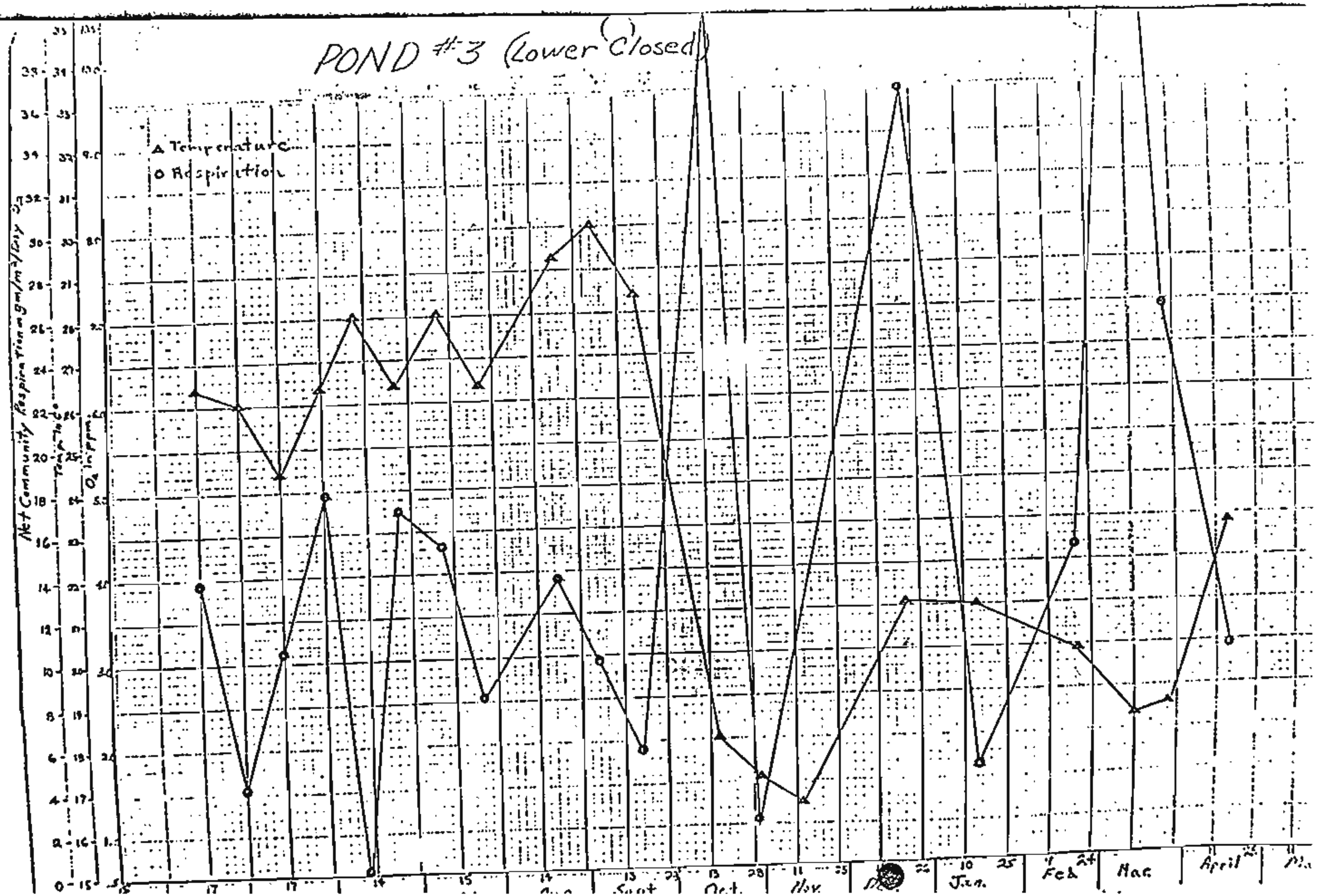

Respiration
x Upper
▲ Closed
o Open
Net Community Respiration as gm/m²/Day of O2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Mar
April
May
June
July
Aug.
1970
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
1971
Mar
April
May

POND #1 (Upper)



Net Community Respiration gm/m²/Day O₂
Temp. in C°
O₂ in ppm
o Respiration
Δ Temperature
Mar
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
April
May
1970
1971


POND #2 (Lower Open)
Net Community Respiration gm/m²/Day
Temp. in C°
O₂ in ppm
○ Respiration
▲ Temperature
Mar
April
May
June
July
Aug.
Sept
Oct.
Nov
Dec.
Jan.
Feb
Mar
April
May
1970
1971


POND #3 (Lower Closed)
△ Temperature
○ Respiration
Net Community Respiration gm/m²/Day
Temp. in °C
O₂ in ppm
Sept
Oct.
Nov.
Jan.
Feb
Mar
April

Chlorophyll a Method (From Lorenzen 1967 Limnol. Oceanogr. 12(2):343-346

1. Chlorophyll a Determination - Every month during winter and every 2 weeks during spring thru fall a 1 gal. random sample of the water column was collected.

These were brought immediately to the laboratory and filtered thru 5.5 cm. glass fiber filteres. The phytoplankton in the samples accumulated on the filter. The amount of water filtered varied with the density of phytoplankton populations. The amount of water filtered was recorded for each subsample. The filters were then stored in glassine envelopes in a freezer until extraction of chlorophyll could be done.

The extraction process was performed as follows: The filters were first ground in a tissue grinder with a few mls. of acetone (Spectrograde). A hand power drill with variable speed control was used to turn the pestle of the grinder. Usually one minute at maximum speed was sufficient to disintegrate the filter and in the process to break up all the cells. The ground up filters and acetone were then poured into centrifuge tubes. A few mls. of clean acetone was used to rinse the grinding vessel. The total volume was kept under 10 ml. The tubes were allowed to sit for 20-60 mins. to pervit pigment extraction. The tubes were then shaken, centrifuges, shaken again and centrifuged thoroughly. The acetone containing extracted pigments was measured for volume and pipeted into cuvettes. Light absorption as O. D. was measured at 665 mu and 750 mu. The samples were then acidified with 2 drops of HCl and the O. P. determined at 665 and 750 mu. Chlorophyll a in mg/m^3 was then calculated according to the following formula. See attachment.

$$Chla(mg/m^3) = \frac{26.73 \times (665_o - 665_a) \times v}{V_f \times 1}$$

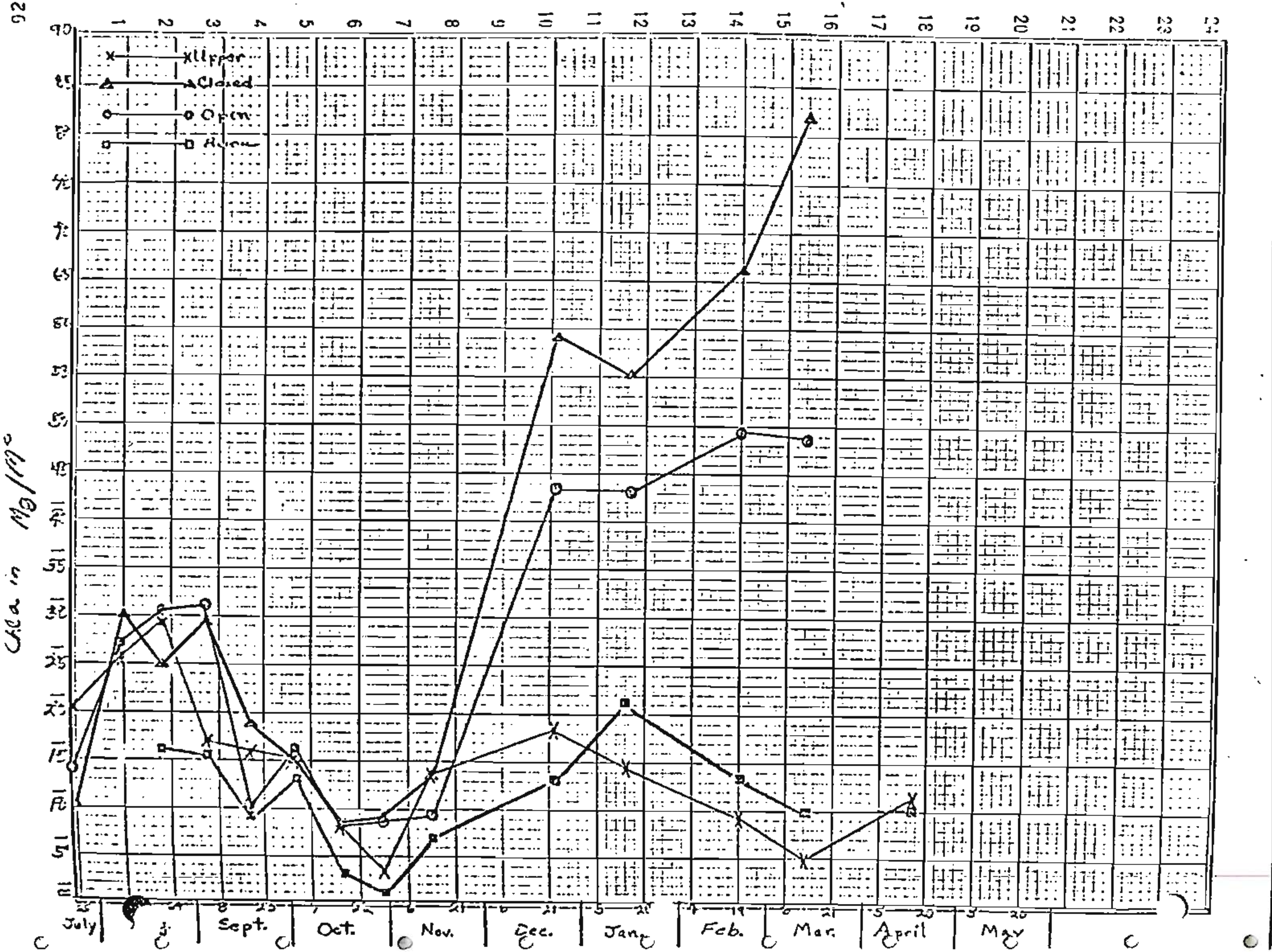
665_o = absorbance before acidification

665_a = absorbance after acidification

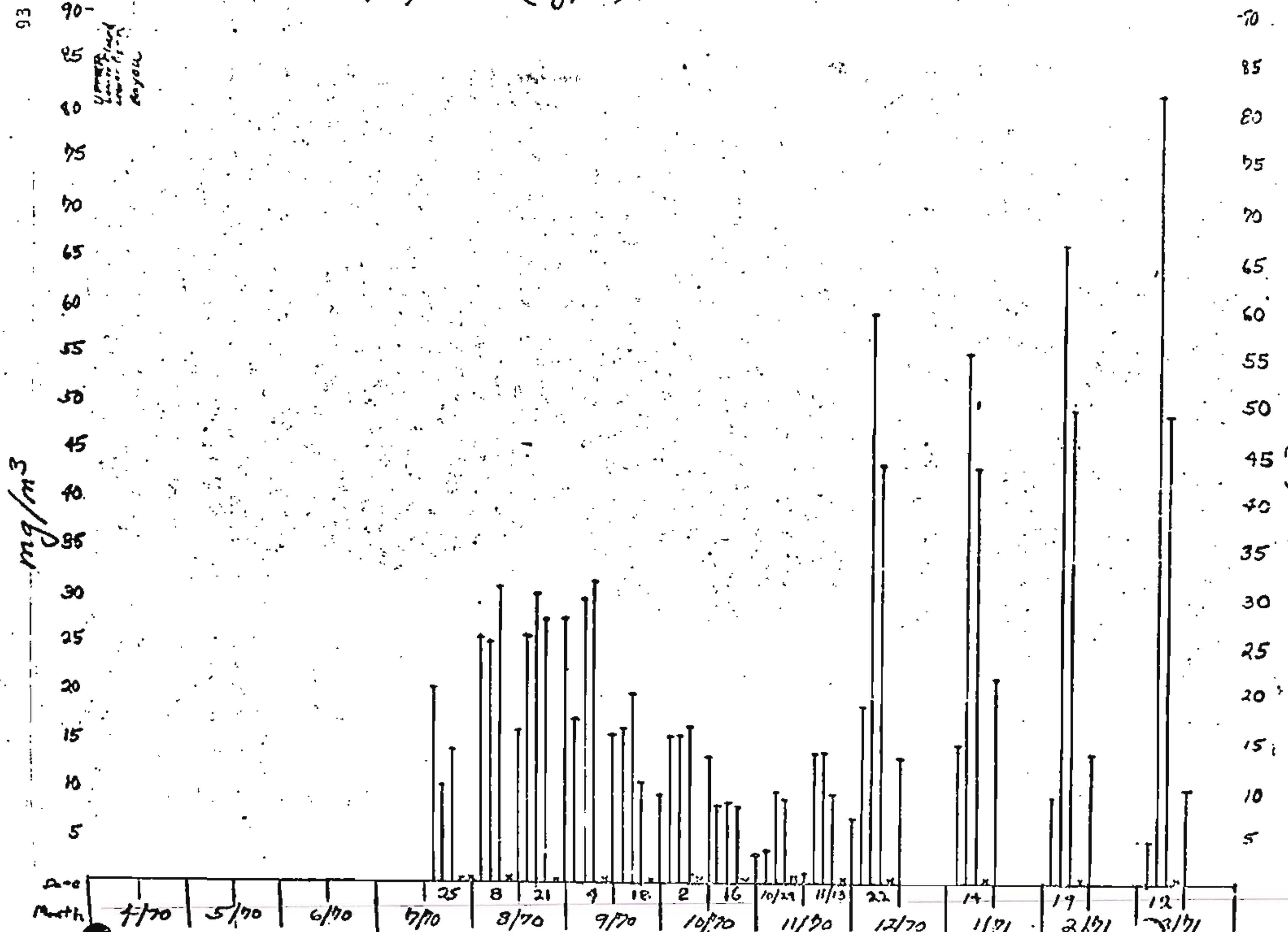
v = volume of acetone used for extraction (ml).

V_f = liters of water filtered

1 = path length of cuvette (cm.) = 1.17


Upper
Closed
Open
Chla in Mg/M³
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
July
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
April
May

Chlorophyll a (mg/m³)



FLOW POND BOTTOM INVERTEBRATES 1970-71

Date		Polychete	Oligochetes	Round worms	Amphipods	Insect Larvae	Ostracods	Isopod	Zoea	Clam
4-3-70	Total No./m^2			720		1440	160		80	80
	% of Total			29.0		58.1	6.5		3.2	3.2
4-18-70		80	160			240				80
		14.3	28.6			42.8				14.3
5-1-70		1,040		80		80			80	
		81.25		6.25		6.25			6.25	
5-14-70		400				160				
		71.4				28.6				
5-28-70		320				400				
		44.4				55.6				
6-12-70		80						80		
		50.0						50.0		
6-29-70		80				80				
		50.0				50.0				
8-7-70		160	240			160				
		28.6	42.8			28.6				
8-21-70						80				
						100.0				
9-4-70						240				
						100.0				
9-18-70		80				240				
		25.0				75.0				
10-9-70		80				240				
		25.0				75.0				
12-4-70		160				720				
		18.2				81.8				
12-14-70		No Results Found								
1-22-71		80	160							
		33.3	66.7							

CLOSED POND BOTTOM INVERTEBRATES 1970-71

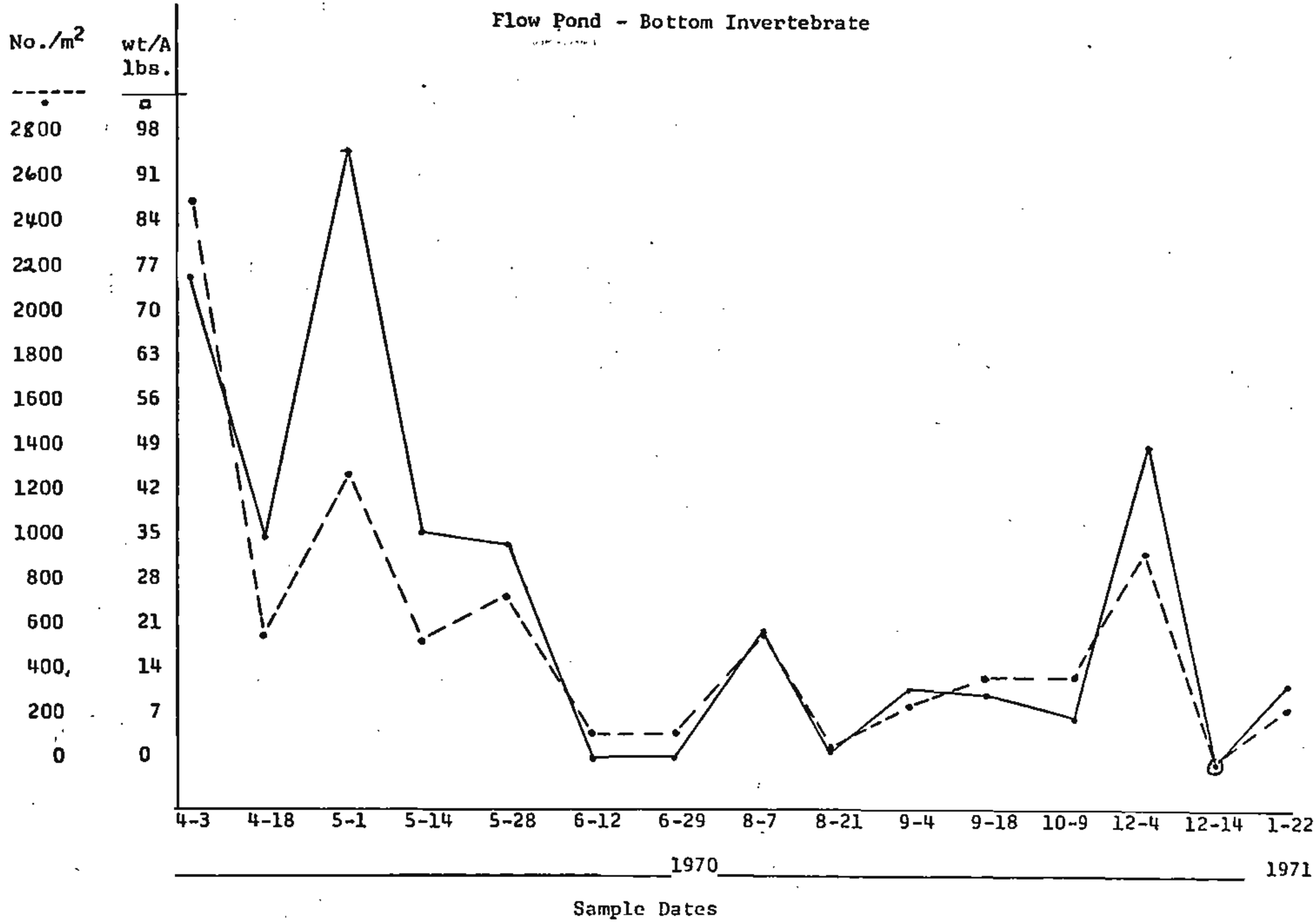
Date		Polychete	Oligochetes	Roundworms	Amphipods	Insect Larvae	Spider	Crustac
4-3-70	Total No./m^2	720	160	160	1,280	240		
	% of Total	28.1	6.3	6.3	50.0	9.3		
4-18-70		640	720			560		
		33.3	37.5			29.2		
5-1-70		800			80			
		90.9			9.1			
5-14-70						320		
						100.0		
5-28-70					160	160		
					50.0	50.0		
6-12-70		No						
		Results Found						
6-29-70						160		
						100.0		
8-7-70						80	80	
						50.0	50.0	
8-21-70		160				560		80
		20.0				70.0		10.0
9-4-70		80				80		
		50.0				50.0		
9-18-70		240				1,920		
		11.1				88.9		
10-9-70						80		
						100.0		
12-4-70		160			80	960		
		13.3			6.7	80.0		
12-14-70		No						
		Results Found						
1-22-71					80	160		
					33.3	66.7		

UPPER POND BOTTOM INVERTEBRATES 1970-71

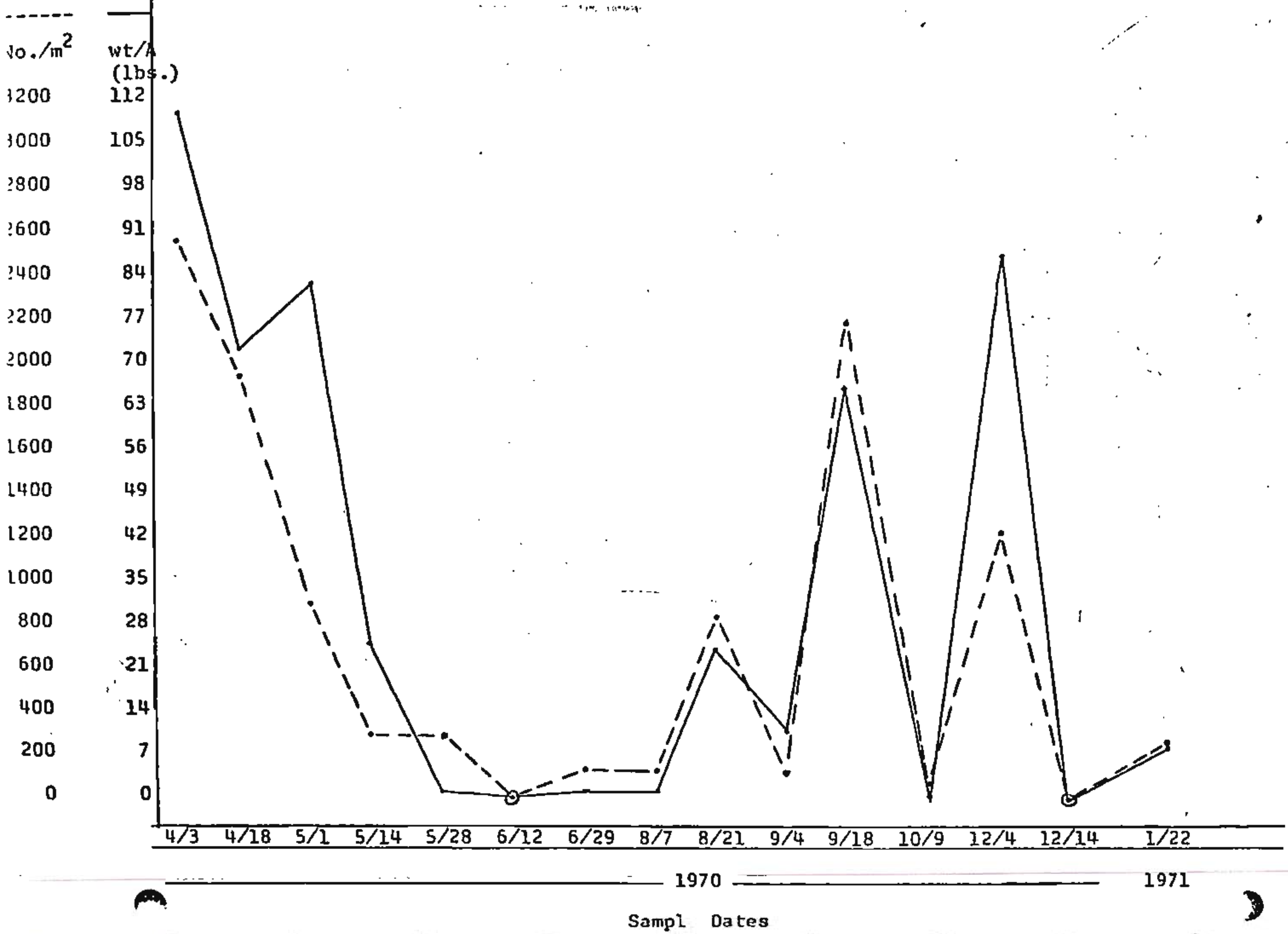
Date		Polychetes	Oligochetes	Roundworms	Amphipods	Insect Larvae	Ostracods	Clam
4-3-70	Total No./m^2	80		160		320	160	
	% of Total	11.2		22.2		44.4	22.2	
4-18-70		160		160				560
		18.2		18.2				63.6
5-1-70		80	2,480			80		
		3.0	94.0			3.0		
5-14-70						80	80	
						50.0	50.0	
5-28-70		1,280				80		
		94.1				5.9		
6-12-70						80		
						100.0		
6-29-70					160			
					100.0			
8-7-70						80		
						100.0		
8-21-70					80	160		
					33.3	66.7		
9-4-70						160		
						100.0		
9-18-70						80		
						100.0		
10-9-70						160		
						100.0		
12-4-70						80		
						100.0		
12-14-70					80	80		
					50.0	50.0		
1-22-71		240	80		240			
		42.9	14.2		42.9			

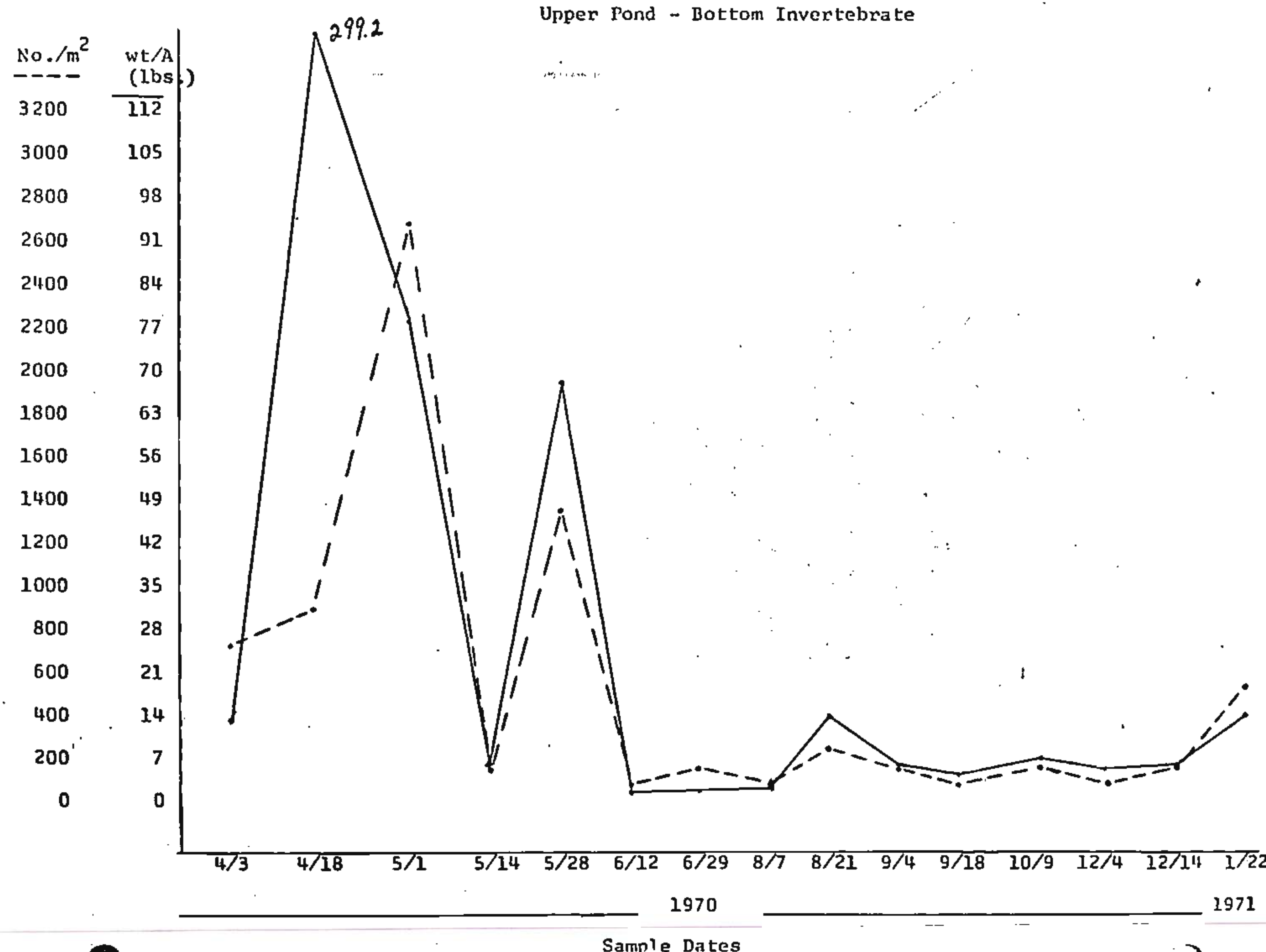
Bottom Invertebrate Report 1970-71

Date	Flow Pond No./m^2	Flow Pond wt/A (lbs.)	Closed Pond No./m^2	Closed Pond wt/A (lbs.)	Upper Pond No./m^2	Upper Pond wt/A (lbs.)
4-3-70	2,480	73.76	2,560	108.08	720	13.03
4-18-70	560	34.41	1,920	71.19	880	299.20
5-1-70	1,280	93.21	880	81.94	2,640	78.16
5-14-70	560	35.30	320	23.59	160	6.48
5-28-70	720	33.09	320	1.34	1,360	67.16
6-12-70	160	.14	0	0	80	.14
6-29-70	160	.28	160	1.41	160	.28
8-7-70	560	18.59	160	1.67	80	1.62
8-21-70	80	1.97	800	22.90	240	14.08
9-4-70	240	11.69	160	11.44	160	5.91
9-18-70	320	10.84	2,160	64.78	80	3.24
10-9-70	320	6.41	80	1.58	160	8.45
12-4-70	880	50.08	1,200	85.73	80	4.29
12-14-70	0	0	0	0	160	4.72
1-22-71	240	12.18	240	7.83	560	13.55


Flow Pond - Bottom Invertebrate
No./m2
wt/A lbs.
2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400 200 0
98 91 84 77 70 63 56 49 42 35 28 21 14 7 0
4-3 4-18 5-1 5-14 5-28 6-12 6-29 8-7 8-21 9-4 9-18 10-9 12-4 12-14 1-22
1970
1971
Sample Dates

CLOSED POND - BOTTOM INVERTEBRATE




Upper Pond - Bottom Invertebrate
No./m2 ----
wt/A (lbs.)
3200 112
3000 105
2800 98
2600 91
2400 84
2200 77
2000 70
1800 63
1600 56
1400 49
1200 42
1000 35
800 28
600 21
400 14
200 7
0 0
299.2
4/3 4/18 5/1 5/14 5/28 6/12 6/29 8/7 8/21 9/4 9/18 10/9 12/4 12/14 1/22
1970
1971
Sample Dates

BROWN POST LARVAE SHRIMP RECEIVED FROM

FISH AND WILDLIFE SERVICE - GALVESTON, TEXAS

6-5-70	Date Received:	Time: 2:30 A.M.
	No. Shipped	: 30,000
	% Mortality	: Less than 5%
	H_2O Temp.	: 21.5°C
	Salinity	: 27.11 ppt
	O_2	: 16 ppm
	NH_3	: 0.5 ppm

6-2-70 Two swimming pools - 3' x 12' were set-up for Acclimation.
H_2O Temp. : 23.5°C
Salinity : 26.01 ppt (Rila Marine Mix-Synthetic Sea H_2O Compound used to raise salinity from 17.76 ppt to 26.01 ppt.)

O_2 : 6.04 ppm

Post Larvae were released into pools after 1 1/2 hrs. of H_2O temperature adjustment.
Copepods were used as food for Post Larvae shrimp.
Copepod count was maintained at 4/ml. of water throughout acclimation.

6-5-70 Dropped salinity from 26.01 ppt to 24 ppt. from 2:00 P.M. to 3:15 P.M.

6-5-70 Dropped salinity from 24 ppt. to 22 ppt. from 8:45 P.M. to 9:30 P.M.

6-6-70 Dropped salinity from 22 ppt. to 19 ppt. from 12:30 P.M. to 2:30 P.M.

6-6-70 Dropped salinity from 19 ppt. to 17.76 ppt. from 4:00 P.M. to 5:30 P.M.

6-7-70 Drained pools: No post larvae recovered.

*Each pool was covered during acclimation by a 14'x18' trap.
**H_2O in each pool was circulated by the use of an electric circulating pump.

Table I. Lower Pond Tagging Study 1970 (5½ Acres)

Stocking Dates	No. Brown Stocked	Range mm	Av. Size mm	No. White Stocked	Range mm	Av. Size mm
9-8-70	79	120-155	133.6	1	--	145.0
9-9-70	173	115-155	133.4	7	110-145	137.5
9-10-70	162	120-150	131.0	1	-	140.0
9-16-70	258	120-155	135.3	18	105-150	138.9
9-17-70	85	120-150	135.1	2	135-150	142.5
9-23-70	86	125-155	137.2	1	-	140.0
10-1-70	-	-	-	47	115-175	144.5
10-6-70	-	-	-	22	115-160	146.4
10-7-70	-	-	-	17	95-160	143.7
10-8-70	-	-	-	90	130-170	150.1
TOTALS	843	115-155	134.3	206	95-175	142.9

Table II. Lower Pond Tagging Study 1970 (5½ Acres)

Harvest Dates	No. of Tag Brown Recovered	Range mm	Av. Size mm	No. Tag White Recovered	Range mm	Av. Size mm
10-13-70	21 -	115-145	132.4	6 -	128-162	140.4
10-15-70	413 -	119-153	134.8	68 -	116-152	137.8
10-19-70	63 -	120-157	137.1	13 -	128-144	137.3
10-20-70	45 -	117-152	130.1	54 -	111-151	137.0
10-21-70	16 -	120-150	134.5	12 -	127-148	138.1
10-28-70	16 -	122-155	133.0	7 -	133-147	139.5
11-3-70	4 -	118-132	-	4 -	125-142	-
11-4-70	2 -	139-147	-	2 -	110-138	-
11-16-70	3 -	127-140	-	0	-	-
11-17-70	1 -	130	-	0	-	-
11-18-70	0	-	-	0	-	-
11-23-70	1 -	133	-	0	-	-
TOTALS	585 69.4%	115-157*	133.7	166-80.6%	110-162	138.4

*1 unknown

Table I. Lower Pond Harvest Study - 1970 (5½ Acres).

Date	No. Crabs Large (>3")	Harvested Small (<3")	Unmarked Shrimp Browns Lbs.	Oz.	Count	White Lbs.	Oz.	Count	Harvest Time (P.M.)	H_2O Temp. at time of Harvest °C	Head of H_2O in Inches	Moon Phases
10-13-70	33	86	-	12	51.3	3	7.5	128.3	8-10:30	23.0	1/8	Full
10-15-70	66	114	3	15.5	67.0	105	15	118.6	7:15 - 9:00	20.0	6½	Full
10-19-70	61	350-400	2	11	71.3	29	2	99	8:00 - 9:00	21.5	6	Last Quarter
10-20-70	30	250-300	9	0	66	64	12	96.6	7:30 - 9:00	19.5	8	Last Quarter
10-21-70	10	60-80	2	10	76.5	37	9	109.0	7:30 - 9:00	19.0	8	Last Quarter
10-28-71	11	150-200	3	14.5	81.6	34	7	70.6	7:30 - 8:30	18.0	5	New
11-3-70	30	800-1000	4	14	75.6	81	15	113.6	6:00 - 7:45	16.5	10	New
11-4-70	16	450-600	1	6.6	83.6	41	13.4	128.0	6:00 - 7:30	16.0	12	First Quarter
11-16-70	35	600-725	1	10	116.8	26	15	118.0	6:30 - 8:30	12.0	12	Full
11-17-70	8	226	-	3	184	1	13	130.6	6:30 - 7:45	13.5	6	Last Quarter
11-18-70	17	475-525	-	1.5	176	4	11	131.6	5:15 - 6:45	17.5	10	Last Quarter
11-23-70	3	90-100	-	5	168.5	1	8	158.4	5:15 - 8:30	10.5	9	Last Quarter
TOTALS	1744*	3998							21 hrs.			

*1,424 collected from 3-17-70 to 10-12-70 by use of crab pots.

Table II. Lower Pond Harvest - Fish (5½ Acre) - 1970

No. Harvested	Common Name	Genus	species
271	Fat Sleeper	Dormitator	maculatus
610	Spotted Sea Trout	Cynoscion	nebulosus
382	Sand Sea Trout	Cynoscion	arenarius
7	Striped Mullet	Mugil	cephalus
22	Killfish	Fundulus	grandis
655	Bay Anchovies	Anchoa	mitchilli
24	Hog Choker	Trinectes	maculatus
10	Blackcheek Tongue Fish	Symphurus	plagiusa
53	Sailfin Molly	Mollienesia	latysinna
15	Bighead Sea Robin	Prionotus	tubulus
3	Southern Flounder	Paralichthys	lethostigma
6	Eel	Anguilla	bostoniensis
50	Puffer	-	-
30	Silver Perch	Boirdiella	chrysura
7	Lizard Fish	Synodus	foetens
8	Sheephead Minnow	Cyprinoden	variegatus
8	Lady Fish	Elops	saurus
11	Tidewater Silverside	Menidia	beryllina
2	Gulf Menhaden	Brevoortia	patronus
3	Oyster Toadfish	Opsanus	tau
1	Black Drum	Pogonias	cromis
1	Snapper	Lutjanus	sp.
3	Midshipmen	Porichthys	porosissimus
53	Diamond Killfish	Adinia	xenica
5	Leather Jacket	Oligoplites	saurus
1	Atlantic Cutlassfish	Trichiurus	lepturus
1	Blenny	-	-
4	Gray Snapper	Lutjanus	griseus
1	Gulf Pipe Fish	Syngnathus	scovelli

F = Flood
D = Drained
C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
*5-4-70 - Rotenone Lower Pond - 2 1/4 gal/2 1/2 Acre (Rotenone)			
*6-4-70 - Poisoned Lower Pond - Fintrol - 5 (Antimycin A-1%)			
6-22-70	F	2:30 PM	.6
6-22-70	D	8:30 PM	13
6-23-70	F	9:30 AM	10 1/2
6-23-70	D	8:00 PM	14 1/2
6-24-70	F	10:30 AM	9 1/2
6-24-70	D	8:00 PM	11
6-25-70	F	7:00 AM	7
6-25-70	D	2:00 PM	2
6-25-70	C	4:00 PM	-
6-26-70	C	-	-
6-27-70	C	-	-
6-28-70	C	-	-
6-29-70	F	6:30 AM	4
6-29-70	D	11:30 AM	17 1/2
6-20-70	F	5:00 AM	7
6-20-70	D	12:00 (Noon)	17 1/2
7-1-70	F	5:30 AM	7
7-1-70	D	12:30 PM	18
7-2-70	F	6:30 AM	7
7-2-70	D	1:30 PM	-

Recap Levees around lower pond 4-30-70 to 5-1-70.

F = Flood
D = Drained
C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970

Continued

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
7-3-70	-	-	-
7-4-70	-	-	-
7-5-70	F	9:00 AM	8 1/4
7-5-70	D	5:15 PM	18
7-6-70	F	11:15 AM	5 3/4
7-6-70	D	5:00 PM	18
7-7-70	F	11:00 AM	5 1/2
7-7-70	D	4:30 PM	21 1/4
7-8-70	F	1:45 PM	3
7-8-70	D	4:45 PM	21 1/4
7-9-70	F	2:00 PM	-
7-10-70	-	-	-
7-11-70	-	-	-
7-12-70	F	1:00 AM	-
7-12-70	D	9:45 AM	-
7-13-70	F	1:30 AM	8 1/4
7-13-70	D	9:45 AM	15 3/4
7-14-70	F	1:30 AM	8
7-14-70	D	9:30 AM	16 1/2
7-15-70	F	2:00 AM	9 1/2
7-15-70	D	11:30 AM	14 3/4
7-16-70	F	2:15 AM	1 1/4
7-16-70	D	3:00 AM	-
7-16-70	F	5:00 AM	-

F = Flood
D = Drained
C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970
(Continued)

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
7-16-70	D	1:00 PM	--
7-17-70 to 8-1-70	-	-	-
8-2-70	F	3:30 PM	-
8-2-70	D	6:30 PM	-
8-3-70	F	3:00 AM	-
8-3-70	D	4:00 PM	-
8-4-70	D	3:30 PM	-
8-5-70	-	-	-
8-6-70	F	4:00 AM	-
8-6-70	D	9:00 AM	-
8-7-70	D	5:45 AM	-
8-7-70	F	9:45 PM	-
8-8-70	-	-	-
8-9-70	-	-	-
8-10-70	F	11:00 PM	-
8-10-70	D	8:45 AM	-
8-11-70	D	9:15 AM	-
8-11-70	F	11:45 PM	-
8-12-70	F	3:00 AM	-
8-12-70	D	9:30 PM	-
8-13-70	D	11:30 PM	-
-14-70	-	-	-

D = Drained
C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970
(Continued)

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
8-15-70	-	-	-
8-16-70	-	-	-
8-17-70	D	3:45 PM	-
8-18-70 to	-	-	-
8-24-70	D	8:15 AM	-
8-24-70	F	11:00 PM	-
8-25-70 to	-	-	-
8-30-70	D	3:00 PM	-
8-31-70* to	C* Rotenone Pond 6 1/2 gals		
9-2-70	C		
9-3-70	D	4:30 PM	10 1/2
9-4-70	-	-	-
9-5-70	-	-	-
9-6-70	F	10:30 PM	-
9-7-70	-	-	-
9-8-70	F	11:30 PM	-
9-9-70	D	6:30 AM	-
9-10-70	F	12:45 AM	-
9-11-70	-	-	-
9-12-70	-	-	-
9-13-70	D	2:00 PM	8
9-14-70	F	6:45 AM	13
9-14-70	D	3:00 PM	8 1/4

D = Drained
C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970
Continued

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
9-15-70	F	5:45 AM	12
9-15-70	C	5:00 PM	12 1/2
9-16-70 to 9-29-70	C	-	-
	C	-	-
9-30-70	D	3:30 PM	8 3/4
10-1-70	D	4:15 AM	10⁻
10-1-70	F	2:15 PM	12⁻
10-2-70	-	-	-
10-3-70	-	-	-
10-4-70	-	-	-
10-5-70	D	4:15 AM	7 1/2
10-5-70	F	8:15 PM	13 1/4
10-6-70	D	9:00 AM	3 3/4
10-6-70	F	9:00 PM	9 1/4
10-7-70	D	6:45 AM	14
10-7-70	F	9:30 PM	9
10-8-70	D	9:00 AM	13
10-9-70	-	-	-
10-10-70	-	-	-
10-11-70	D	3:00 PM	-
10-12-70	F	6:00 AM	4 1/2
10-12-70	D	3:00 PM	2
10-12-70	C	8:00 PM	4 1/2
10-13-70	C	-	-

D = Drained
C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970
Continued

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
10-13-70	D	8:00 PM	4
10-13-70	C	10:30 PM	-
10-14-70	D	8:00 PM	6 1/2
10-15-70	C	7:30 AM	11 1/4
10-15-70	D	7:15 PM	-
10-15-70	C	9:00 PM	-
10-16-70	C	-	-
10-17-70	C	-	-
10-18-70	C	-	-
10-19-70	D	8:00 PM	-
10-19-70	C	9:30 PM	-
10-20-70	D	7:30 PM	-
10-20-70	C	9:00 PM	-
10-21-70	D	7:30 PM	-
10-21-70	C	9:00 PM	-
10-22-70 to	C	-	-
11-22-70 to	C	-	-
11-2-70	C	-	-
11-3-70	* Someone removed screen and allowed shrimp escapement		
11-3-70	D	6:00 PM	-
11-3-70	C	7:45 PM	-
11-4-70	D	6:00 PM	-
11-4-70	C	7:30 PM	-

C = Closed

(5 1/2 Acre) Lower Pond H_2O Exchange Management Record - 1970
(Continued)

Date	H_2O Flow	Time	H_2O Level in Inches Above Weir
11-5-70	C	-	-
to			
11-15-70	C	-	-
11-16-70	D	6:30 PM	-
11-16-70	C	8:30 PM	-
11-17-70	D	6:30 PM	-
11-17-70	C	7:45 PM	-
11-18-70	D	5:15 PM	-
11-18-70	C	6:45 PM	-
to			
11-22-70	C	-	-
11-23-70	D	5:15 PM	-
11-23-70	C	8:30 PM	-
to			
11-27-70	C	-	-
11-28-70	D	7:30 PM	-
11-28-70	C	8:30 PM*Closed until 1971	

Upper Pond Harvest - 1970 - (38.75 - .52 Acres) = 38.23A

Harvest Dates	Total lbs. Harvested	Lbs. White Harvested	Count	Lbs. Brown Harvested	Count	Harvest Time P.M.	No. Hrs. Harvested	Head of H_2O Inches	Air Temp oF	Climatic Conditions
10-29-70	381	361.95	57	19.05	36	7:00 - 8:00	2	2	60°	Clear-N
10-30-70	14¼	13¼	119	1	49	5:30 - 6:15	3/4	1/2	62°	Clear-Calm
11-2-70	378½	347.84	80	30.66	45	5:15 - 9:45	4½	8	55°	Clear-N-15-2[illegible]
11-4-70	44	-	104	-	32	5:05 - 10:50	5 3/4	-	54°	Clear-N-5-10 Moon - 1st quarter
TOTALS	817 3/4						13			

UPPER POND H_2O EXCHANGE MANAGEMENT RECORD - 1970

Date	H_2O Flow	Time
6-1-70	D	6:30 PM
6-2-70	F	2:00 AM
6-2-70	D	8:30 PM
6-3-70	F	5:00 AM
6-4-70 to 6-29-70	-	-
6-30-70	*	-
7-1-70 to 7-17-70	-	-
7-18-70	F	11:30 AM
7-19-70 to 7-25-70	-	-
7-26-70	D	4:30 PM
7-27-70	F	4:30 AM
7-27-70	D	9:30 AM
7-28-70	F	4:30 AM
7-28-70	D	10:30 AM
7-29-70	F	4:00 AM
7-29-70	D	11:45 AM
7-30-70	F	3:30 AM
7-30-70	D	12:30 PM
7-31-70 to 8-6-70	-	-
8-7-70	D	7:30 AM

*Water control boards removed; 1/2" screen put in place and tidal exchange was allowed to occur.

UPPER POND H_2O EXCHANGE MANAGEMENT RECORD - 1970

Date	H_2O Flow	Time
8-7-70	F	11:15 PM
8-8-70	-	-
to		
8-10-70	-	-
8-11-70	D	11:00 AM
8-12-70	F	1:30 AM
8-12-70	D	12:30 PM
8-13-70	D	1:30 PM
8-14-70	-	-
to		
8-16-70	-	-
8-17-70	D	4:45 PM
8-18-70	-	-
8-19-70	D	4:30 PM
8-20-70	-	-
to		
8-24-70	-	-
8-25-70	F	12:30 AM
8-25-70	D	2:00 PM
8-26-70	D	5:30 PM
8-27-70	D	1:45 PM
8-28-70	-	-
to		
8-31-70	-	-
9-1-70	D	6:45 PM
9-2-70	D	4:00 PM
9-3-70	D	12:00 PM
9-4-70	-	-
9-5-70	-	-
9-6-70	F	11:45 PM

UPPER POND H_2O EXCHANGE MANAGEMENT RECORD - 1970

Date	H_2O Flow	Time
9-7-70	-	-
9-8-70	F	1:15 AM
9-9-70	D	9:00 AM
9-10-70	F	2:00 AM
9-10-70	D	12:15 PM
9-11-70	-	-
9-12-70	-	-
9-13-70	D	3:45 PM
9-14-70	F	6:15 AM
9-14-70	D	4:15 PM
9-15-70	F	6:15 AM
9-15-70	C	9:30 AM
9-16-70	C	-
9-17-70	D	-
9-18-70	-	-
9-19-70	-	-
9-20-70	C Screen missing	7:00 PM
9-21-70	Screen Replaced	
9-22-70	F	10:30 PM
9-22-70	C	11:00 PM
9-23-70	D	5:00 PM
9-23-70	C	11:00 PM
9-24-70 to	C	-
9-26-70	C	-
9-27-70	D	11:30 AM
9-28-70	-	-
9-29-70	D	7:30 AM

UPPER POND H_2O EXCHANGE MANAGEMENT RECORD - 1970

Date	H_2O Flow	Time
9-29-70	F	8:00 PM
9-30-70	D	5:30 AM
10-1-70	D	5:00 AM
10-1-70	C	8:00 PM
10-2-70	C	-
10-3-70	C	-
10-4-70	D	6:00 PM
10-5-70	D	5:00 AM
10-5-70	F	7:45 PM
10-6-70	C	6:15 AM
10-6-70	D	10:00 AM
10-6-70	C	9:00 PM
10-7-70	C	-
10-8-70	D	4:00 PM
10-8-70	C	6:00 PM
10-9-70	C	-
to		
10-13-70	C	-
10-14-70	D	8:30 AM
10-14-70	C	3:30 PM
10-15-70	D	10:00 AM
10-16-70	No more records of water exchange kept.	
11-3-70	Screen removed by someone between 11:30 PM (11-2-70) and 5:30 AM (11-3-70).	

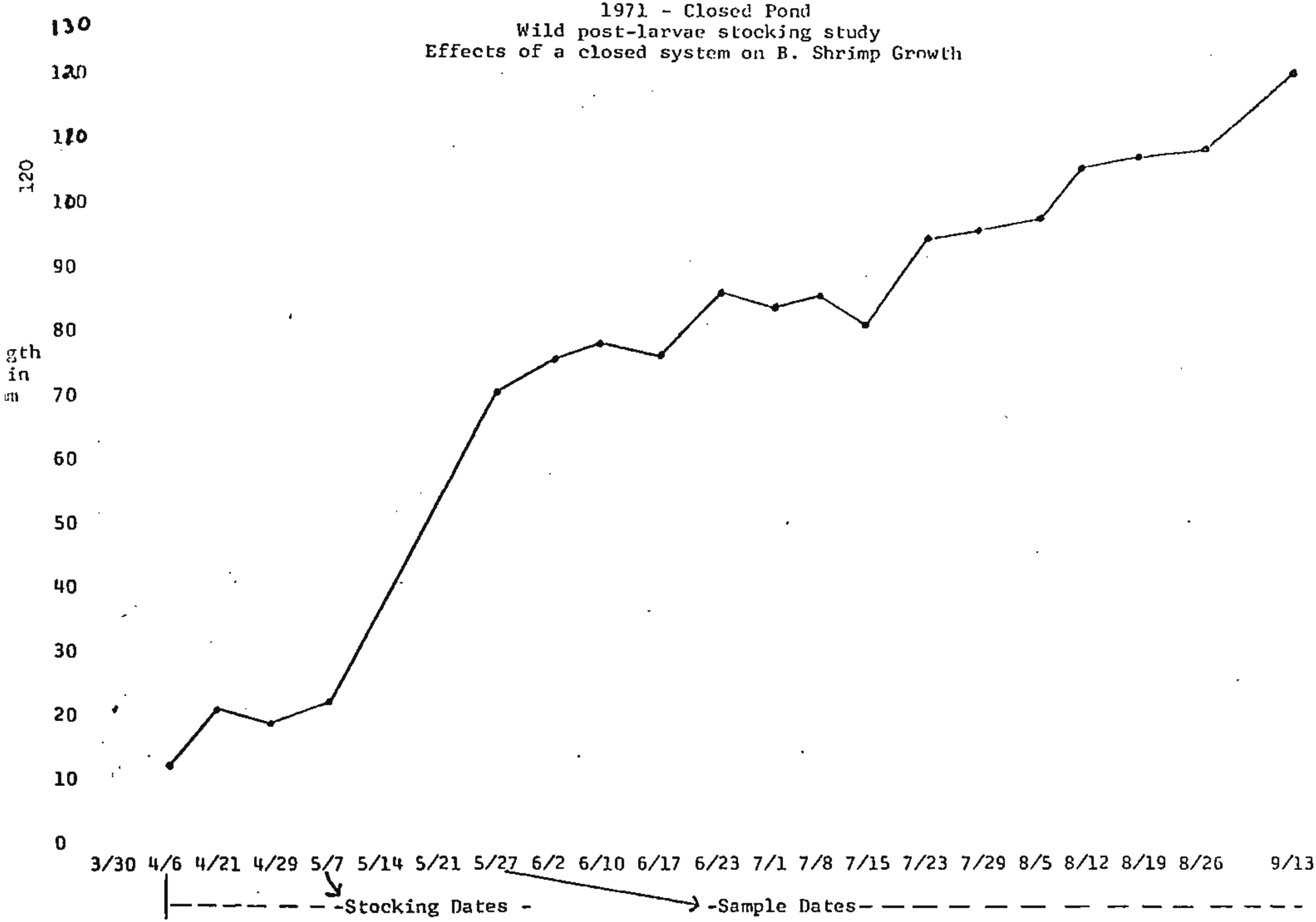
PL Stocking in NSF Pond - 1971

Date Stocked	# Stocked in Closed Pond	Size mm	# Stocked in Flow Pond	Size (mm)	Total # Stocked
3-30-71	130	Range - 10-28 Av.-14	120	Range-10-28 Av.-14	250
3-31-71	440	Range-10-22 Av.-14	440	Range-10-22 Av.-14	880
4-1-71	250	Range-12-24 Av.-15	---	---	250
4-3-71	3,640	Range-10-26 Av.-13	---	---	3,640
4-5-71	---	---	130	Range-12-27 Av.-14	130
4-6-71	---	---	80	Range-12-26 Av.-15	80
4-13-71	---	---	590	Range-12-32 Av.-14	590
4-14-71	---	---	670	Range-12-18 Av.-14	670
4-15-71	---	---	550	Range-12-20 Av.-14	550
4-16-71	---	---	240	Range-10-22 Av.-13	240
4-17-71	---	---	210	Range-12-15 Av.-13	210
4-18-71	325	Range-10-30 Av.-14	500	Range-10-25 Av.-14	825
4-19-71	---	---	350	Range-12-20 Av.-16	350
4-20-71	4,300	Range-18-30 Av.-22	4,000	Range-18-24 Av.-20	8,300
4-20-71	---	---	570	Range-10-32 Av.-16	570
4-21-71	310	Range-16-40 Av.-25	500	Range-16-40 Av.-25	810
4-22-71	8,610	Range-10-30 Av.-18	6,735	Range-10-30 Av.-18	15,345
4-23-71	7,800	---	8,475	---	16,275
4-26-71	---	---	1,880	Range-12-28 Av.-18	1,880
4-27-71	1,430	Range-12-50 Av.-18	270	Range-12-28 Av.-16	1,700

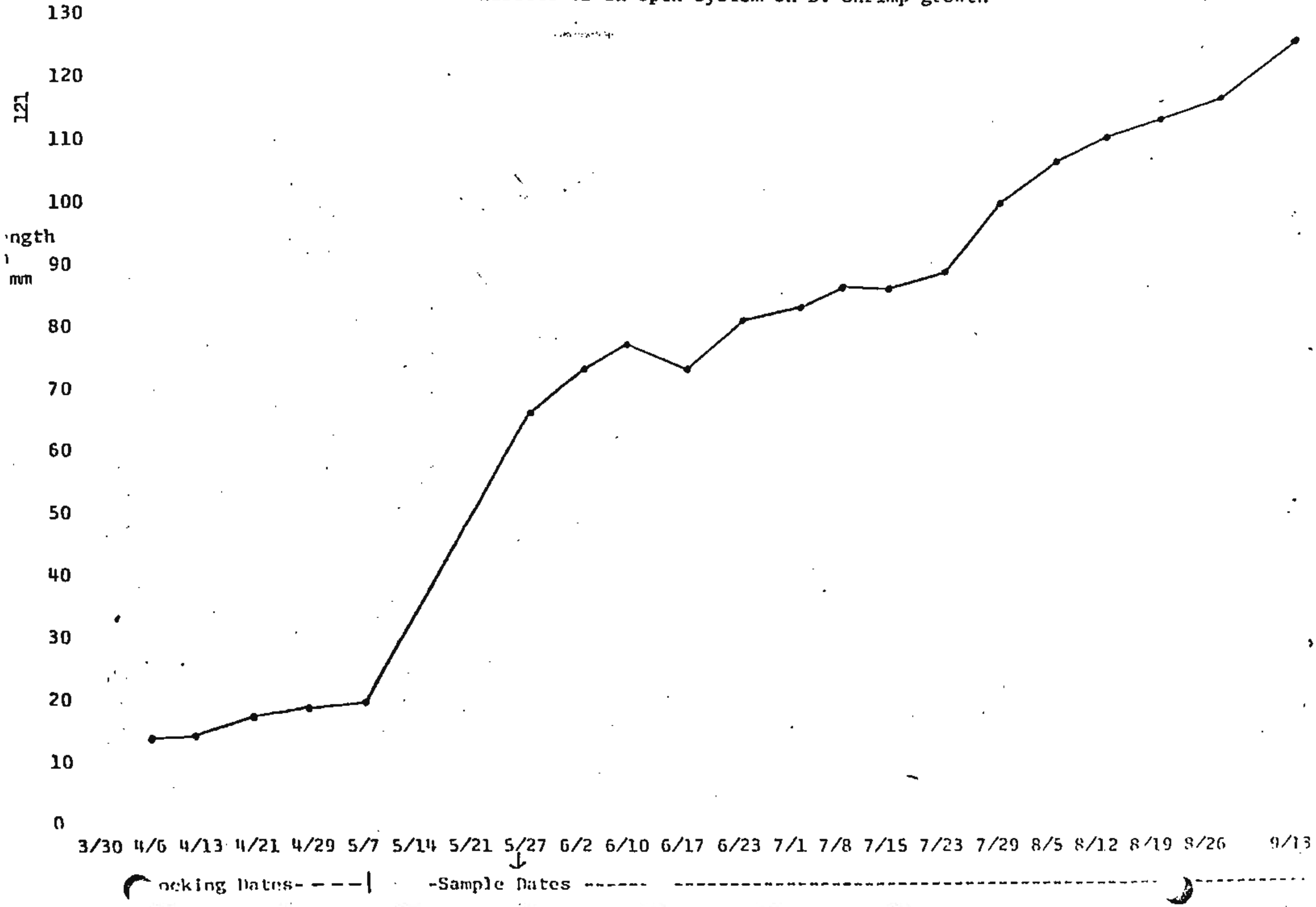
PL Stocking in NSF Pond - 1971

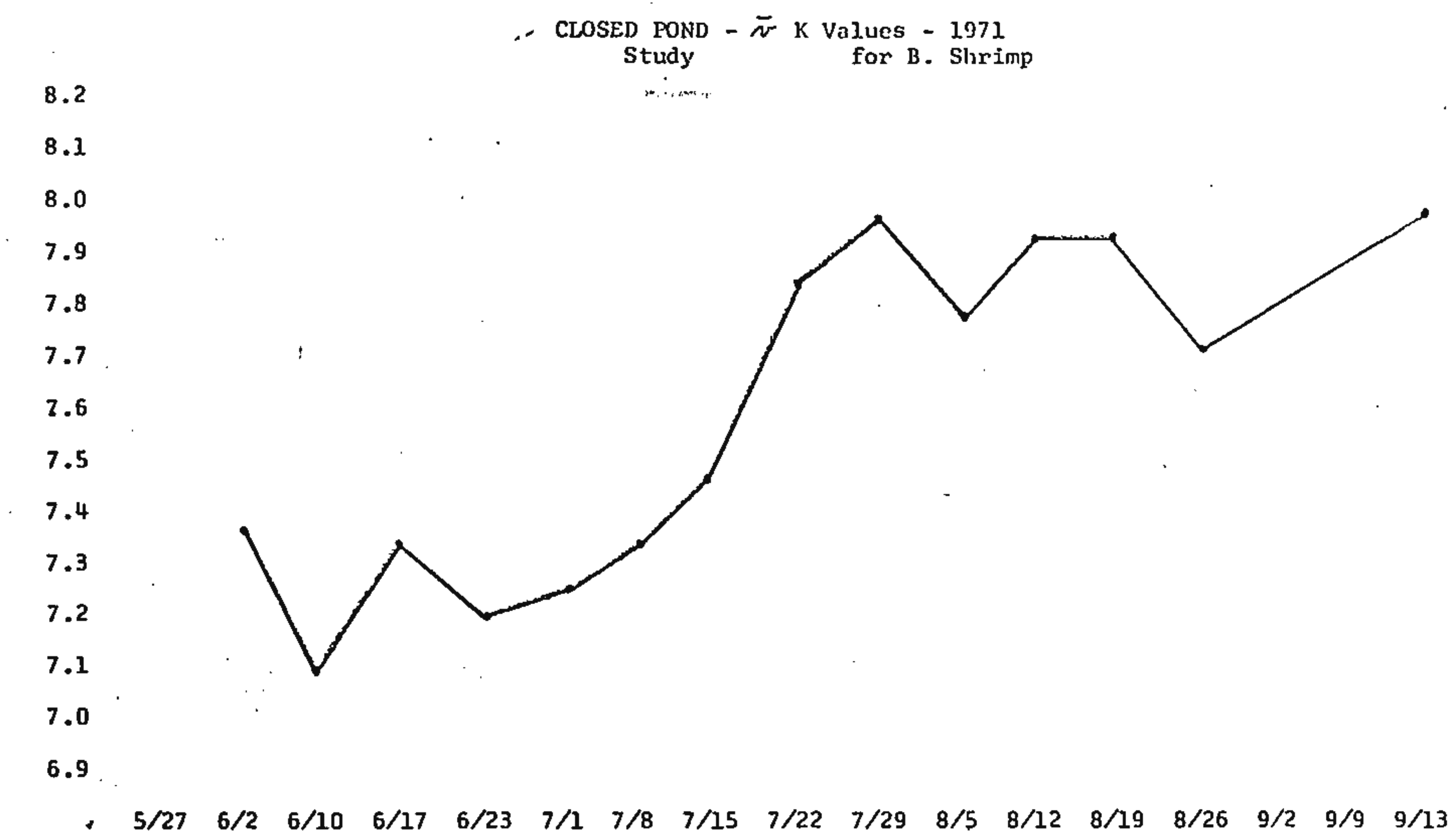
Date Stocked	# Stocked in Closed Pond	Size mm	# Stocked in Flow Pond	Size (mm)	Total # Stocked
4-28-71	730	---	1,330	Range-10-30 Av.-18	2,060
4-29-71	---	---	1,400	Range-10-32 Av.-18	1,400
5-5-71	2,035	Range-12-70 Av.-23	---	---	2,035
5-6-71	---	---	960	Range-12-50 Av.-20	960
TOTALS	30,000		30,000		60,000

1971 - Closed Pond
Wild post-larvae stocking study
Effects of a closed system on B. Shrimp Growth



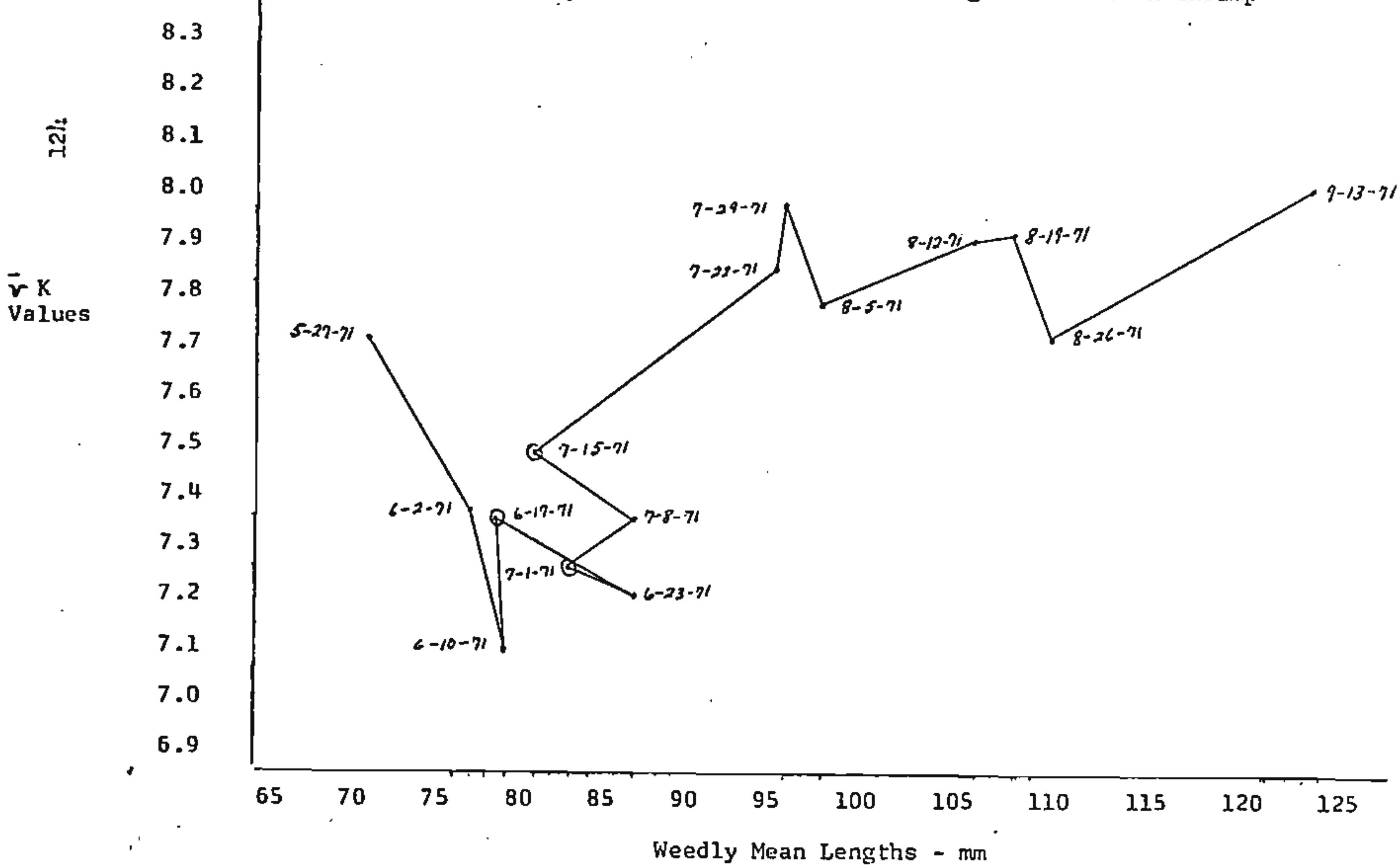
1971 - Flow Pond
Wild post-larvae stocking study
Effects of an open system on B. shrimp growth



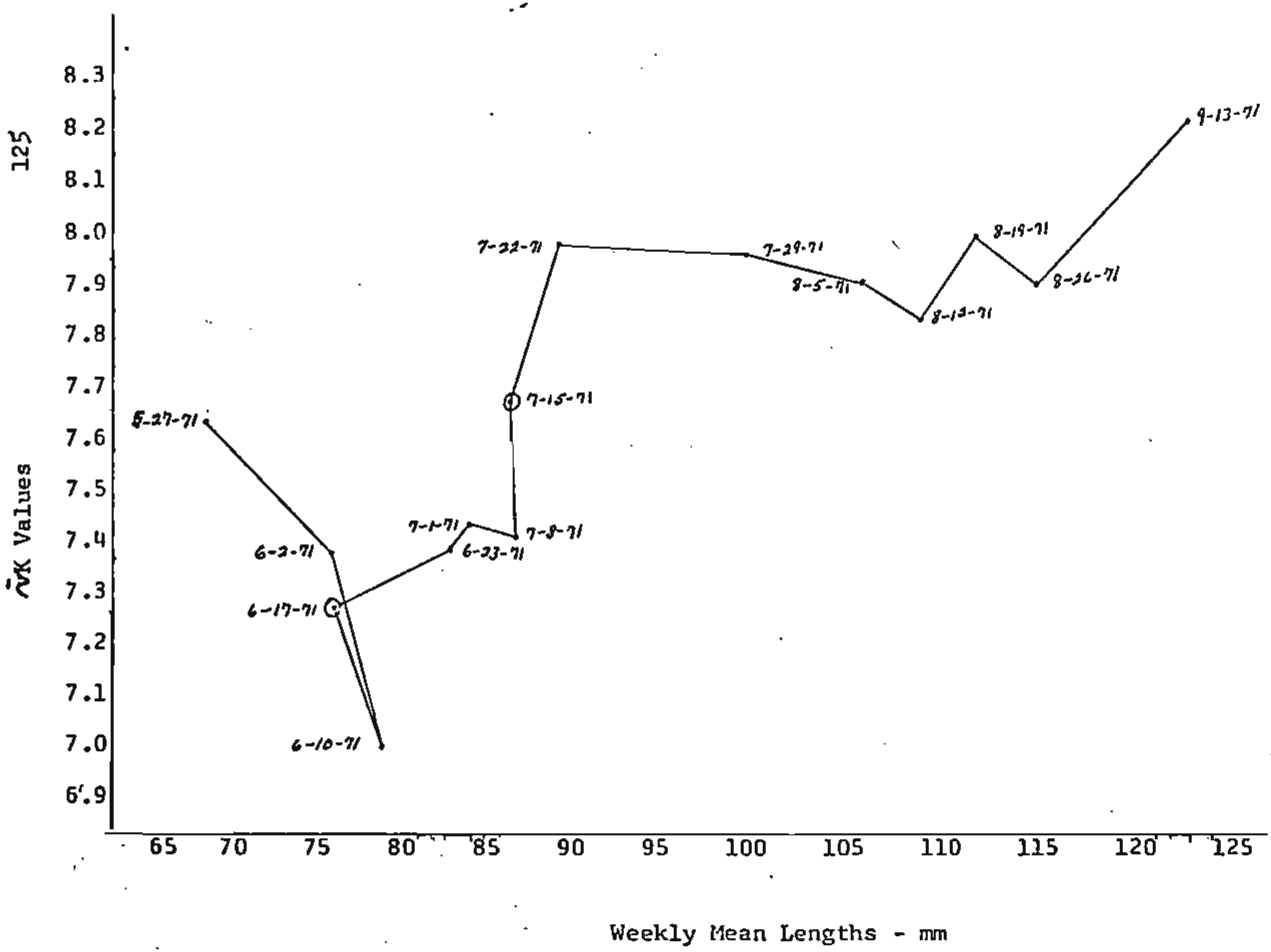

CLOSED POND - $\bar{w}$ K Values - 1971
Study for B. Shrimp
8.2
8.1
8.0
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
5/27 6/2 6/10 6/17 6/23 7/1 7/8 7/15 7/22 7/29 8/5 8/12 8/19 8/26 9/2 9/9 9/13

Flow Pond - $\bar{\bar{v}}$ K values - 1971
Study for B. Shrimp

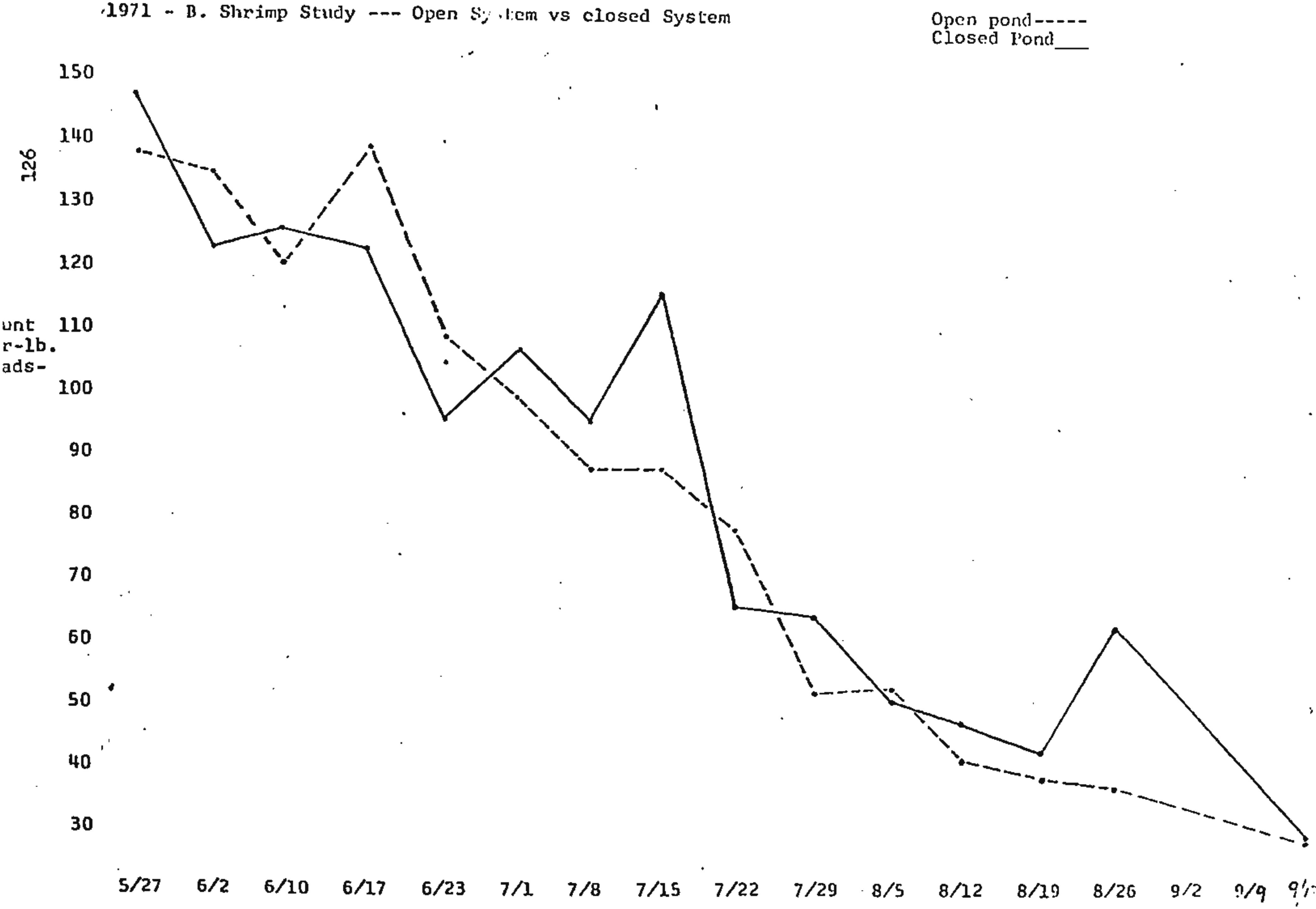
1971 - Closed Pond - $\bar{\nu}$ K-Values vs $\bar{\nu}$ mm - Lengths for Brown Shrimp



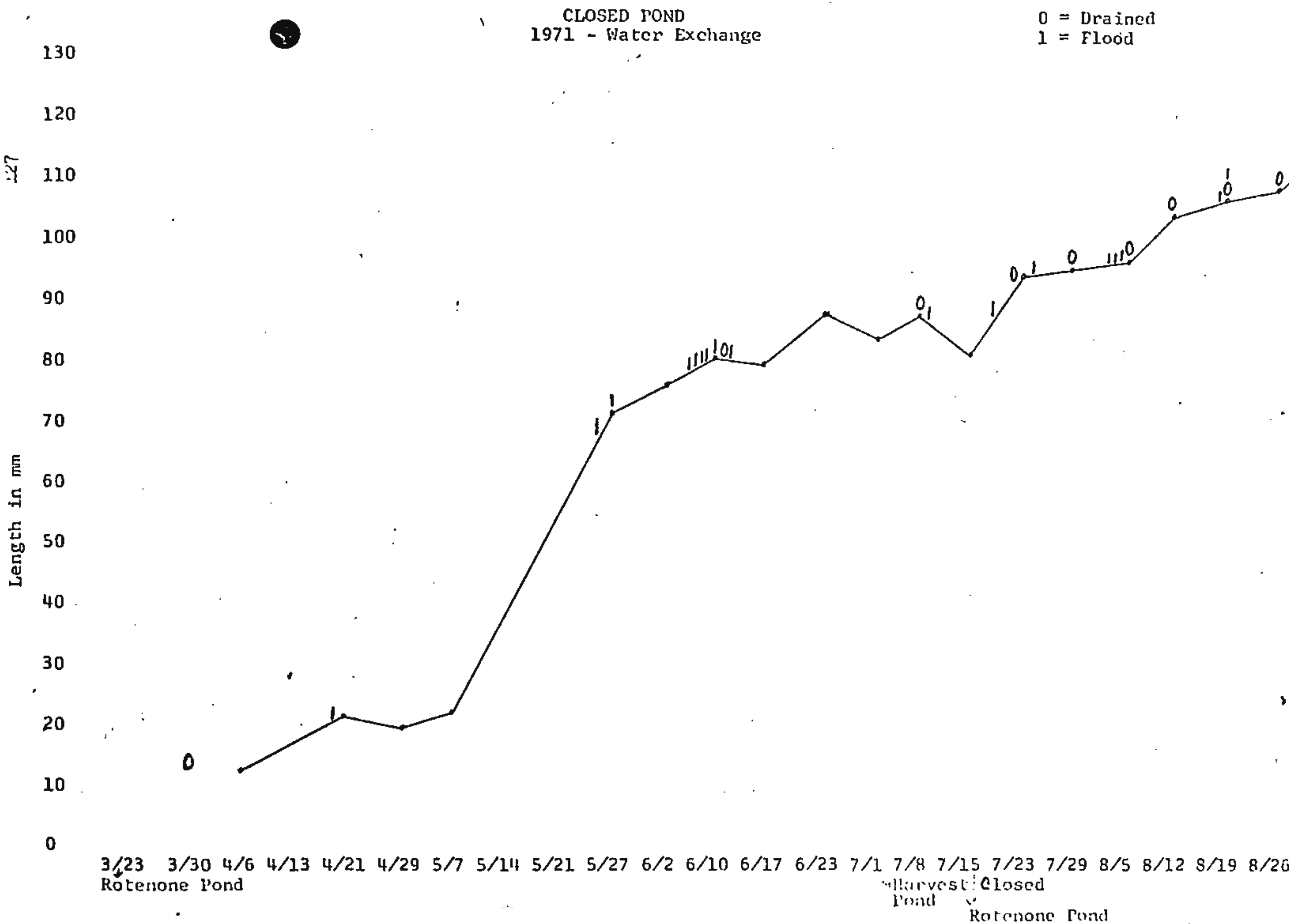
1971 - Flow Pond - $\bar{v}$K-Values vs $\bar{v}$ mm-Lengths for Brown Shrimp

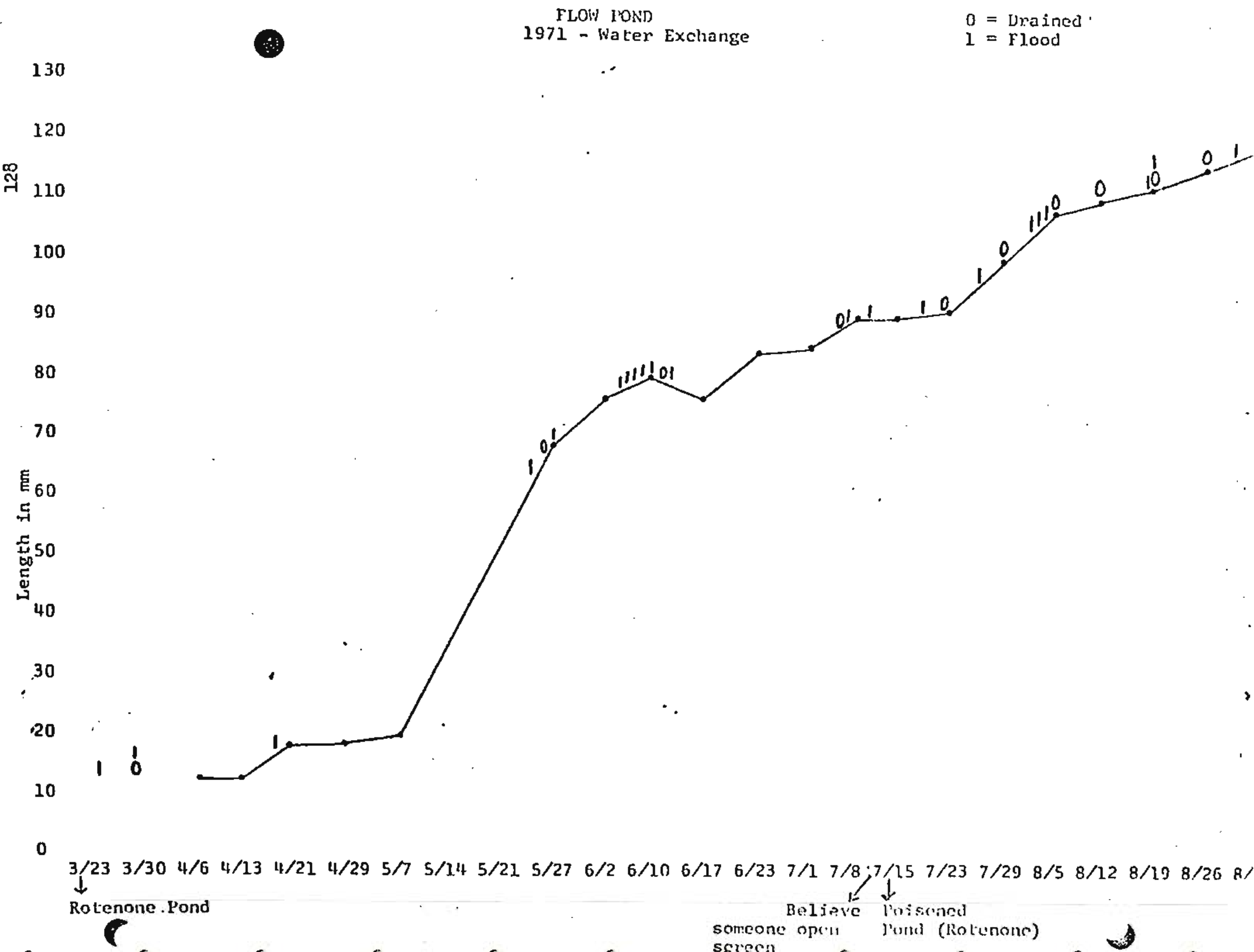


1971 - B. Shrimp Study --- Open System vs closed System



CLOSED POND
1971 - Water Exchange




FLOW POND
1971 - Water Exchange
0 = Drained
1 = Flood
Length in mm
0
10
20
30
40
50
60
70
80
90
100
110
120
130
3/23 3/30 4/6 4/13 4/21 4/29 5/7 5/14 5/21 5/27 6/2 6/10 6/17 6/23 7/1 7/8 7/15 7/23 7/29 8/5 8/12 8/19 8/26 8/
Rotenone Pond
Believe someone open screen
Poisened Pond (Rotenone)

LOWER POND HARVEST - 1971

Date	No. Harvested Flow Pond	Lbs. Harvested	Count	No. Returns	No. Harvested Closed Pond	Lbs. Harvested	Count	No. Returns	No. H Contr
6-17-71	100	.72	139	-	97	.79	123	-	
6-23-71	99	.94	105	-	99	1.08	92	-	
7-1-71	116	1.17	99	-	107	1.05	102.4	-	
7-8-71	111	1.27	87	-	10,893	112.38	96.9	-	
7-15-71	106	1.22	87	-	66	.60	111	-	
7-22-71	53	.69	77	-	52	.80	65	-	
7-29-71	56	1.01	55.3	-	54	.86	62.9	-	
8-5-71	53	1.13	47.5	-	21	.40	52.5	-	
8-12-71	52	1.19	43.8	-	6	.13	47.1	-	
8-19-71	51	1.28	39.8	-	25	.56	44.5	-	
8-26-71	52	1.40	37.1	-	3	.07	42.9	-	
9-13-71	915	32.75	27.9	*1	60	2.04	29.4	*1	
TOTALS	1,764	44.77			11,483	120.76			

*50 Tag B. Shrimp placed in pond 9/7 & 8/71.

**10 Tag B. Shrimp placed in pond 9/7&8/71.

***1,327 Large Crabs and 88 small crabs (Less than 3") removed with minimum crab control.

C - Closed
F - Flood
D - Drain

5.5 Lower Pond H_2O Exchange Management Record - 1971

% based on 18"
Depth - 2" removed
= 1/9 = 11%

Date	No Exchange	Exchange in inches Before	After	% Removed	% Replaced
3-23-71	Pond Rotenone - 2¼ gals.				
3-24-71	C				
3-25-71		F	+2	-	-
3-26-71	C				
+o					
3-28-71	C				
3-29-71		F	+3½	-	-
3-29-71		D	-4¼	-	-
3-30-71	C				
+o					
4-18-71	C				
4-19-71		F	+2½	-	-
4-20-71	C				
+o					
5-23-71	C				
5-24-71		F	+9½	-	-
5-25-71	C* H_2O level 19 inches above weir				
5-26-71		D 17 3/4	15 7/8	11.1	
5-27-71		F 15 15/16	19 1/4		17.8
5-28-71	C				
+o					
6-5-71	C				
6-6-71		F 13	13½		2.8
6-7-71		F 13¼	16		15.3
6-8-71		F 15¼	16¼		5.6
6-9-71		F 15½	15 3/4		1.4
6-10-71		F 15	17		11.1

C - Closed
F - Flood
D - Drain

5.5 Acre Lower Pond H_2O Exchange Management Record - 1971

Date	No Exchange	Exchange in inches Before	After	% Removed	% Replaced
6-11-71	C				
6-12-71		D 15 1/2	14 1/2	5.6	
6-13-71		F 14	15 1/4		6.9
6-14-71	C 14 1/2				
6-15-71	C 14 1/4				
6-16-71	C 14 1/4				
6-17-71	C 14				
6-18-71	C -				
6-19-71	C -				
6-20-71	C 13 1/2				
6-21-71	C 12 3/4				
6-22-71	C 12 3/4				
6-23-71	C 12 3/4				
6-24-71	C 12 3/4				
6-25-71	C -				
6-26-71	C -				
6-27-71	C 11 3/4				
6-28-71	C 11 1/2				
6-29-71	C 11 1/2				
6-20-71	C 13				
7-1-71	C 13 1/4				
7-2-71	C -				
7-3-71	C -				
7-4-71	C 13 1/2				
7-5-71	C 13 1/2				
7-6-71		D 13 1/2	13 1/4	1.4	
7-7-71		F 13 1/2	19		30.6
7-8-71	C 16 3/4				
7-9-71	C -				
7-10-71		F 15	19		22.2
7-11-71	C 17 1/2				
7-12-71	C 17 1/4				
7-13-71	C 17 1/4				
7-14-71	C* 15 3/4 Believe someone let H2Oout of pond			8.3	
7-15-71	*	D 15 1/4	14 3/4 Rotenone Pond 0.9 ppm	2.8	
7-16-71	C 14 1/2				

5.5 Acre Lower Pond H_2O Exchange Management Record - 1971

Date	Exchange	Exchange in inches Before	After	% Removed	% Replaced
7-17-71	C 14 1/2				
7-18-71	C 14 1/4				
7-19-71		F 14 1/8	15 1/4		6.3
7-20-71	C 14 1/4				
7-21-71	C 14 1/2				
7-22-71		D 14 1/4	13 3/4	2.8	
7-23-71	C 13 1/2				
7-24-71	C -				
7-25-71	C 13 1/4				
7-26-71		F 13	13 1/2		2.8
7-27-71	C 13				
7-28-71	C 12 3/4				
7-29-71		D 13	12 3/4	1.4	
7-30-71	C -				
7-31-71	C -				
8-1-71	C 16 1/2				
8-2-71		F 16 1/2	17 1/2		2.8
8-3-71		F 16 1/2	18		8.3
8-4-71		F 17	17		0
8-5-71		D 16 3/4	16	4.2	
8-6-71	C -				
8-7-71	C -				
8-8-71	C 14 3/4				
8-9-71	C 14 1/8				
8-10-71	C 13 3/4				
8-11-71	C 13 1/2				
8-12-71		D 13 1/4	12 1/2	4.2	
8-13-71	C -				
8-14-71	C -				
8-15-71	C 12				
8-16-71	C 12				
8-17-71	C 12				
8-18-71		F 12	14		11.1
8-19-71		F 13 3/4	14 1/2		4.2
8-19-71		D 14 1/2	14	2.8	
8-20-71	C -				
8-21-71	C -				
8-2[illegible]	C 14				

5.5 Acre Lower Pond H_2O Exchange Management Record - 1971

Date	No Exchange	Exchange in inches Before	Exchange in inches After	% Removed	% Replaced
8-23-71	C 13 3/4				
8-24-71	C 16				
8-25-71	C 15 1/2				
8-26-71		D 14 3/4	14	4.2	
8-27-71	C -				
8-28-71	C -				
8-29-71	C -				
8-30-71	C 15 1/2				
8-31-71		F 15 1/2	17 1/2		11.1
9-1-71	C -				
9-2-71	C 19				
9-3-71	C -				
9-4-71	C -				
9-5-71	C 20 1/2				
9-6-71	C 19 1/2				
9-7-71	C 19 1/2				
9-8-71	C 20				
9-9-71	C 21				
9-10-71	C 23				
9-11-71	C -				
9-12-71	C -				
9-13-71		D 21 1/2	11*Harvest Pond	58.3	
9-14-71		F 11	17		33.3
9-15-71		F 17 1/2	18		2.8
9-16-71*	Termination of H_2O Control due to Hurricane Edith flood waters.				

Chart I

1970 Experiment No. 1A (Blue Crab Predation)	Shrimp Stocking Dates	Size of Enclosures	Shrimp Stocking Rates	Size of shrimp at stocking mm	Date Stocked Blue Crabs	No. Blue Crabs Stocked
Pen 1	8-27-70	50'x50'	928w 72B 1,000	Brown Range-55-130 Av. - 90.7 Range-40-130 Av. - 72.1	No	Crabs
(Control) Pen 2	(Control)	50x45'	15B Shrimp Stocked by error	Brown Range-80-120	No	Crabs
Pen 3	8-20-70	50x50'	w-692 B-308 1,000	Brown Range-45-135 Av.-87.9 White Range-35-145 Av. 81.6	No	Crabs
Pen 4	8-31-70	50'x50'	w-928 b-72 1,000	Range-45-120 Av.-87.00 White Range-45-135 Av.-77.10	9-1-70	60
(Control) Pen 5	Control	50'x50'	No	Stocking	No	Crabs
Pen 6	8-25-70	50'x50'	w-854 b-146 1,000	Brown Range55-115 Av.-84.14 Range-35-130 Av.-61.44	9-1-70	60
Pen 7	9-1-70	50'x50'	w-950 b-50 1,000	Range-40-100 Av.-76.6 White Range-50-135 Av.-63.3	No	Crabs
(Control) Pen 8	(Control)	50'x45'	No	Stocking	No	Crabs
Pen 9	8-26-70	50'x50'	w-844 b-156 1,000	Brown Range-40-115 Av.-84.84 White Range-35-130 Av.-66.70	No	Crabs

B.--Brow[illegible]rimp
W.--Whit[illegible]rimp

Page II (Blue Crab Predation) CHART I

Size of Blue Crabs Stocked	No. Shrimp Harvested	Total Av. Size of Shrimp Harvested mm	Total Lbs. of Shrimp Harvested Lbs. per Pen	Ozs.	No. of Seining and Catch per seine 1	2	3	4	5	6	7	8	No. of Crabs Harvested
No Crabs Stocked Pen 1	Brown 14 White 797	Brown Range-86-108 Av-98.85 White Range-43-119 Av-85.98	B. W. 9	3 6	B - 6 W - 232 (N.H.)			B - 8 W - 525 (D.H.)			B-0 W-40 (D.H.)	---	Large - 3 Small - 27
Stocked No Crabs Pen 2	Brown 8 White 188	Brown Range-107-127 Av-116.3 White Range-58-136 Av-93.53	B. W. 1	4 13.8	B. - 8 W. - 177 (D.H.)			B-0 W-11	-	-	-	-	Large - 2 Small - 26
Stocked No Crabs Pen 3	Brown 7 White 517	Brown Range-91-108 Av-101.3 White Range-68-124 Av-100.89	B. W. 8	1.5 14.8	B.-5 W.-350 (D.H.)		B-2 W-163 (D.H.)		B-0 W-4 (D.H.)	-	-	-	Large-15 Small-57
Range-108-175 Av-135.0 Pen 4	Brown 19 White 839	Brown Range-69-120 Av-96.41 White Range-55-121 Av-85.13	B. W. 9	3.5 5.8	B-8 W-64 (N.H.)	B-10 W-752 (D.H.)						B-1 W-23 (D.H.)	Large-13 Small-14
Stocked No Crabs Pen 5	Brown 16 White 49	Brown Range-65-128 Av-101.12 White Range-65-126 Av-96.83	B. W.	5 10.7	B. - 16 W. - 47 (D.H.)		B-0 W-2 (D.H.)	-	-	-	-	-	Large-3 Small-11
Range-102-181 Av-131.0 Pen 6	Brown 5 White 677	Brown Range-76-101 Av-85.25 White Range-59-108 Av-92.39	B W. 8	1 4.7	B. - 2 W. - 542 (D.H.)			B - 3 W-131 (D.H.)		B-0 W-4 (D.H.)	-	-	Large-3 Small-88
Stocked No Crabs Pen 7	Brown 16 White 230	Brown Range-80-107 Av-92.59 White Range-76-98 Av-87.48	B. W. 1	3 4	B-9 W-43 (N.H.)		B - 6 W - 187 (D.H.)				B-1 W-0 (D.H.)	-	Large--12 Small-22

B.--Brown Shrimp
W.--White Shrimp

N.H.--Night Harvest
D.H.--Day Harvest

Chart I
Page III

1970 Experiment No. 1A
(Blue Crab Predation)

Size of Blue Crabs Stocked	No. Shrimp Harvested	Tot. Av. Size of Shrimp Harvested	Total Lbs. Shrimp Harvested lbs.	oz.	No. of Seining and catch per seine 1	2	3	4	5	6	7	8	No. of Crabs Harvested
Pen 8 No crabs	B.-18 W.-76	Brown Range-76-130 Av.-114.33 White Range-50-125 Av.-88.21	B. W.	8 8.4	B-17 W-21 (N.H.)		B-1 W-55 (D.H.)						Large-2 Small-5
Pen 9 No Crabs	B.-7 W.-418	Brown Range-69-118 Av.-90.11 White Range-60-100 Av.-84.34	B. W.-3	1.5 12.4	B-2 W-190 (N.H.)		B-3 W-183 (D.H.)			B-2 W-42 (D.H.)		B-0 W-3 (D.H.)	Large-21 Small-32

B.--Brown Shrimp
W.--White Shrimp

N.H.--Night Harvest
D.H.--Day Harvest

Chart II

1970 Experiment No. 1A (Blue Crab Predation	Stocking Dates	Harvest Dates	No. Days in Study	Size of Shrimp at Harvest mm	Av. Size at stocking mm	Growth per day mm	Count per Lb. Heads-On	H_2O Temp. Range OC	Av. Sal. PPT
Pen 1	8-27-70	10-14-70	48	Brown R-86-102 Av-98.33	90.7	0.2	64.2	Min 20.0 to 31.0 Max 23.0 to 34.5	6.65
				White R-43-119 Av-91.48	72.1	0.4	84.0		
Pen 1	8-27-70	11-13-70	78	Brown R-91-108 Av-99.37	90.7	0.1	58.6	Min 13.0 to 31.0 Max 18.0 to 34.5	7.20
				White R-60-118 Av-92.20	72.1	0.3	91.0		
Pen 1	8-27-70	12-4-70	99	Brown R-0 Av-0	--	--	--	Min 5.0 to 31.0 Max 8.0 to 34.5	7.20
				White R-50-103 Av-74.26	72.1	0.02	160.0		
Pen 3	8-20-70	10-30-70	71	Brown R-91-105 Av-96.60	87.9	0.1	80.0	Min 19.5 to 31.0 Max 22.5 to 34.5	7.20
				White R-90-118 Av-104.52	81.6	0.3	50.5		
Pen 3	8-20-70	11-2-70	74	Brown R-104-108 Av-106.0	87.9	0.2	48	Min 19.5 to 31.0 Max 22.5 to 34.5	7.20
				White R-90-124 Av-104.92	81.6	0.3	52		
Pen 3	8-20-70	11-30-70	102	Brown-0	---	---	---	Min 5.0 to 31.0 Max 8.0 to 34.5	7.20
				White R-68-108 Av-93.25	81.6	0.1	76		

Chart II

1970 Experiment No. 1A Blue Crab Predation	Stocking Dates	Harvest Dates	No. Days in study	Size of Shrimp at Harvest (mm)	Growth per day (mm)	Count per Lb. Heads-On	Av. Size at Stocking (mm)	H_2O Temp Range °C	Av. Sal. PPT
Pen 4	8-31-70	10-14-70	44	Brown R-83-120 Av-103.37	0.4	51.2	87.0	Min 20.0 to 31.0 Max 23.0 to 34.5	6.65
				White R-60-120 Av-94.48	0.4	83.2	77.1		
Pen 4	8-31-70	11-13-70	74	Brown R-69-110 Av-89.45	0.03	85.0	87.0	Min 13.0 to 31.0 Max 18.0 to 34.5	7.20
				White R-60-121 Av-91.16	0.2	83.0	77.1		
Pen 4	8-31-70	12-4-70	95	Brown - 0	--	--	--	Min 5.0 to 31.0 Max 8.0 to 34.5	7.20
				White R-55-104 Av-69.77	-9.02	202.0	77.1		
Pen 6	8-25-70	10-30-70	66	Brown R-80-87 Av-83.50	-9.85	108.0	84.14	Min 19.5 to 31.0 Max 22.5 to 34.5	7.20
				White R-88-108 Av-97.07	0.5	70.0	61.44		
Pen 6	8-25-70	11-2-70	69	Brown R-76-101 Av-87.0	0.04	96.0	84.14	Min 19.5 to 31.0 Max 22.5 to 34.5	7.20
				White R-59-101 Av-91.6	0.4	83.0	61.44		
Pen 6	8-25-70	11-30-70	97	Brown-0	--	--	--	Min 5.0 to 31.0 Max 8.0 to 34.5	7.20
				White R-75-99 Av-88.5	0.3	91.0	61.44		

Chart II

1970 Experiment No. 1A Blue Crab Predation	Stocking Dates	Harvest Dates	No. Days in Study	Size of Shrimp at Harvest mm	Av. Size at Stocking mm	Growth per day mm	Count per Lb. Heads-On	H_2O Temp. Range °C	Av. Sal. PPT
Pen 7	9-1-70	10-14-70	43	Brown R-86-107 Av-95.77	76.6	0.4	75.6	Min 20.0 to 31.0 Max 23.0 to 34.5	6.65
				White R-76-98 Av-87.92	63.3	0.6	86.0		
Pen 7	9-1-70	11-13-70	73	Brown R-80-102 Av-89.42	76.6	0.2	85.0	Min 13.0 to 31.0 Max 18.0 to 34.5	7.20
				White R-79-96 Av-87.04	63.3	0.3	93.0		
Pen 9	8-26-70	10-22-70	57	Brown R-69-112 Av-90.5	84.84	0.1	83.0	Min 19.5 to 31.0 Max 22.5 to 34.5	6.65
				White R-61-99 Av-85.96	66.7	0.3	95.0		
Pen 9	8-26-70	10-30-70	65	Brown R-73-90 Av-83.33	84.84	-9.87	108.0	Min 19.5 to 31.0 Max 22.5 to 34.5	7.20
				White R-66-100 Av-86.08	66.7	0.3	94.0		
Pen 9	8-26-70	11-2-70	68	Brown R-75-118 Av-96.5	84.84	0.2	75.0	Min 19.5 to 31.0 Max 22.5 to 34.5	7.20
				White R-60-97 Av-84.0	66.7	0.3	103.4		
Pen 9	8-26-70	11-30-70	96	Brown-0	--	---	---	Min 5.0 to 31.0 Max 8.0 to 34.5	7.20
				White R-69-97 Av-81.33	66.7	0.2	114.0		

1971 Page I

periment No. 1 lue Crab edation)	Date Stocked B. Shrimp	Size of Enclosures	Stocking Rates B. Shrimp	Size at Stocking B. Shrimp mm	Date Stocked Blue Crabs	Stocking Rates Blue Crabs	Size at Stocking Blue Crabs
n 1	5-11-71	50'x50'	500	Range-41-95 Av-75.3	5/18&19/71	35	Range-61-89 Av-75.6
n 2	5-14-71	50'x45'	500	Range-41-100 Av-70.5	5/19&20/71	35	Range-52-92 Av-66.9
n 3	5-14-71	50'x50'	500	Range-41-95 Av-75.1	5/18&19/71	50(H)	Range-25-49 Av-34.6
						25(P)	Range-41-60 Av-50.2
n 6	5-14-71	50'x50'	500	Range-41-100 Av-73.2	5/18,19& 20/71	50(H)	Range-30-50 Av-39.3
						25(P)	Range 34-73 Av-52.9
n 4	5-11-71	50'x50'	500	Range-41-100 Av-79.2	No	Crabs	Stocked
n 7 rsh Pen)	5-12-71	50'x50'	500	Range-46-100 Av-72.6	No	Crabs	Stocked
n 8 arsh Pen)	5-13-71	50'x45'	500	Range 36-95 Av.65.5	5/17/71	25	Range-140-182 Av-158.8
n 5	5-13-71	50'x45'	500	Range-36-95 Av-68.8	5/17/71	25	Range-133-175 Av-142.1
n 9 arsh Control en)	-----	50'x50'	0	------	-----	0	------

ige II
.periment No. 1

ırvest ıtes	No. Days in Study	No. Shrimp Harvested	Size of Shrimp Harvested mm	Count per Lb. Heads-on	Lbs. B. Shrimp Harvested Lbs.	Oz.	Growth per day B. Shrimp mm	No. Shrimp Harvested per Seine 1st	2nd	3rd	4th
								No. of Seining			
'en 1 -20-71	40	451	Range-102-129 Av-117.8	33	14	2	1.1	243	128	64	16
'en 2 -20-71	37	474	Range-93-124 Av-108.1	43	11	2	1.0	357	76	27	14
'en 3 -20-71	37	387	Range-102-130 Av-116.1	35.5	11	0	1.1	241	75	35	36
'en 6 -20-71	37	395	Range-85-125 Av-111.1	40.5	10	0	1.0	146	85	101	63
'en 4 -20-71	40	407	Range-94-132 Av-116.5	33	12	3	0.9	242	92	61	12
'en 7 -20-71	39	66	Range-103-125 Av-112.9	36	1	12	1.0	52	13	1	0
en 8 -20-71	38	3	Range-94-105 Av-99.3	---	---	---	0.9	2	1	---	---
en 5 -20-71	38	449	Range-92-117 Av-107.3	46	10	8	1.0	349	88	9	3
en 9 -20-71	---	20	Range-67-122 Av.-90.4	---	---	--	---	12	3	2	3

No. Crabs Harvested	Size of Blue Crabs Harvested		H_2O Temp. Range °C	Salinity Range (PPT)
Pen 1 30	Range-39-148 Av.-90.1		Min. 23.5 to	21.06 to
Pen 2 19	Range-30-107 Av.-79.5		29.0	26.56
Pen 3 33(H) 8(P)	Range-21-158 Range-45-70	Av.-67.6 Av.-58.0	Max.28.0 to	Av.-23.81
Pen 6 13(H) 11(P)	Range-43-101 Range-40-64	Av.-60.3 Av.-53.8	32.5	
Pen 4 14	Range-43-138 Av.-98.6			
Pen 7 33	Range-31-164 Av.-94.8			
Pen 8 65	Range-143-177 Av.-157.9	*Range-38-82 Av.-64.5		
Pen 5 35	Range-44-177 Av.-109.1			
Pen 9 32	Range-38-133 Av.-80.0			

*A small hole was located in this pen causing an influx of small crabs.

1971

:periment No. 2 ılue Crab :edation)	Date Stocked B. Shrimp	Size of Enclosures	Stocking Rates B. Shrimp	Size at Stocking B. Shrimp mm	Date Stocked Blue Crabs	Stocking Rates Blue Crabs	Size at Stocking Blue Crabs mm
n 1	6-29-71	50'x50'	500	Range-41-90 Av-75.9	6-30-71	35	Range=64-95 Av-77.1
n 2	7-5-71	50'x45'	500	Range-51-90 Av-79.8	7-6-71	35	Range64-89 Av-73.3
n 3	7-1-71	50'x50'	500	Range-46-90	7-6-71	50(H)	Range-25-61 Av-49.6
				Av-74.9	7-6-71	25(P)	Range-44-80 Av-59.2
n 6	7-1-71	50'x50'	500	Range-51-90	7-7-71	50(H)	Range-31-61 Av-49.5
				Av-76.5	7-7-71	25(P)	Range-40-75 Av-56.9
n 4	7-5-71	50'x50'	500	Range-46-90 Av-78.9	No	Crabs	Stocked
arsh) n 7	7-5-71	50'x50'	500	Range-61-90 Av-80.9	No	Crabs	Stocked
arsh) n 8	7-7-71	50'x45'	500	Range-61-91 Av-79.2	6-30-71	25	Range-133-163 Av-146.9
n 5	7-7-71	50'x45'	500	Range-56-90 Av-77.5	6-30-71	25	Range-127-185 Av-146.7
rsh) n 9 ontrol)	---	50'x50'	0	---	---	-0-	---

ge II

periment No. 2

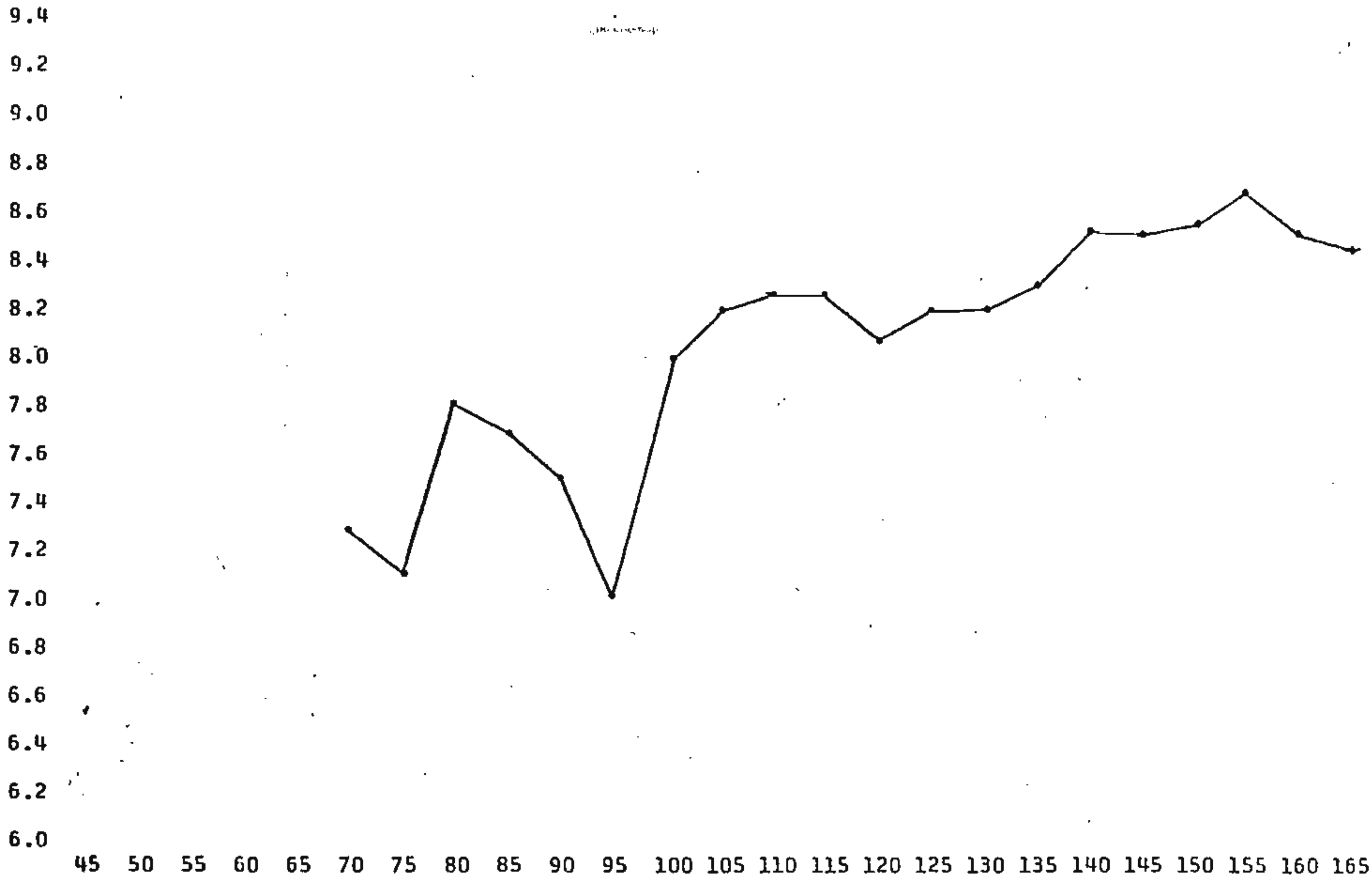
rvest tes	No. Days in Study	No. Shrimp Harvested	Size of Shrimp Harvested mm	Count per Lb. Heads-on	Lbs. B. Shrimp Harvested Lb.	Oz.	Growth per day mm	No. Shrimp Harvested per Seine 1st	2nd	3rd	4th
								No. of Seining			
Pen 1 -29-71	30	455	Range-89-107 Av-98.7	54.6	8-4		0.8	410	33	9	3
Pen 2 -29-71	24	467	Range-85-112 Av-101.0	53.4	8	13	0.9	367	76	16	8
Pen 3 -2-71	32	497	Range-86-114 Av-101.9	57.6	8	11	0.8	414	54	20	9
Pen 6 -2-71	30	388	Range-87-109 Av-97.4	57.4	6	12	0.7	233	102	47	6
Pen 4 -4-71	30	412	Range-87-109 Av-97.5	57.8	7	2	0.6	302	88	16	6
Pen 7 -4-71	30	197	Range-78-103 Av-93.3	65	2	15	0.4	129	60	7	1
Pen 8 -5-71	29	83	Range 79-105 Av-93.1	66	1	4	0.5	62	14	4	3
Pen 5 -5-71	29	435	Range-90-108 Av-98.4	54	8	2	0.7	322	77	22	14
Pen 9 -5-71	0	31	Range-95-124 Av-105.96		0	11	-	20	9	2	0

Page III
Experiment No. 2

No. Crabs Harvested	Size of Blue Crabs Harvested mm	H_2O Temp. Range °C	Salinity Range (PPT)
Pen 1 19	Range-30-145 Av.-82.4		Range 6.65 to
Pen 2 17	Range-30-113 Av.-83.8	Range- Min-26.5 to 30.5	23.26
Pen 3 28 = 26(H)+2(P)	Range-40-162 Av.-75.9	Range Max.- 28.5 to 33.0	Av.-16.08
Pen 6 20=17(H)+3(P)	Range-40-150 Av.-65.8		
Pen 4 6	Range-45-156 Av.-98.2		
Pen 7 4	Range-100-125 Av.-114.5		
Pen 8 27	Range-62-163 Av.-131.7		
Pen 5 13	Range-55-169 Av.-119.7		
Pen 9 24	Range-35-131 Av.-66.9		

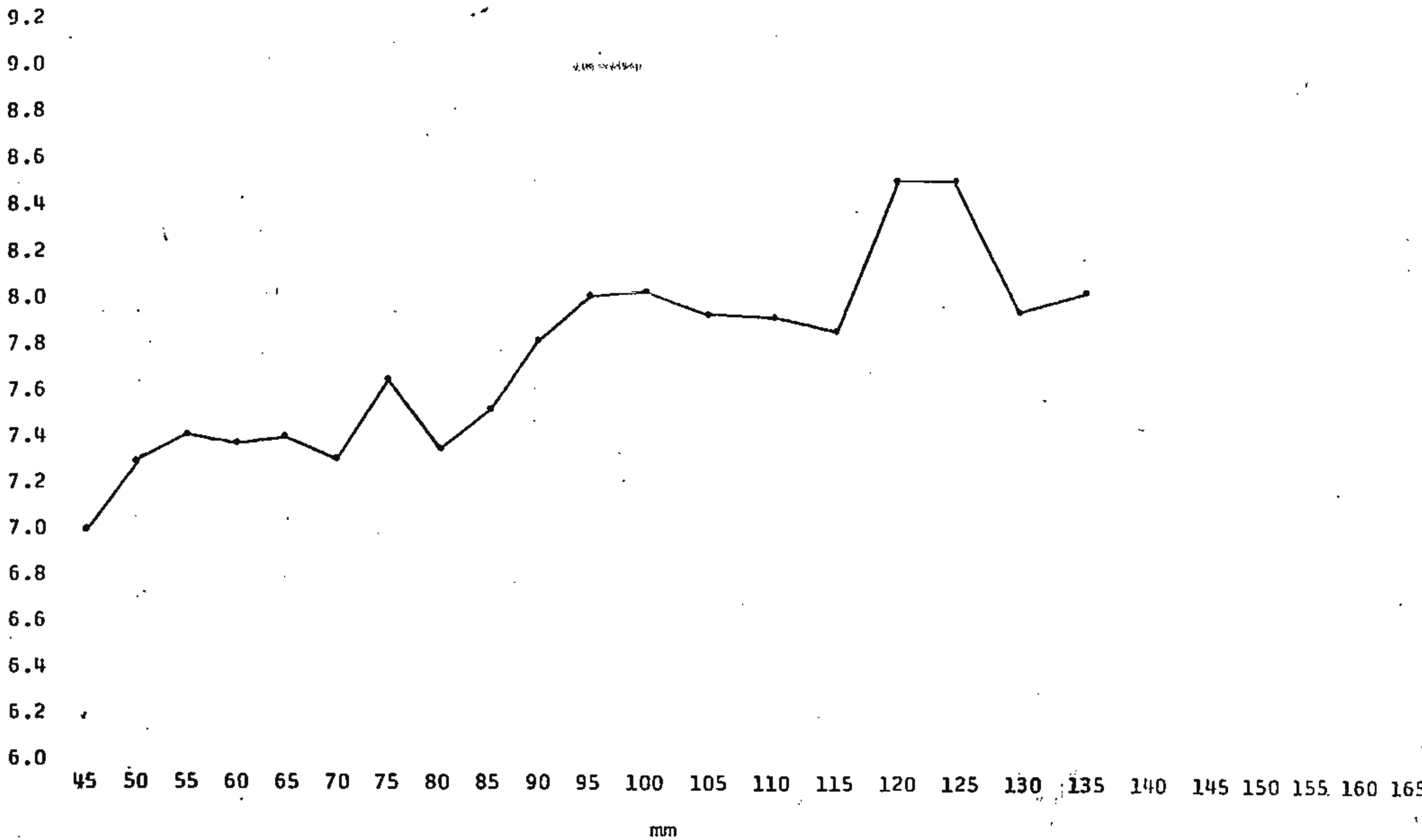
(H) - Unparasitized
(P) - Parasitized

K Value
Wild Texas Brown Shrimp - Galveston Bay - 1960*



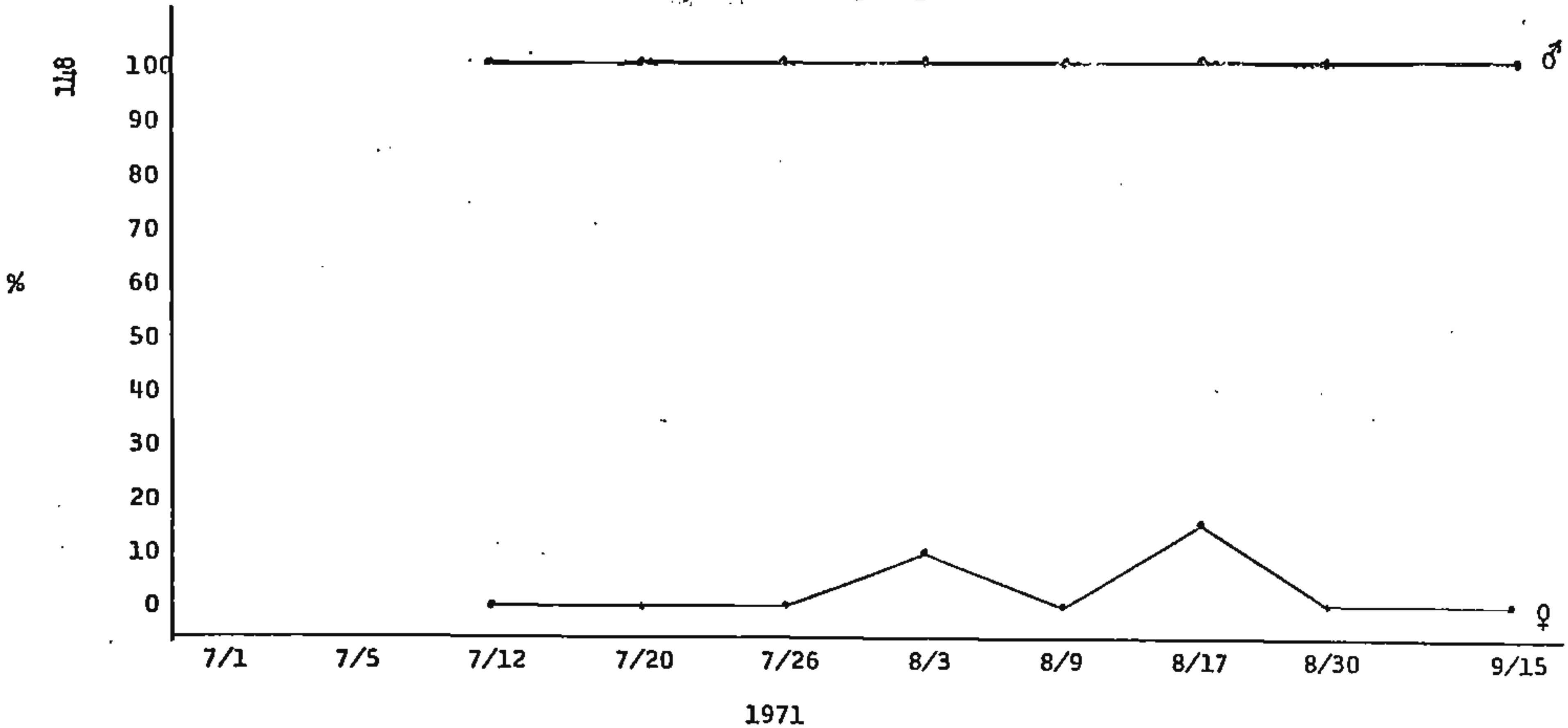
*Converted from Chin, Edward. 1960.

K Value vs. MM Length
La. Wild Brown Shrimp - Jean Lacrox Bayou & Lake Chein 6/1-2/71



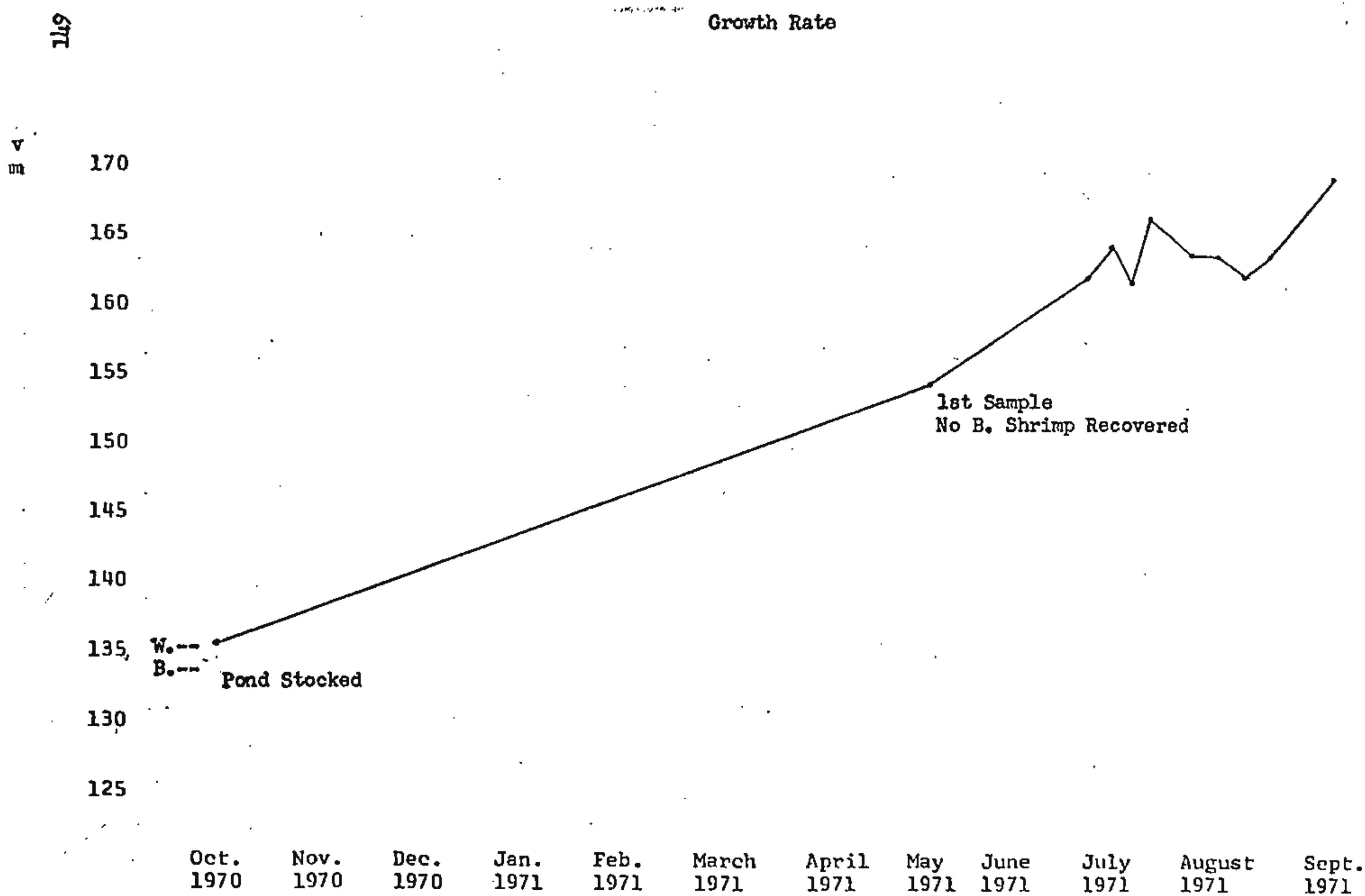
% Male and Female White Shrimp - showing Gonad and Ovary

Development Deep Right Pond - 1971



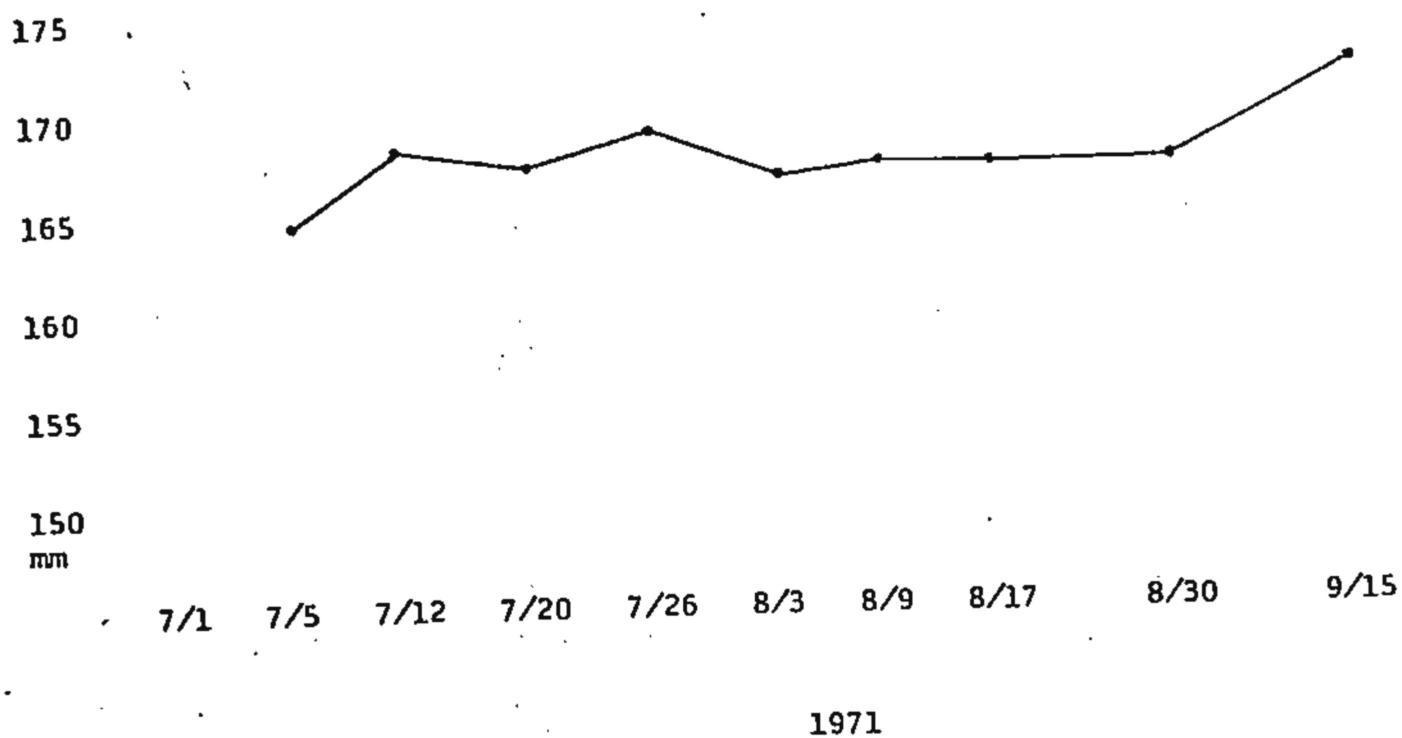
1970 - Pond Stocked - 100 White Shrimp
50 Brown Shrimp

Deep Right Pond Study of Over-Winter Brown and White Shrimp.



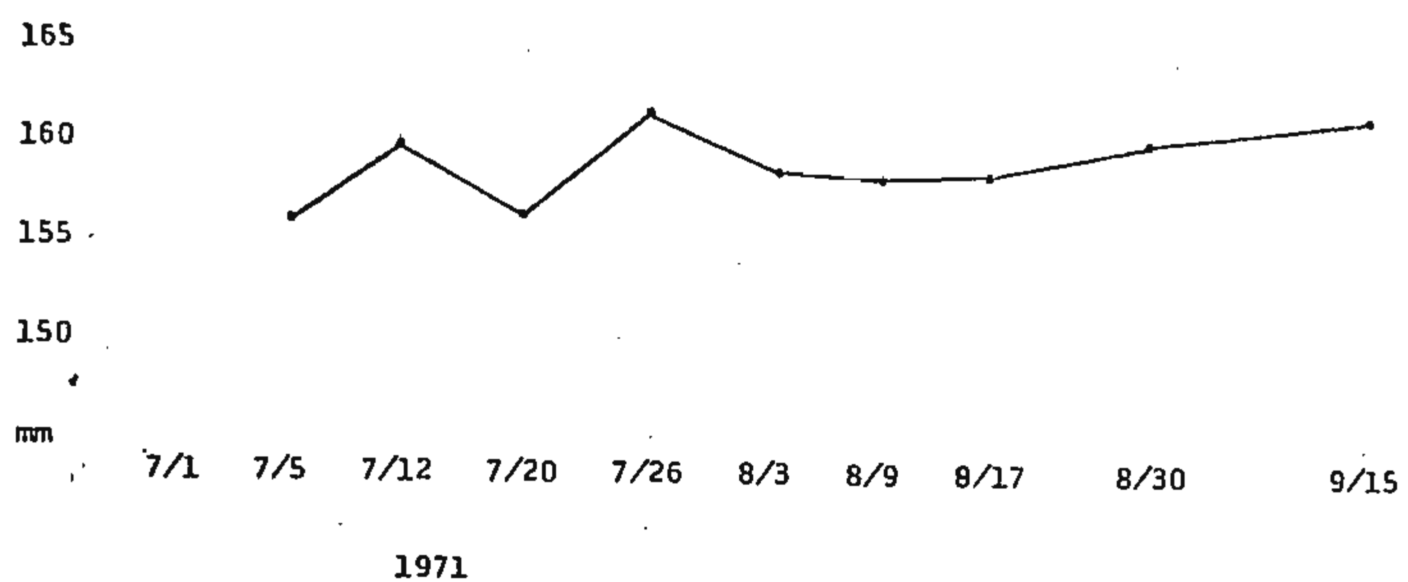
♀ White Shrimp - Deep Right Pond - 1971 Study

Growth Rate



♂ White Shrimp - Deep Right Pond - 1971
Study

Growth Rate



APPENDIX

25 March 1971

Mr. Robert Wildman
National Sea Grant Program
National Oceanic and Atmospheric Administration
U. S. Department of Commerce
Rockville, Maryland 20852

Dear Bob:

My expectations were accurate. I have been forced to resign from my position at Nicholls State University for non-academic reasons. I will let you know more of the details later. Other faculty members, students, and myself are presenting formal complaints to AAUP.

Alva and I have agreed that I will assume full responsibility for publishing results of the 1968-69 investigation. Publication will be in the Transactions of the American Fisheries Society. I am planning to submit a popularized version to the American Fish Farmer. We have also agreed that he will assume full responsibility for publishing the 1970-71 results, and, in addition will have full responsibility for the planning of the 1971 research. I have suggested that the 1971 research be conducted according to guidelines established in the original proposal. I believe it would also be wise to continue determining chlorophyll A levels in impoundment and bayou waters (Measurement of this parameter was not indicated in the original proposal.). Alva will, of course, have full accountability for fiscal matters after 25 May 1971. Alva will acknowledge by letter agreement with the above divisions of responsibilities.

Will try to get up and see you this summer. Heard of any hot jobs?

Cordially,

C. D. Rose, Associate Professor
Division of Marine Science

dab

cc: Gerald Voisin
Louisiana Land & Exploration Company

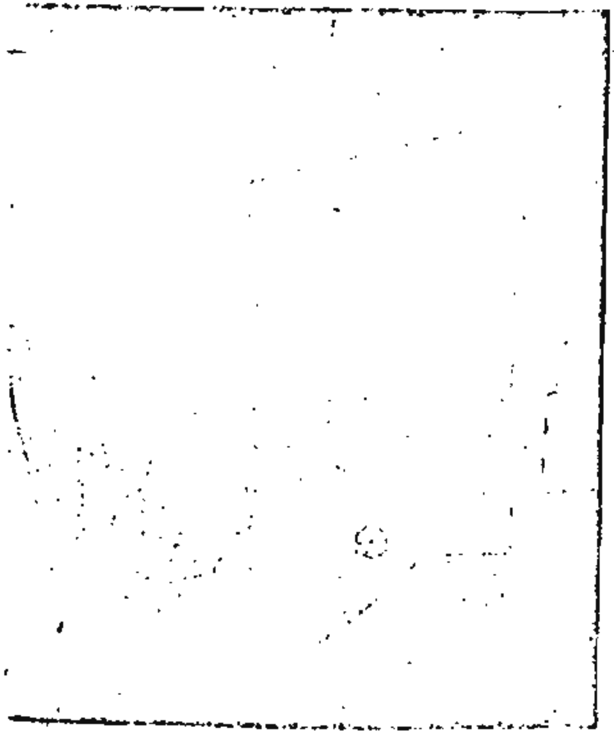
(239)

Penaeid Shrimp Production in a Managed, Unfed, Natural Pond in South Louisiana

ALVA H. HARRIS AND CURT D. ROSE
Nicholls State College

Water control in a 20-acre salt-marsh natural pond was effected by erection of earthen dikes. A weir was constructed to allow tidal flow. Ingressing post-larval shrimp were stocked utilizing night-time flood tides. Screening through hardware cloth prevented entrance of large shrimp and predators. Predator control was exercised by rotenone applications for fish and baited wire traps for crabs. The blue crab, *Callinectes sapidus*, was the most abundant predator and proved uncontrollable with traps. Supplemental food was not added. Brown shrimp, *Penaeus aztecus*, grew to 34-count (heads-on) in 75 days and 12-count in 200 days. White shrimp, *Penaeus setiferus*, reached 34-count in 60 days. Harvesting consisted of draining surface water at night across the weir into a net. Water level dropped no more than 2 inches during any harvest period, and was maintained by day-time flooding. Approximately 70% of the crop was harvested during the first 20 hours of draining. Total harvest was 125 lb. of shrimp per acre. (Supported in part by Sea Grant Program of NSF.)

Reprinted from *The ASB Bulletin*,
Vol. 17, No. 2, April 1970, p. 46.



'GHT ABOUT HERE" — Dr. Alva Harris, NSU fessor and director of the university's experimental ımp farm located in the marshlands of Pointe-Aux-nes, points to the location of a weir in the farm's 20- pond. Instrumental in harvesting the shrimp crop ing the ebb tide, Dr. Harris says that a second weir also been constructed in a larger 40-acre salt marsh undment. The shrimp farm will celebrate its h year of existence in February, at which time the biol[illegible] says the experimental program will inate [illegible]tivities. (Staff Photo)

Farming at Pointe-aux-Chenes

Shrimp Study Ends in February

By LOUISE BADEAUX

Come February, activity will slow down some in the marshlands of Pointe-Aux-Chenes, when the Nicholls State University biology department terminates a four-year experimental shrimp farm program.

The program, authored by Dr. Alva E. Harris, NSU associate professor, biology department, and former NSU biology professor Dr. Curtis Rose, is part of the Sea Grant Program sponsored by the National Oceanic and Atmospheric Administration of the United States Department of Commerce.

Program director Dr. Harris explained that the Sea Grant Program supplies the cash support of the NSU program. In the past two years, Dr. Harris said the experimental farm has received $96,000.

The marine biologist added that the Louisiana Land and Exploration Company, located in Houma, has furnished the university with the equipment, materials, and land necessary for the shrimp farm.

Included is the use of a camp which Dr. Harris says has been located in the Pointe-Aux-Chenes marshlands for years. Dr. Harris said the ca

provides living quarters for farm personnel, laboratory facilities, a full-time cook, a boat operator, as the camp may only be reached by water, electricity and a telephone.

NSU biology major Danny Kraemer, a native of Raceland, works at the shrimp farm site on a full-time basis during the week, and receives relief on weekends, Dr. Harris stated.

The farm needs continuous attention, the program director said, explaining that continuous checks must be made on high tides, the oxidation level of the farm ponds, and any possible poachers.

Burt Wilson and Dr. Robert Falgout, both members of the biology department at NSU are also involved with the experimental work of the shrimp farm, Dr. Harris stated, and marine biology majors from the university are also assisting with the work of the experimental farm.

Two natural ponds or impoundments have been set up in the area, Harris said, enclosed with dykes and equipped with water-control structures or weirs. Each pond is half water and half marsh, one measuring 40 acres and the other 20.

Parasitologist Harris spoke of the latest experiments conducted, explaining that the NSU research team utilized the 20-acre pond by sectioning off two 2½ acre ponds side by side.

The water was allowed to flow in one pond while the water flow in the second was stymied. Dr. Harris said that so far, no difference in the production of the shrimp has been detected in either impoundment.

In a second and more recent experiment, Dr. Harris and his team undertook a study of the effects of water exchange and blue crab control on the shrimp production in Louisiana salt-marsh impoundments.

For this experiment, Dr. Harris explained that pens of vinyl-coated wire were constructed within the larger or 40-acre impoundment to facilitate the study. Each pen, measuring 50' x 50', was stocked with juvenile shrimp and blue crabs for 30 day periods, Dr. Harris said. Harris said that following a 30-day stocking, the shrimp showed no increase in mortality of those pens stocked with crabs than those pens which had no crabs added.

The program director said conclusions drawn from the crab experiment show that the blue crab may not be as serious a predator as previously suspected. "Every one has always assumed the blue crab to be a predator", Dr. Harris stated, "but no one has ever tried to find out exactly what effect the crab has on shrimp. The crab has always been the control factor." Harris said the reason most shrimpers feel the crab is a threat to shrimp is because they see the crab eating shrimp in the trawl net. "In an open system where shrimp can escape, there seems to be no effect", the biologist reported.

In a third recent experiment, the NSU biology professor said his research team discovered that white shrimp can be successfully over-wintered. Harris explained further that the white shrimp can be stocked as early as September, October and November and ready for harvest in the spring.

At the present time, Harris said farm personnel are collecting evidence that indicates the white shrimp might possibly spawn within the estuary on that area of salt water located between fresh water and the gulf.

Within the first two years of the program, Dr. Harris said shrimp had "pretty [illegible] [illegible]

FOUR

(Continued From Page One)

flounder, and redfish in the farm's 40-acre impoundment, as they performed experiments using rotenona, a chemical which Harris says kills fish without endangering shrimp or crabs.

The team also attempted to control the blue crab, but was unable to successfully remove the crab from the shrimp pond area, the professor reported.

The larger pond with predator control yielded a harvest of 125 pounds per acre at ebb tide, with 34 count shrimp, Dr. Harris said, while the 20-acre pond, in which no predator control was exercised, yielded a harvest of 44 pounds per acre with 70 count shrimp.

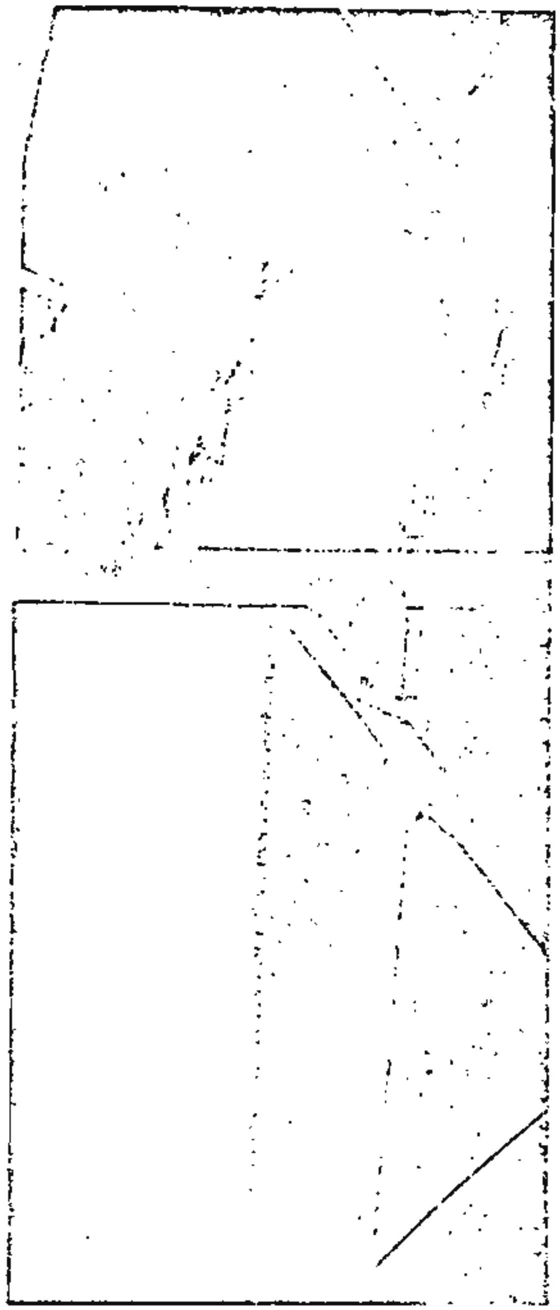
Dr. Harris said this experiment proved that greater shrimp production can be achieved by managing ponds in the marsh. "There's a catch to this", Harris said, "that prevents managing from becoming commercially feasible". Harris went on to say that the cost of managing the shrimp in the proposed manner would surpass the profit from shrimp yield. For the management process to work, Harris said the shrimper would have to produce a crop that could yield at least 500 pounds per acre.

Dr. Harris stated that "information obtained by the experiments will ultimately be employed when enough knowledge about shrimp farming has been obtained to make the venture economically feasible." The NSU professor continued, "Other states are conducting similar studies. It will take pooling of everyone's results over a long period of research to make shrimp farming an actuality. The main problem at present that researchers are faced with is dependence upon wild shrimp larva for experiments."

Dr. Harris, continuing on the same trend of thought, said shrimp hatcheries are being developed and citing examples in Texas and Florida, but claimed that these have not developed to the stage that they can supply the needs of experimenters and beyond this, the needs of commercial shrimp farmers. Harris, who has employed the use of both wild and hatched shrimp larva in his farm experiments, said the wild shrimp have already adapted to their surroundings, while shrimp from the hatchery have difficulty adjusting. Dr. Harris claims he has never had "successful stocking from hatchery shrimp".

Author of the shrimp farm project, Harris has been with the Sea Grant Program since its beginning four years ago. Prior to joining the NSU staff, he received a fellowship at North Carolina State University.

Harris said he has a commercial background, as he once owned and operated a shrimp and oyster boat in his native North Carolina and fished commercially for salmon in



SHRIMP FARM WEIR — To the left is a photo taken of a weir installed in a 20-acre salt marsh impoundment and part of an experimental farm program behind conducted by Nicholls State University in the marshlands of Pointe-Aux-Chenes. The photo to the right, shot at a slightly different angle, shows the same weir used on the NSU shrimp farm after the screen was removed and a wing net put in its place. The weir and net both serve to help with the harvest of the shrimp crop. (Photo Courtesy NSU Biology Dept.)

...is said that final con...ns on the four-year ...m will be available at the ...ation of the NSU project ...ruary.

...Is noted that LSU was ...ting a similar program ...e NSU experimental site, ...ld "a concentrated effort ...ing made not to duplicate ...o studies". Harris also ...nt any inf... ...from the p... [illegible]