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THE DISTRIBUTION OF CTENOPHORA IN THE PATUXENT ESTUARY DURING THE SUMMER OF 1958

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By

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Introduction

Ctenophora have received perhaps less attention and study than any other phylum. There have been several extensive works concerning Ctenophores, such as Mayer's (1912) Ctenophores of the Atlantic Coast of North America; however, publications are relatively few and far between. Nothing could be located in the literature dealing with the subject of this study, namely, the distribution and abundance of Ctenophores in an estuary. Therefore, any investigation that is carried out on this phylum will be of value.

One possible reason for the lack of study is that their biological importance has not been and is not being fully realized. They constitute a major consumer of zooplankton and phytoplankton. In fact, according to Nelson (1925), the relative amounts of some forms of plankton are "to some extent correlated" with the abundance of the Ctenophores in the plankton. An example of their economic importance is their predation upon oyster larvae, which is of special interest to the Chesapeake Bay region.

The entire investigation of Ctenophores in the Chesapeake Bay area, of which this study is a part, will include some aspects of their life history, growth, reproduction, feeding and food habits, abundance and distribution, plus other aspects of their biology which will probably be added to the program later. The purpose of the entire project is to supplement and add to the biological knowledge and understanding of Ctenophores as a group and of the several individual species found in the area to be studied. That part or phase of the project with which this report is concerned deals with the abundance, distribution and size range of Ctenophores in the Patuxent River estuary of the Chesapeake Bay, the possible factors involved, and implications which can be drawn from the observations.

According to Mayer (1912), three species of Ctenophores are found in the Chesapeake Bay: Beroe ovata, Mnemiopsis gardeni and Mnemiopsis leidyi. Thus far in the collections of this summer, no specimens of Beroe ovata have been observed. Separation of the two species of Mnemiopsis was very difficult partly because the specimens are very delicate and easily damaged and partly because of the apparently unsatisfactory systematics in the genus. Mayer (1912) gives the following distinguishing features between the two species:

1/ Conducted field work, summarized data, and presented summary upon which this paper is based.

2/ Suggested problem, provided general supervision of field work, analysis, and presentation.

M. leidyi	M. gardeni
1. Up to 100 mm. in length when mature.	1. 35-40 mm. in length when mature.
2. Large, widely flaring oral lobes.	2. Oral lobes small, one-sixth to one-fifth of the length of the body.
3. Pinkish hue.	3. Bluish hue.
4. No discoidal warts on oral lobes.	4. Discoidal warts on oral lobes.

A large number of the specimens which were observed either did not conform to the above characteristics or displayed an intermediate condition. For example, many individuals possessed large flaring oral lobes and a bluish or purplish hue. Others which also had the large oral lobes were covered with discoidal warts on the entire body, including the oral lobes. Still others which were large in size (50-60 mm.) possessed small oral lobes. Only two specimens were seen which possessed all of the above-named features for M. gardeni. The majority conformed to the description of M. leidyi. Therefore, there appears to be considerable variation and overlapping of the two species and these characteristics do not seem to provide a satisfactory distinction between them. The above-mentioned observations were merely field observations and further study must be made to determine the validity of Mayer's separation. Mayer states further that "M. leidyi is a creature of the pure sea water along the outer shores, while M. gardeni thrives in protected bays and brackish waters". This is definitely in error as far as M. leidyi is concerned. Throughout this report only the term Mnemiopsis will be employed which will refer to M. leidyi.

In reference to previous reports of the distribution and abundance of Mnemiopsis, Mayer (1912) states that its range extends from Vinyard Sound to South Carolina. Nelson (1925) cites several accounts in which it was reported to have occurred in "great rafts" or "myriads" off the coast of New Jersey, Rhode Island and Woods Hole in some years. In other years it was very rare.

Procedure

Sampling was carried out by making weekly field trips up the Patuxent River, which is characterized by a decreasing salinity gradient. Seven stations were established at which samples were taken. These stations were:

1. The Chesapeake Biological Laboratory pier.
2. Town Point.
3. Broome's Island.
4. The Patuxent River Bridge at Benedict.
5. The mouth of Hunting Creek.
6. Deep Landing.
7. The mouth of Black Swamp Creek.
8. Lower Marlboro (if needed).

Collections were made two stations beyond where the last Ctenophore was taken. At each station, fifteen minute bottom and surface tows were taken. The towing time was later decreased to ten minutes because of the very large numbers of animals that were being caught. Large meshed plankton nets were employed in sampling. Several weights were attached to the rope about a foot above one of the nets so that it would remain on the bottom while being towed. The nets were thirty centimeters in diameter and the estimated flow of water through the net during a fifteen minute tow was not more than approximately 44 cubic meters. During a ten minute tow the flow was about 29 cubic meters.

Each specimen that was collected was measured to the nearest half centimeter for total length. Measurements were made in a white enamel pan. The temperature was noted at each station with a reversible thermometer for the bottom and surface. The general weather conditions, wind direction and velocity, and the turbidity and roughness of the water were also recorded for each station. Bottom and surface water samples were taken and the salinity was determined in the laboratory by the hydrometer method.

Of the greatest importance in any abundance and distribution study is the reliability of the sampling technique; that is, is it taking a representative sample from the population? A special trip was made to the Severn River for the purpose of testing the method being used. This was carried out as follows: Nine stations were chosen on what was originally planned to be on the basis of a salinity gradient. The salinities were determined in the field by the hydrometer. This showed that there was so much variation that the original plan had to be disregarded. Bottom tows were made at each station in the form of three circles of approximately the same size. One tow consisted of three circles and three tows were made at each station for the purpose of replication. The animals from each tow were measured to the nearest half centimeter and recorded. The temperature was also taken at each station. The results were graphed and statistical tests were calculated. Figure I shows the mean length and standard deviation of the catch of each tow and station. There does not appear to be a significant variation between any of the means, although this has not been tested mathematically. The means lie between two and three centimeters. Those animals collected in the downstream stations seem to be slightly larger than those upstream. The indication derived from this is that the same population was being sampled at all stations. The results of the replication of the tows suggests that the sampling method provides a reasonably accurate picture of the size of animals in the population from which it is sampling. Assuming that the total number of animals obtained at each station represents the true size frequency range of the population at that station, it can be seen that the means of each tow are quite close to that of the station. This is especially apparent where the sample from a single tow consisted of one hundred or more individuals. A further indication of this observation is Figure II, which shows the size distribution of all the animals collected in the Severn River and that of each tow in which the sample numbered one hundred or greater.

It is not known whether or not the sampling technique gave an accurate picture of the abundance of *Mnemiopsis*. The tows made in the Patuxent River were made in a single straight line. Perhaps a series of short tows or tows made in a circle over the same amount of time would be better.

There are several persons who deserve credit and thanks for their part in this study, including Miss Charlotte Mangum, Mr. Curtis Allen, Mr. William E. Rogers, Dr. R. J. Muncy, and especially Dr. Ruth Griffith, who provided invaluable assistance in organizing the field work and regularly participated in the field operation during most of the summer.

Results

The following are the results produced by eleven weeks of sampling during the summer of 1958:

1. The distribution and abundance of *Mnemiopsis* were quite irregular. This condition was especially evident in the Severn River sampling. The animals appeared to be concentrated in some areas and sparse in other areas only a few hundred yards away. Figure I shows the catch by tow and by station. The numbers of specimens obtained in the three tows at each station were, for the most part, quite uniform. However, there was a large difference between stations. At the most downstream station (I), a large catch was taken. Considerably fewer animals were obtained from the next three stations (II, III and IV), with a large amount of variation among these three. Sampling at the next station (V) resulted in a large catch. The size distribution, on the other hand, was remarkably uniform in the Severn River, as previously indicated. This was quite different from the situation found in the Patuxent River, which will be discussed later in this report.

   This irregularity in abundance and distribution could be seen in the Patuxent River also (Figures III and XII). There was considerable variation at the same station from week to week even though the changes in the salinity and temperature appeared to be minor.

   Another observation of this irregularity was made in front of the Chesapeake Biological Laboratory where specimens were being collected for a salinity tolerance experiment. The tide was flooding and there was a fairly rapid flow of water. A great many *Mnemiopsis* were observed approximately ten to fifteen feet from shore in about two and one-half feet of water. They appeared in a strip five to ten feet wide, moving with the current. Farther out from shore, only an occasional one could be seen.

2. Generally, the larger *Mnemiopsis* were found in higher salinity water and the smaller ones in lower salinity water. This is shown on Figure XIII. The size range was arbitrarily divided on the basis of early samples into two parts, small, up to three centimeters in length, and large, three and one-half centimeters and larger. Figure XIV shows a "typical" catch at an upstream and downstream station during July. Very few of the large individuals were taken below a salinity of 7.0 parts per thousand, whereas the smaller animals were observed down to a salinity of 4.3 parts per thousand. The smaller *Mnemiopsis* were found at the downstream stations, including the Laboratory Wharf and Town Point, in considerable numbers in two succeeding weeks. However, they appeared to be concentrated in the area of the Patuxent River Bridge at Benedict where the salinity ranged between 5.0 and 7.0 parts per thousand throughout most of the summer. The smaller animals were by far more numerous than the larger ones.

3. No pattern of abundance as related to temperature could be found. The complete temperature range in which *Mnemiopsis* was observed during this summer extended from 21.7° C. to 28.8° C. with a general gradual rise throughout most of the summer. There was a rather sharp decrease in temperature noticed the last week of sampling. Other than this, there was little weekly variation. As can be observed in Figures III and VII, apparently no variation in abundance can be attributed to temperature.

4. With regard to salinity, no pattern of abundance of Mnemiopsis could be found as related to variation in salinity except the coincidence of low salinity and the lack of animals. As previously stated, the lowest salinity in which Mnemiopsis was found was 4.3 parts per thousand. In the Severn River, specimens were taken in 3.9 parts per thousand. Below these salinities none were found in the respective estuaries. Therefore, that station, or area, at which the salinity fluctuates around 4.0 parts per thousand perhaps could be called the "fringe area" of occurrence. This area appeared to be located at the mouth of Hunting Creek (Figures XI and XII) during the entire summer, except for one week when the salinity showed a pronounced increase at all stations. At this station there is a weak coincidence between salinity and abundance. On days when the salinity was relatively high, Mnemiopsis were present, and on days when the salinity was relatively low very few or none were found. At the locations where the salinity was above the apparent lower limits of tolerance, no relationship between salinity and abundance was suggested.

5. At the higher salinity stations downstream, there were differences between the abundance of Ctenophores at the surface and at the bottom. However, this was very irregular - some days there were greater numbers at the surface and on other days the situation was reversed. There is no apparent explanation. At first it was thought that the roughness at the surface was responsible for the greater numbers at the bottom. However, this probably was not the case since often greater numbers were taken at the surface when the water was quite choppy. The pattern of abundance throughout the summer was generally similar for the surface and bottom.

The taking of only bottom and surface tows does not give a clear picture of the vertical distribution. The use of one or preferably more nets at intermediate depths and perhaps at ten-foot intervals would be much better.

6. At the upstream stations where the salinity was relatively low, namely the Patuxent Bridge at Benedict and Hunting Creek, more individuals were obtained from the bottom tow than from the surface, except for one case when the salinities of the surface and bottom were the same. At all other times, seventeen in all, the bottom salinities were higher than the surface, suggesting that salinity might be related to the controlling factor. There was one case where the bottom salinity was higher than that of the surface. This appeared at Deep Landing at the time when the salinities at all stations showed a marked increase. The water at this station was not very deep, which may or may not have had something to do with the observation. However, there was a pronounced difference between the bottom (6.2 o/oo) and surface (4.5 o/oo) salinities.

7. The abundance and distribution over the period of sampling can be seen on Figures XV and XVI. An influx of very small individuals was observed at the beginning of July. The vast majority of these were in the one-half centimeter size class, which included all specimens from .75 centimeter down to the smallest that could be seen with the naked eye. The peak of abundance appeared in the middle or toward the end of July. By the first of August, a sharp decrease in numbers was noted and the smallest size class (.5 centimeter) had disappeared by the middle of the month. The great influx appeared first at

the upstream stations and persisted there a greater length of time. Small individuals, but not as small as previously, are still found there but in much reduced numbers.

8. From the time of the peak of abundance of the small animals in mid-July, the individuals taken in the samples became progressively larger. This is indicated on Figures XV and XVI. The increase in size was noted for both upstream and downstream stations.

Discussion

Although this study has covered a relatively short period of time, several things have been learned about Mnemiopsis. It seems reasonably certain that they are not uniformly distributed, that is their occurrence is spotty and uneven. The fact that Mnemiopsis is a planktonic form and its movements are largely, if not wholly, determined by water currents which are in turn controlled by the tidal movements and winds may be one factor concerned. Perhaps Mnemiopsis possess more control over their movements than is realized. If this is the case, they would have the power to concentrate themselves in an area where conditions are more favorable, such as an area of abundant food.

It appears as if Mnemiopsis spawns from late June until mid-August, with the peak appearing mid- to late June. This finding is based on the presence of very small animals, most of which appeared to be passing through the early stages shortly following hatching as described by Mayer (1912). He states that hatching occurs about 30 hours after fertilization of the egg. Therefore, the time of spawning can be fairly well determined. This was an atypical summer as far as salinity, which has been lower than normal, and temperature, which has also shown a generally lower than average trend, are concerned. Therefore, this observed breeding period also may not be typical with regard to time and duration.

The presence of the larger individuals downstream in higher salinities and the smaller individuals upstream in the lower salinities was relatively constant. One possible explanation for this observation is that the eggs are deposited downstream by the larger adult animals and that either the eggs or the young larvae were carried upstream where they developed. The larger animals would have greater control over their movements than the larvae and the eggs and could possibly resist the tendency to drift upstream. Another possibility is that the yound individuals were devoured by enemies and/or by cannibalistic adults. The small did appear in considerable numbers at the downstream stations for two successive weeks and then completely disappeared. It does seem unlikely that the young would undergo complete mortality.

Turning to the question of migration, it appears that Mnemiopsis has little control over horizontal migration. This is probably determined by water currents which are in turn dependant upon many factors such as tidal movements and wind. Vertical migration, on the other hand, would appear to be more voluntary since the forces to be overcome are not so strong. No pattern of vertical migration could be determined. It could be said that Mnemiopsis can regulate their horizontal movement in the sense that they can move vertically up or down to a horizontally moving current and be transported some distance.

There is still much to be done with regard to the abundance and distribution of Ctenophores. Actually, the work done this summer represents only a beginning. Only if this study is carried on over an extended period of time can the abundance and distribution be known and understood. There are several factors which have not yet been included in this study and which are suggested for the future:

1. The vertical distribution of Ctenophores.

2. The influence of tides upon horizontal and vertical distribution.

3. The difference between nighttime and daytime distribution.

4. The difference between summer and winter distribution.

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E 1

N LENGTHS AND STANDARD DEVIATION FROM EACH TOW AND STATION IN THE SEVERN RIVER

STATION	TOW	N	M	α
I	A	144	2.430 CM.	.873 CM.
	B	136	2.404 "	.797 "
	C	75	2.687 "	.896 "
TOTAL		355	2.475 "	.857 "
II	A	18	2.778 "	.877 "
	B	52	2.423 "	.794 "
	C	26	2.981 "	.755 "
TOTAL		96	2.641 "	.829 "
III	A	61	2.377 "	.750 "
	B	36	2.681 "	.776 "
	C	29	2.741 "	.979 "
TOTAL		126	2.480 "	.843 "
IV	A	30	2.367 "	.656
	B	15	2.033 "	.935 "
	C	0	—	—
TOTAL		45	2.256 "	.709 "
V	A	100	2.205 "	.640 "
	B	89	2.129 "	.795 "
	C	138	2.264 "	.750 "
TOTAL		327	2.209 "	.731 "
RAND TOTAL		956	2.392 "	.827 "

FIGURE II

LENGTH-FREQUENCY OF ENTIRE SEVERN RIVER CATCH AND THE CATCHES OF INDIVIDUAL TOWS THAT NUMBERED 100 OR MORE - ~~[illegible]~~ SCALES NOT SAME

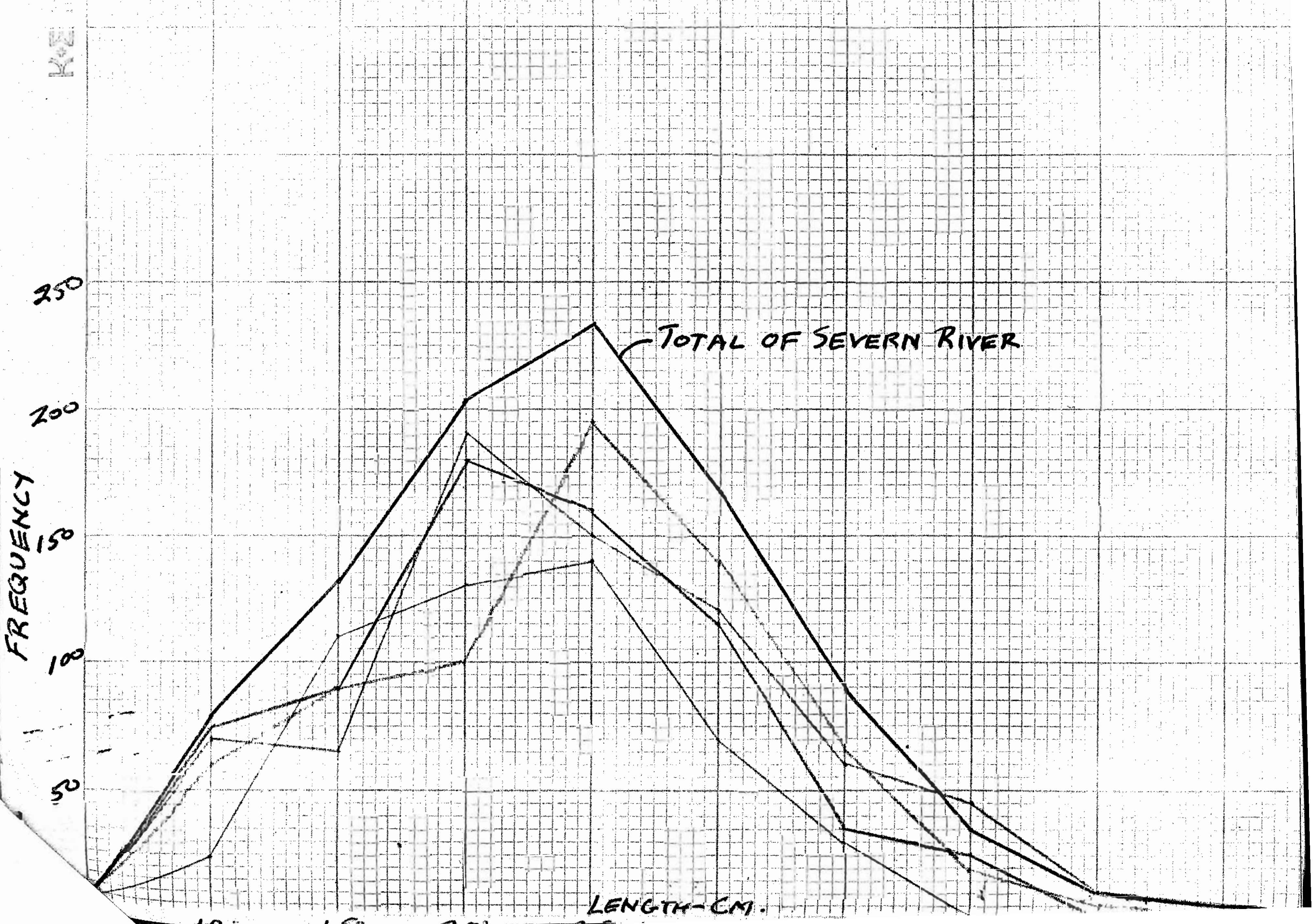
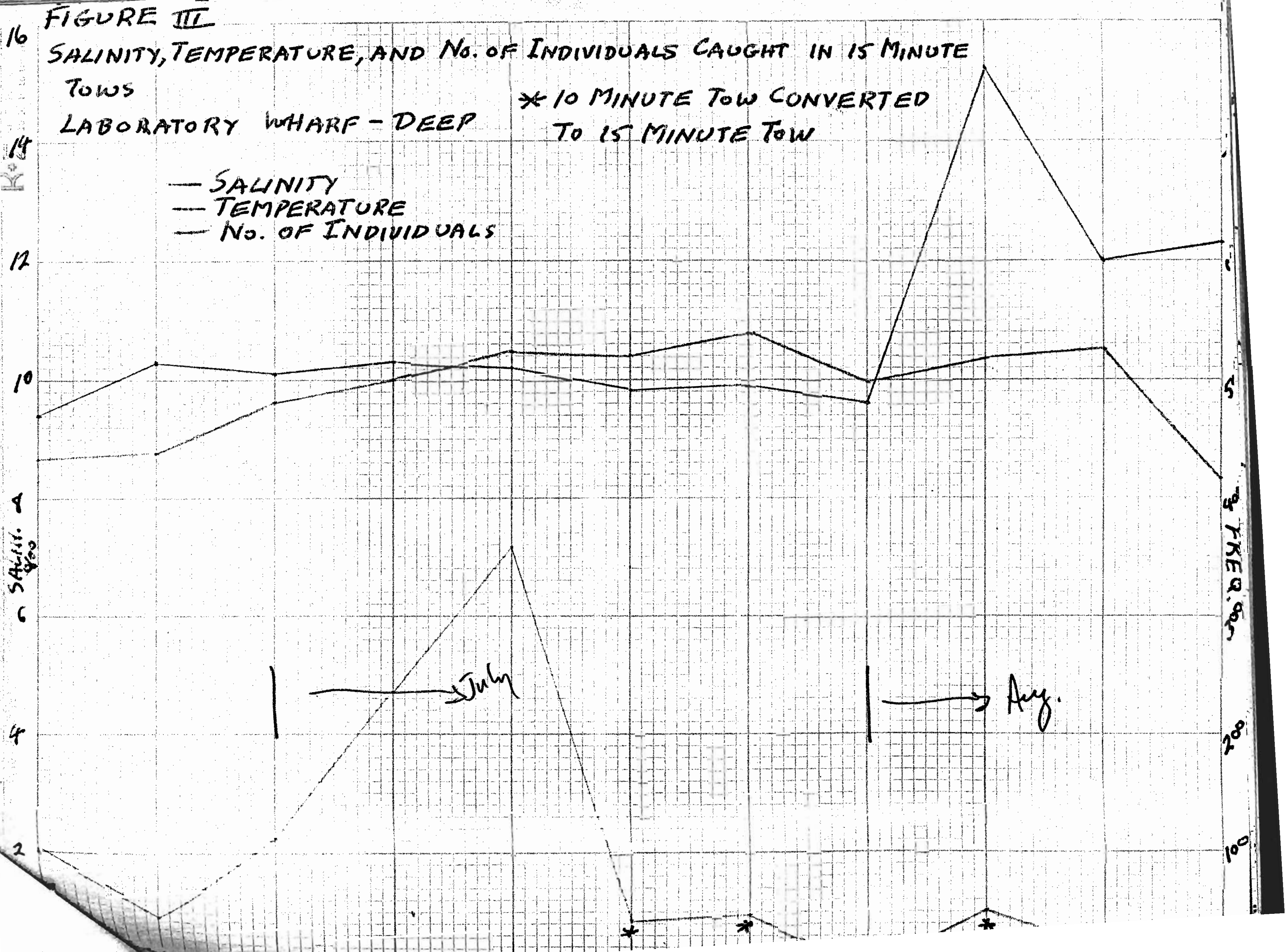


FIGURE III

SALINITY, TEMPERATURE, AND No. OF INDIVIDUALS CAUGHT IN 15 MINUTE TOWS

LABORATORY WHARF - DEEP



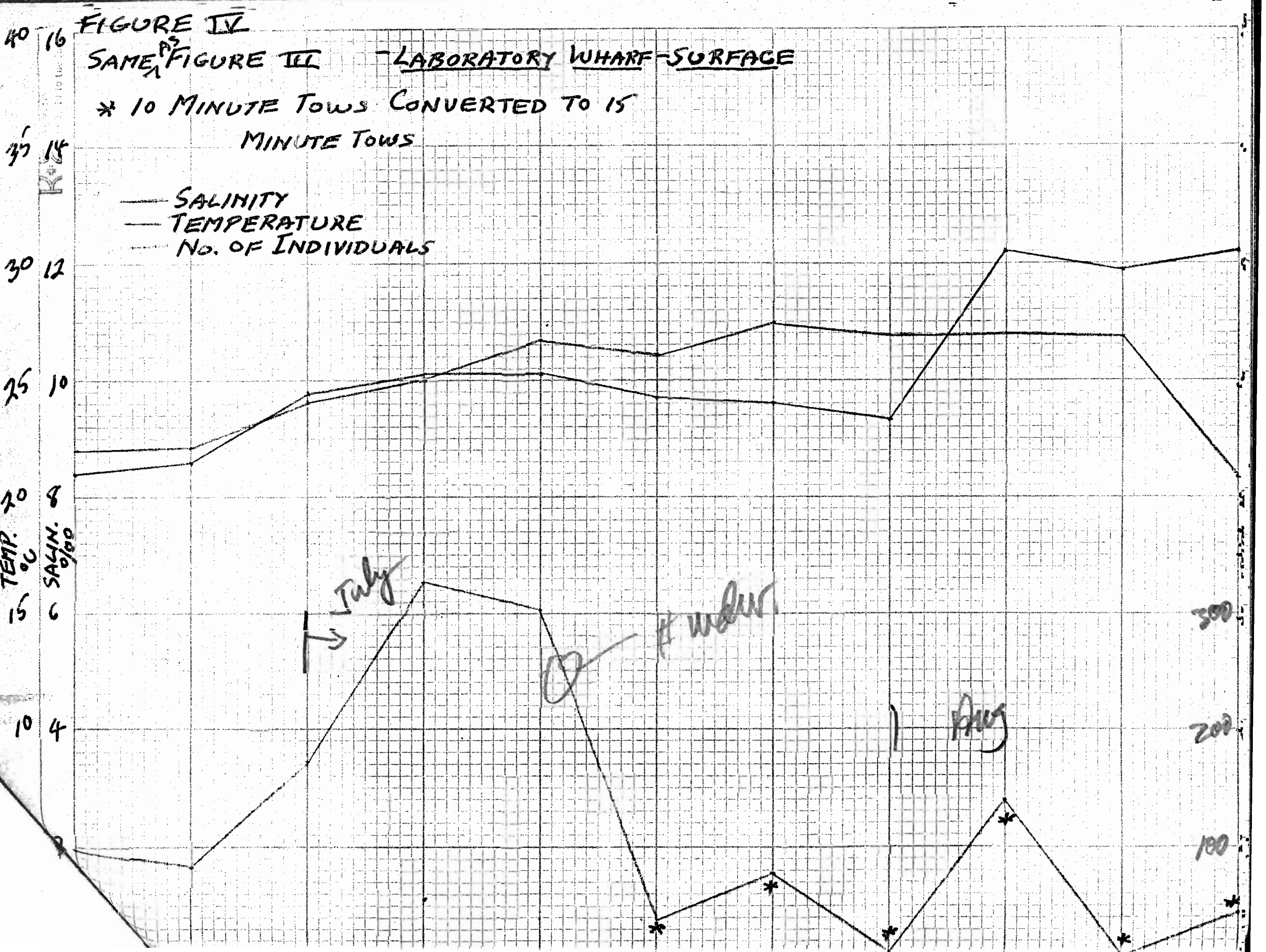


FIGURE IV
SAME AS FIGURE III — LABORATORY WHARF – SURFACE
* 10 MINUTE TOWS CONVERTED TO 15 MINUTE TOWS
SALINITY
TEMPERATURE
No. OF INDIVIDUALS
TEMP. °C
SALIN. 0/00
40
35
30
25
20
15
10
16
14
12
10
8
6
4
300
200
100
July
Aug

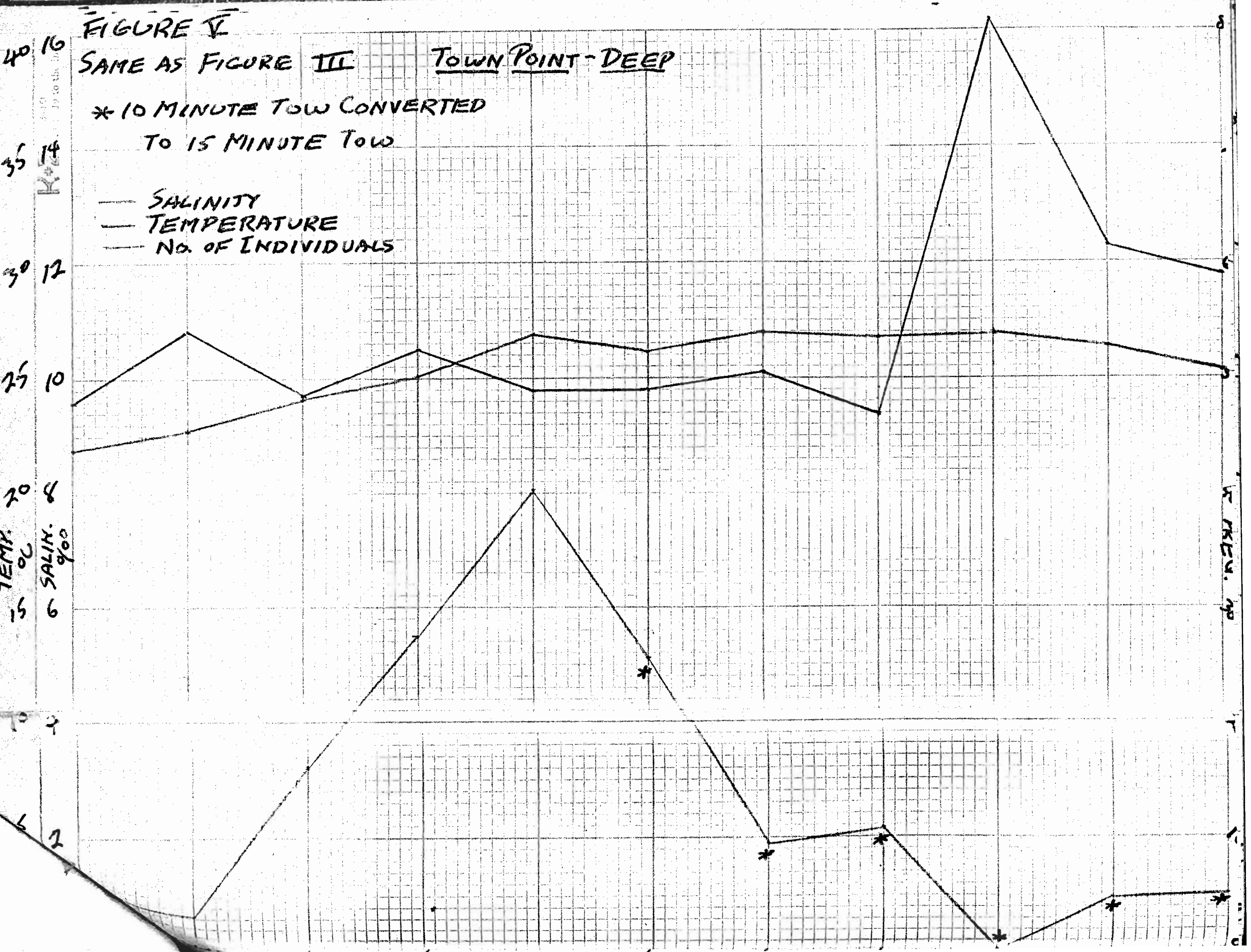


FIGURE V
SAME AS FIGURE III TOWN POINT - DEEP
* 10 MINUTE TOW CONVERTED
TO 15 MINUTE TOW
SALINITY
TEMPERATURE
No. OF INDIVIDUALS
40
35
30
25
20
15
TEMP. °C
16
14
12
10
8
6
2
SALIN. ‰

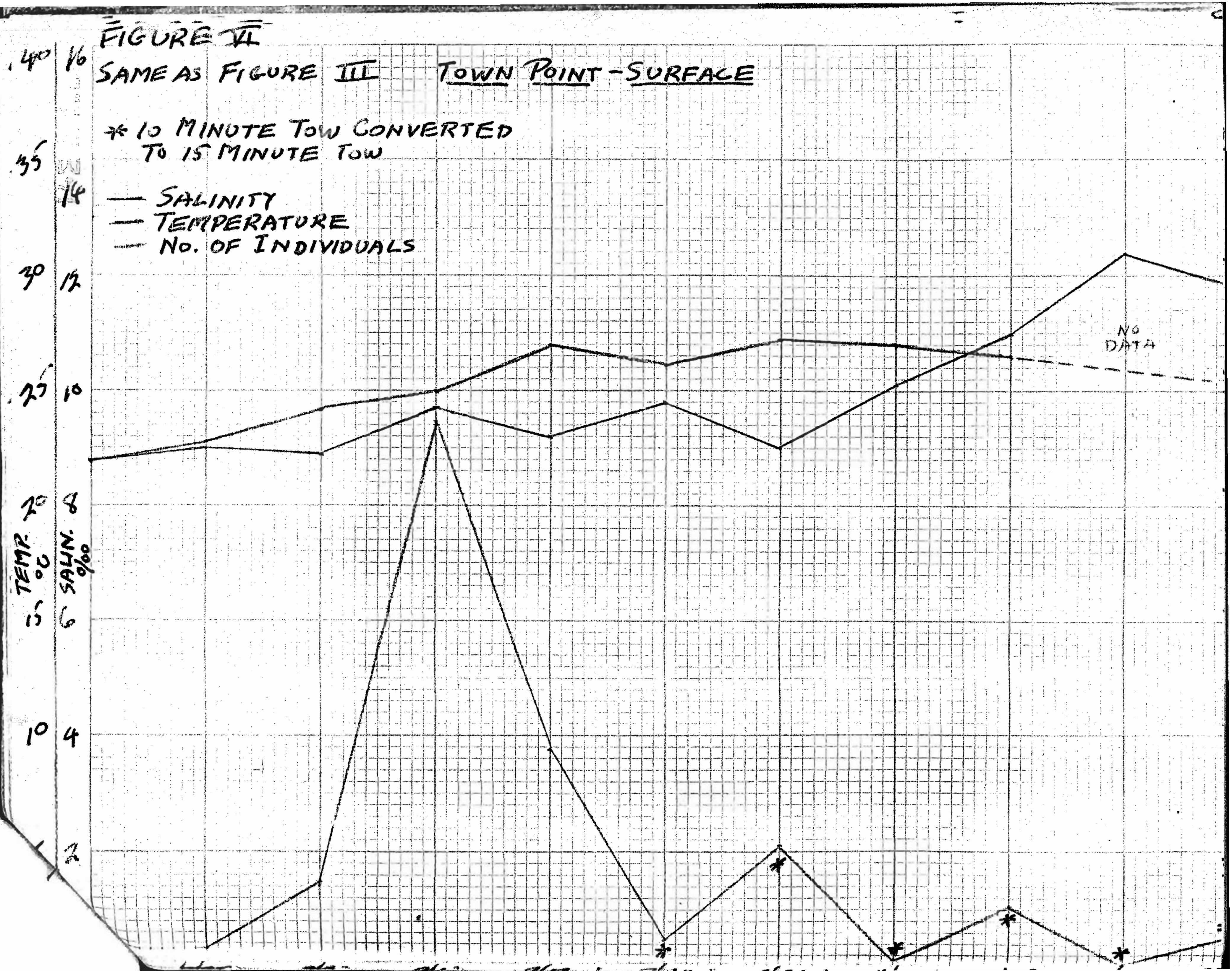


FIGURE VI
SAME AS FIGURE III
TOWN POINT - SURFACE
* 10 MINUTE TOW CONVERTED TO 15 MINUTE TOW
— SALINITY
— TEMPERATURE
— No. OF INDIVIDUALS
NO DATA
TEMP. °C
SALIN. ‰
.40
.35
30
.25
20
15
10
16
14
12
10
8
6
4
2

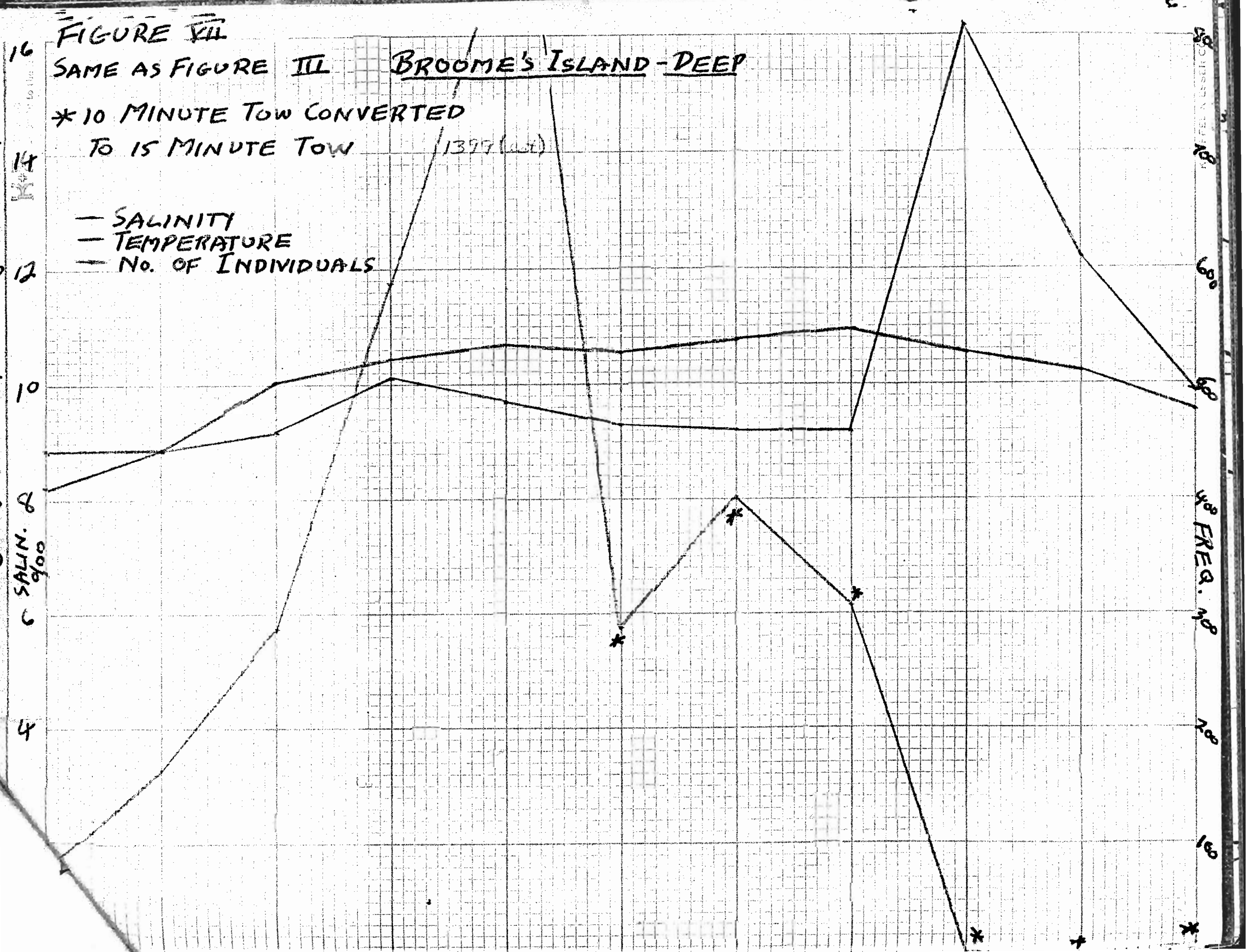


FIGURE VII
SAME AS FIGURE III
BROOME'S ISLAND - DEEP
* 10 MINUTE TOW CONVERTED
TO 15 MINUTE TOW
1397
— SALINITY
— TEMPERATURE
— No. OF INDIVIDUALS
16
14
12
10
8
6
4
SALIN. ‰
FREQ.
800
700
600
500
400
300
200
100

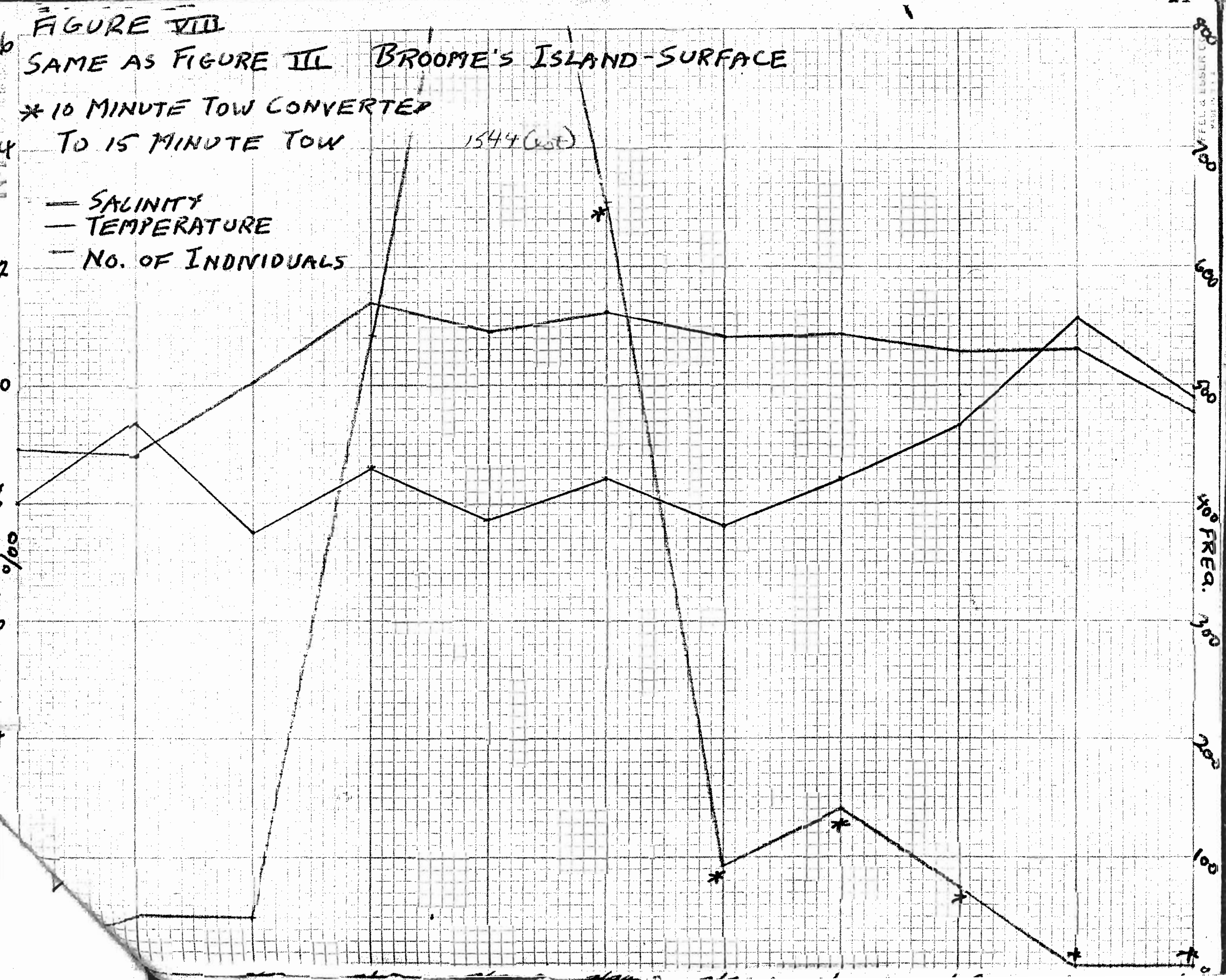


FIGURE VIII
SAME AS FIGURE III BROOME'S ISLAND-SURFACE
* 10 MINUTE TOW CONVERTED TO 15 MINUTE TOW
1544 (est)
— SALINITY
— TEMPERATURE
— No. OF INDIVIDUALS
FREQ.
800
700
600
500
400
300
200
100
0
‰

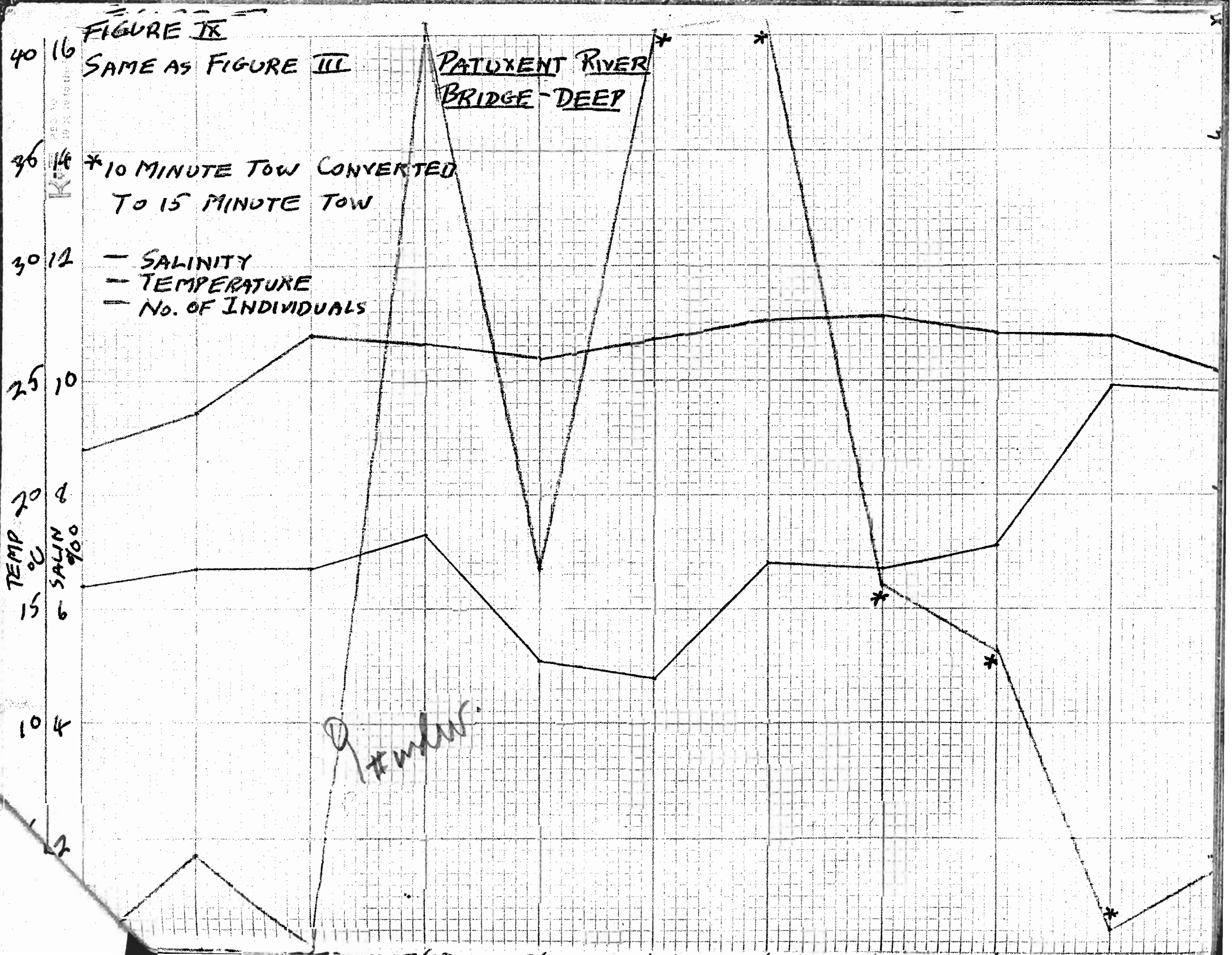
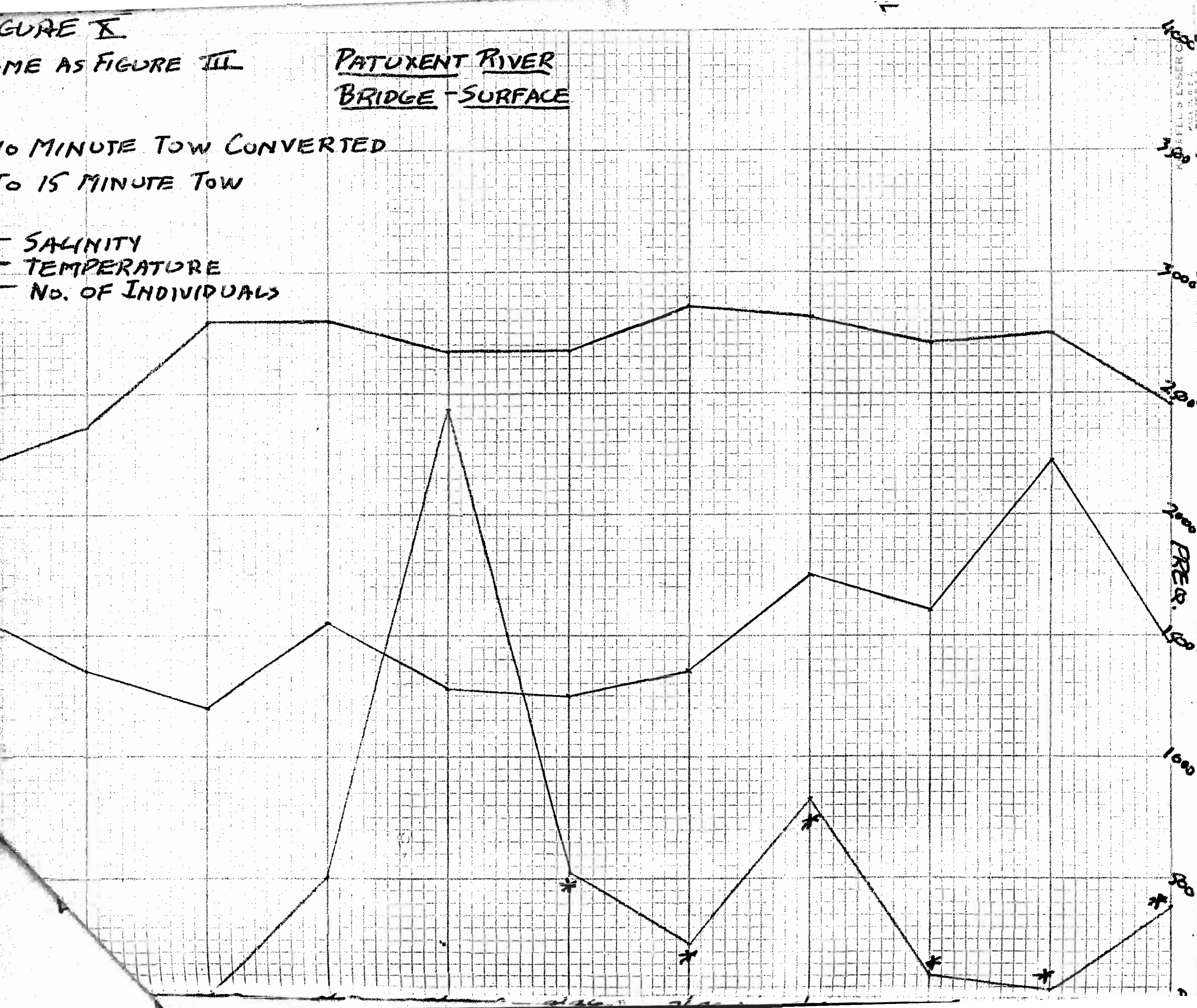


FIGURE IX
SAME AS FIGURE III
PATUXENT RIVER
BRIDGE - DEEP
* 10 MINUTE TOW CONVERTED
TO 15 MINUTE TOW
— SALINITY
— TEMPERATURE
— No. OF INDIVIDUALS
TEMP °C
SALIN ‰
40
16
36
14
30
12
25
10
20
8
15
6
10
4
2



GURE X
ME AS FIGURE III
PATUXENT RIVER
BRIDGE - SURFACE
10 MINUTE TOW CONVERTED
TO 15 MINUTE TOW
— SALINITY
— TEMPERATURE
— No. OF INDIVIDUALS
4000
3500
3000
2500
2000
FREQ.
1500
1000
500
0

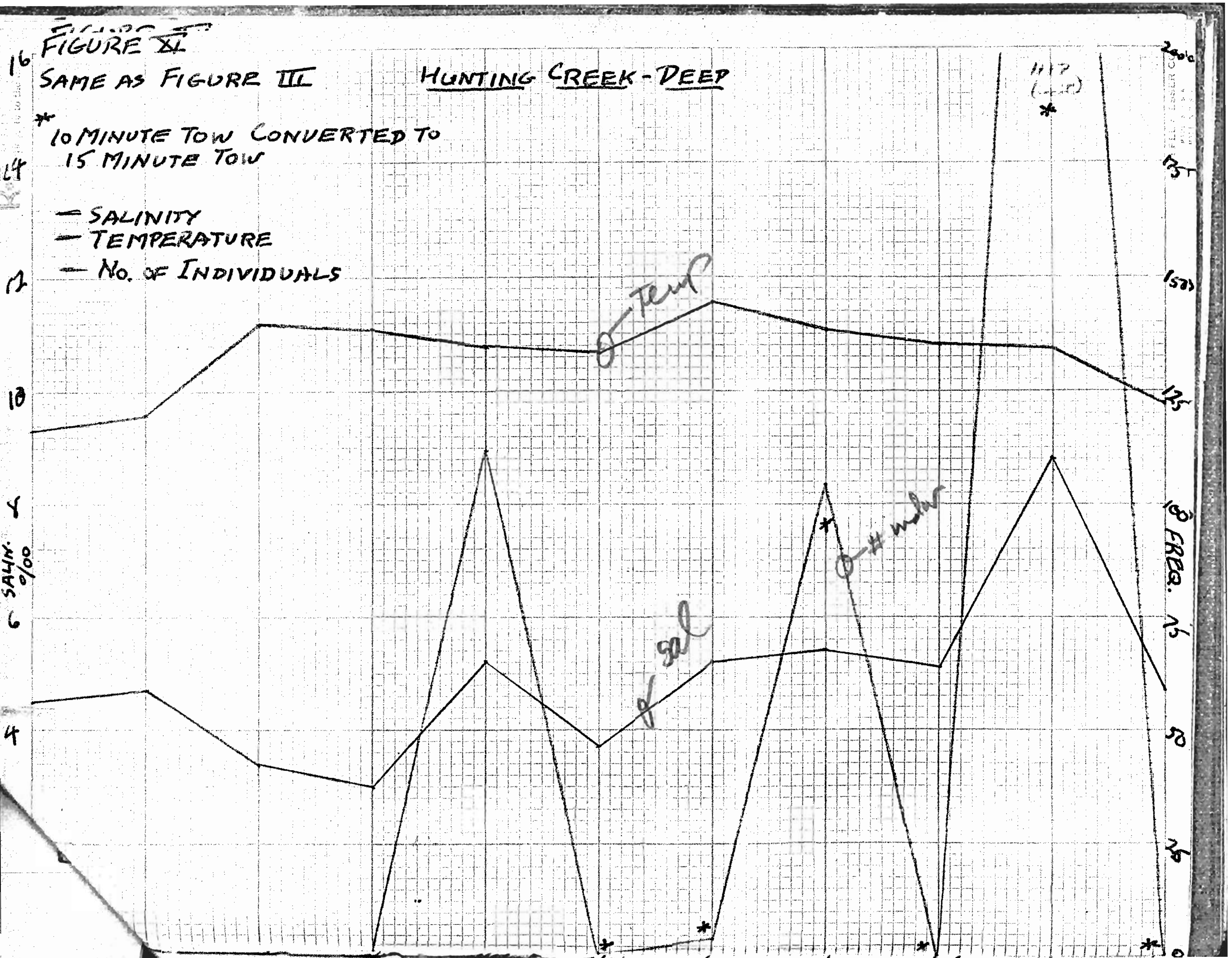


FIGURE XI
SAME AS FIGURE III
HUNTING CREEK - DEEP
* 10 MINUTE TOW CONVERTED TO 15 MINUTE TOW
— SALINITY
— TEMPERATURE
— No. OF INDIVIDUALS
16
14
12
10
8
6
4
SALIN. o/oo
200
175
150
125
100
FREQ.
75
50
25
0
117
Temp
indiv
sal

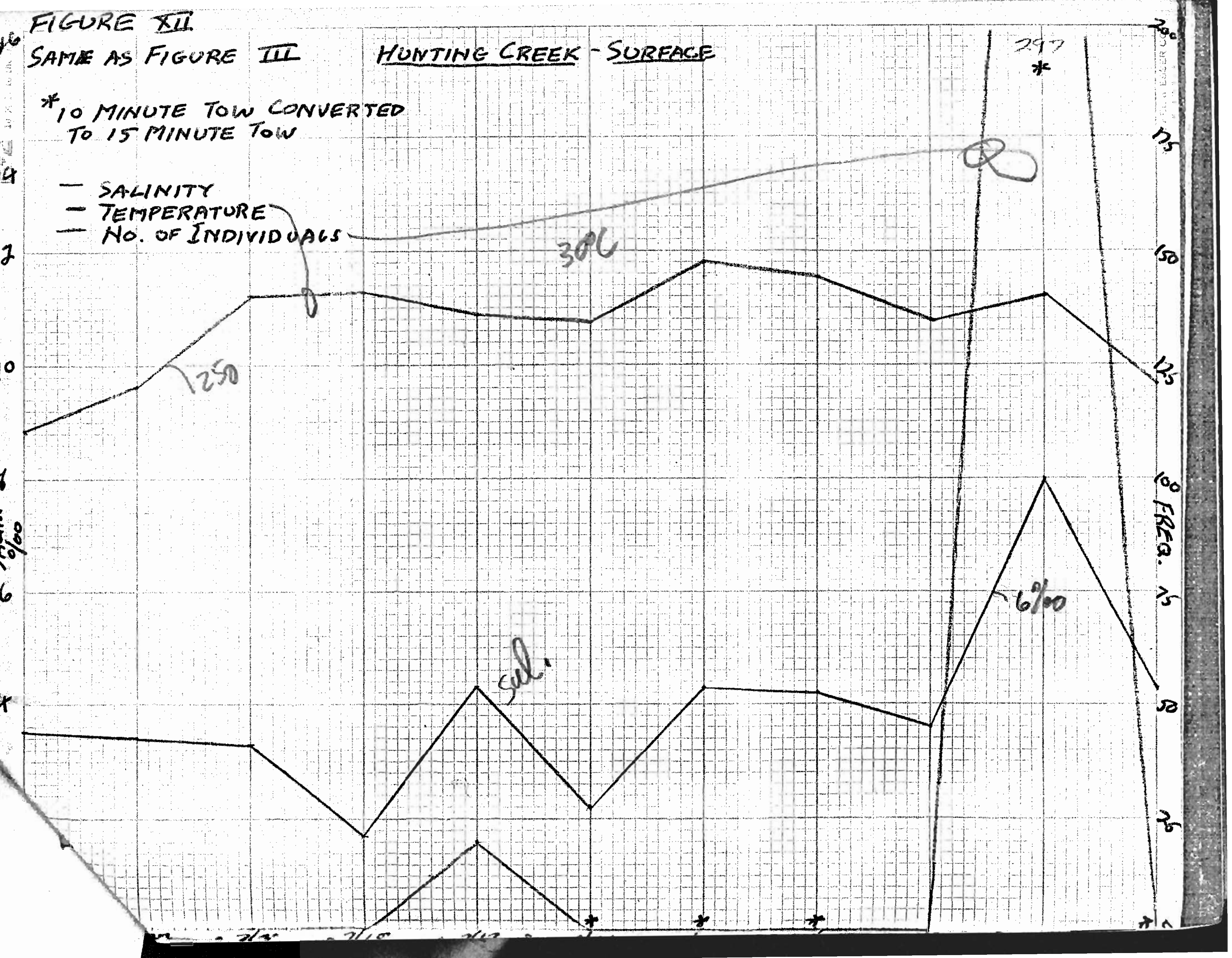
FIGURE XII

SAME AS FIGURE III

HUNTING CREEK - SURFACE

*10 MINUTE TOW CONVERTED TO 15 MINUTE TOW

— SALINITY
— TEMPERATURE
— NO. OF INDIVIDUALS



XII

...AL" PICTURE OF NUMBER OF M. LEIDYI, LARGE AND SMALL, CAUGHT AT EACH STATION - SCALES NOT SAME

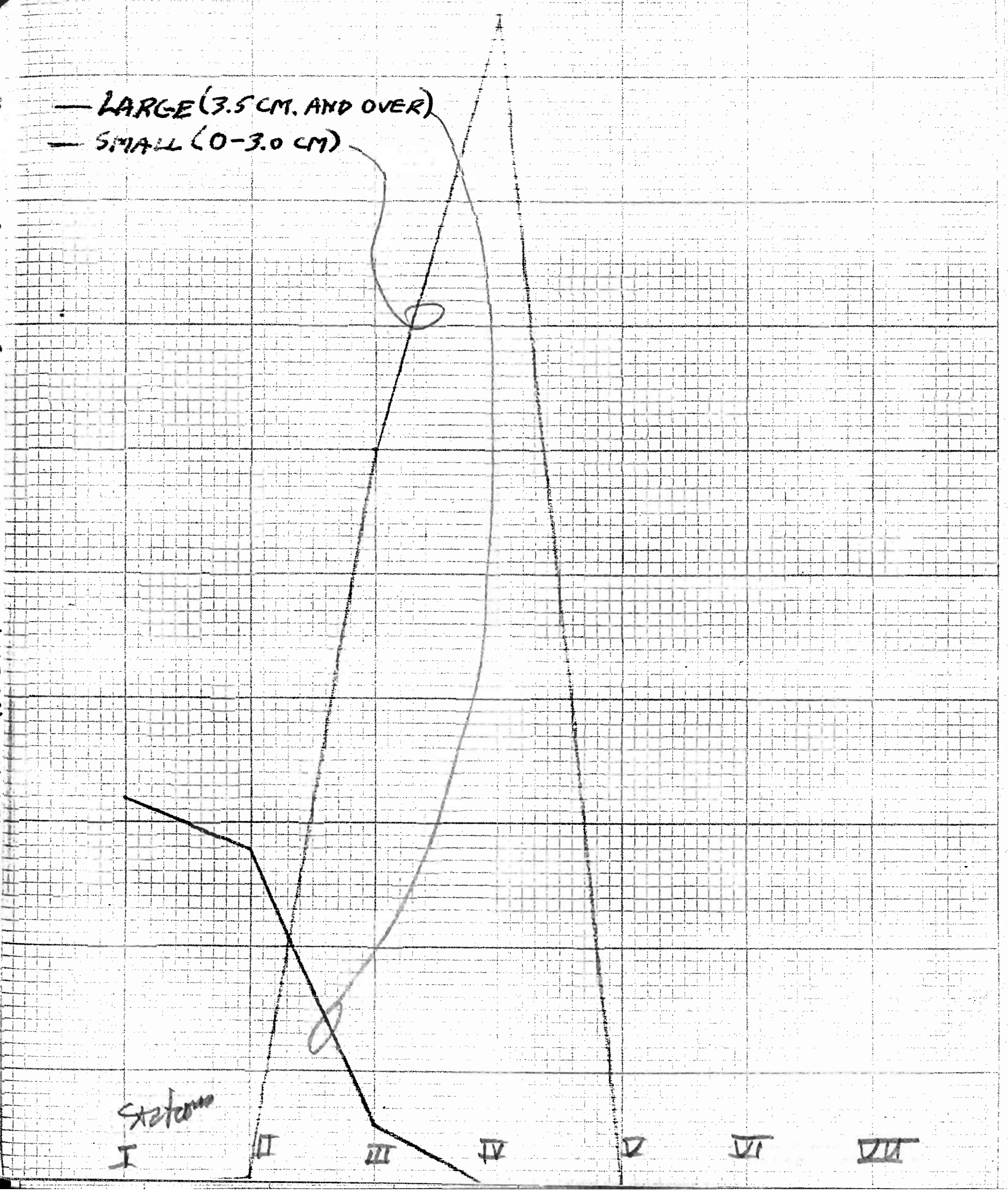


FIGURE XVI
DIFFERENCE OF LENGTH-FREQUENCY DISTRIBUTION OVER A PERIOD OF TIME AT AN UPSTREAM STATION - (SCALES NOT SAME)

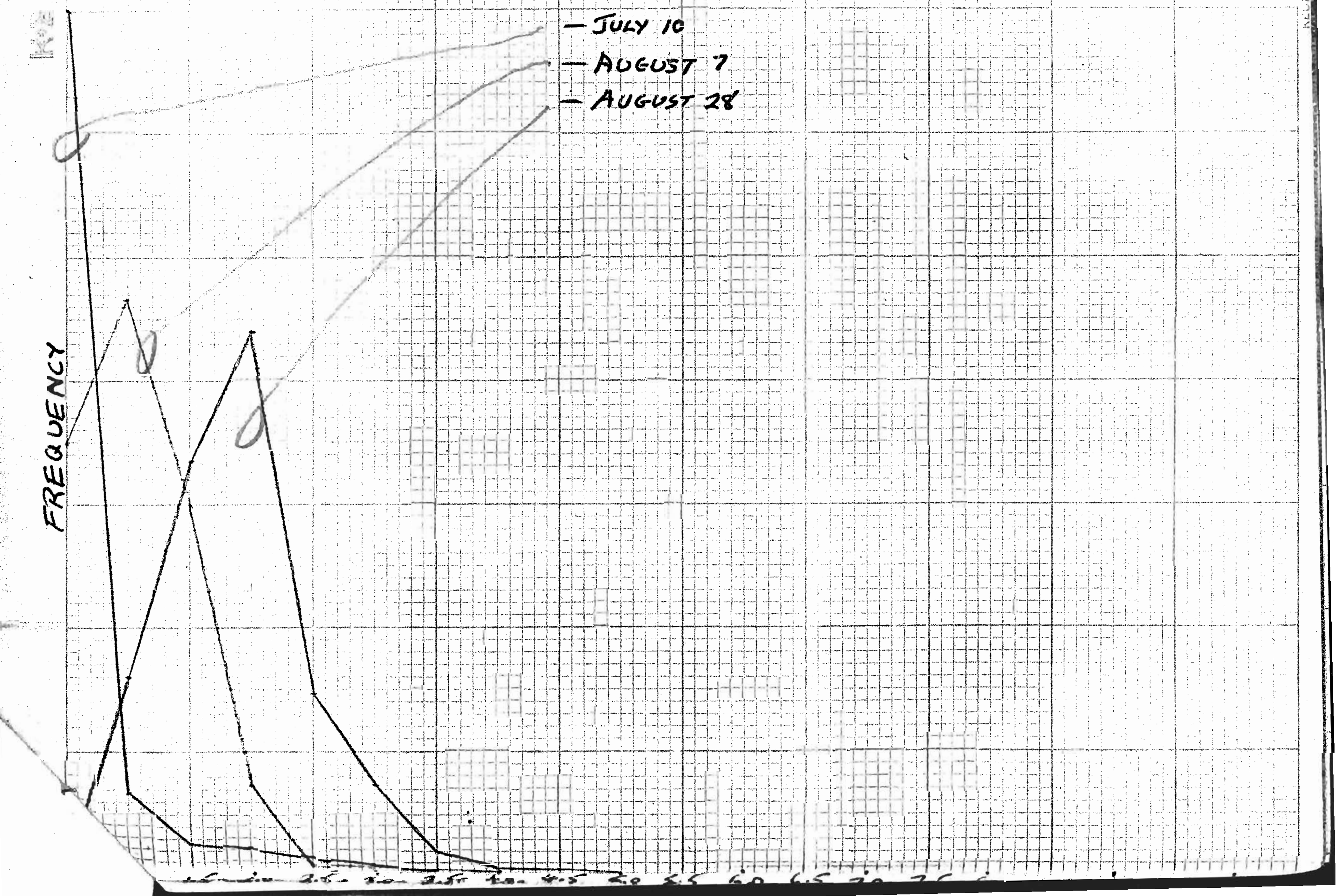


FIGURE [redacted] XIV

"TYPICAL" DOWNSTREAM AND UPSTREAM LENGTH-FREQUENCY - SCALES NOT SAME

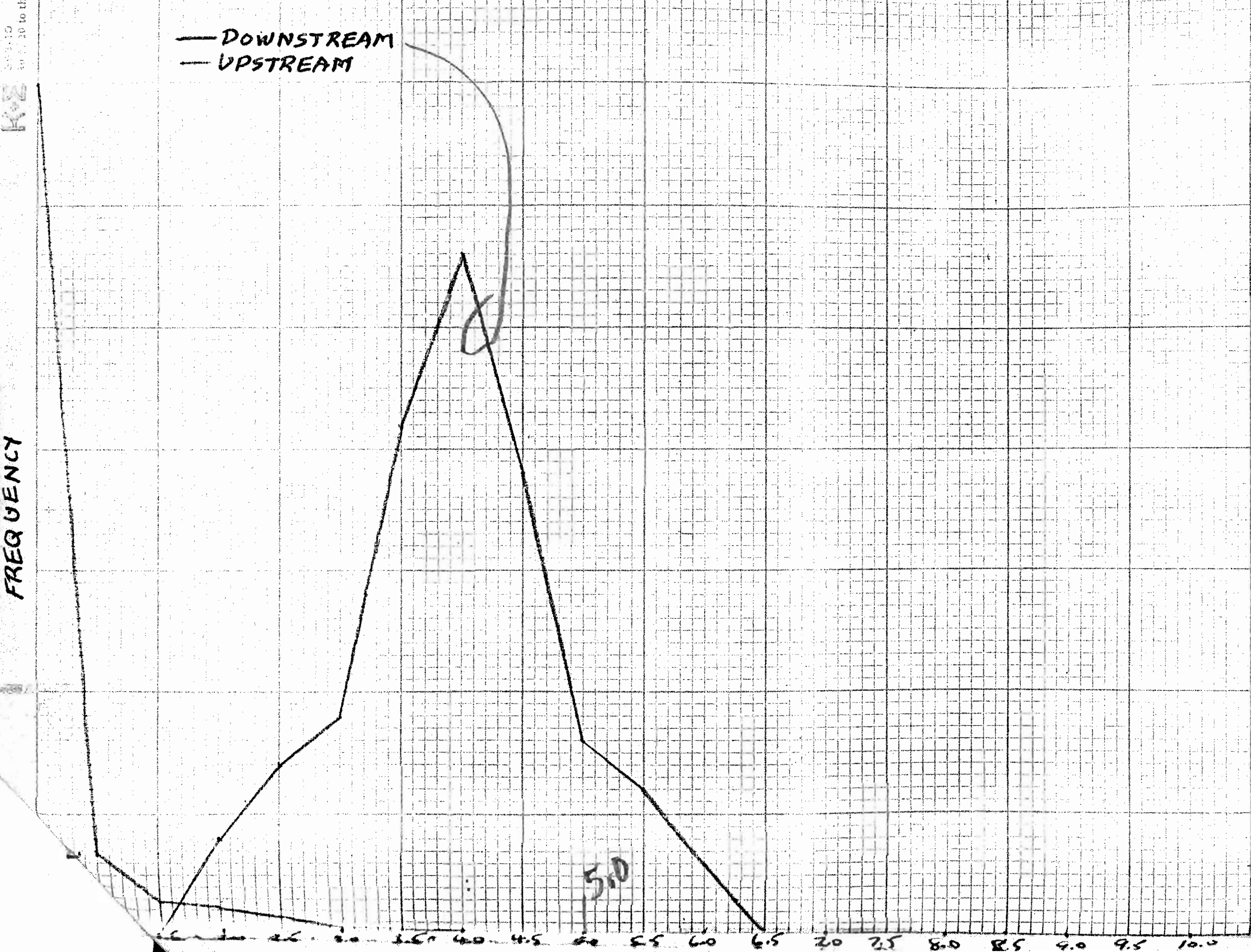
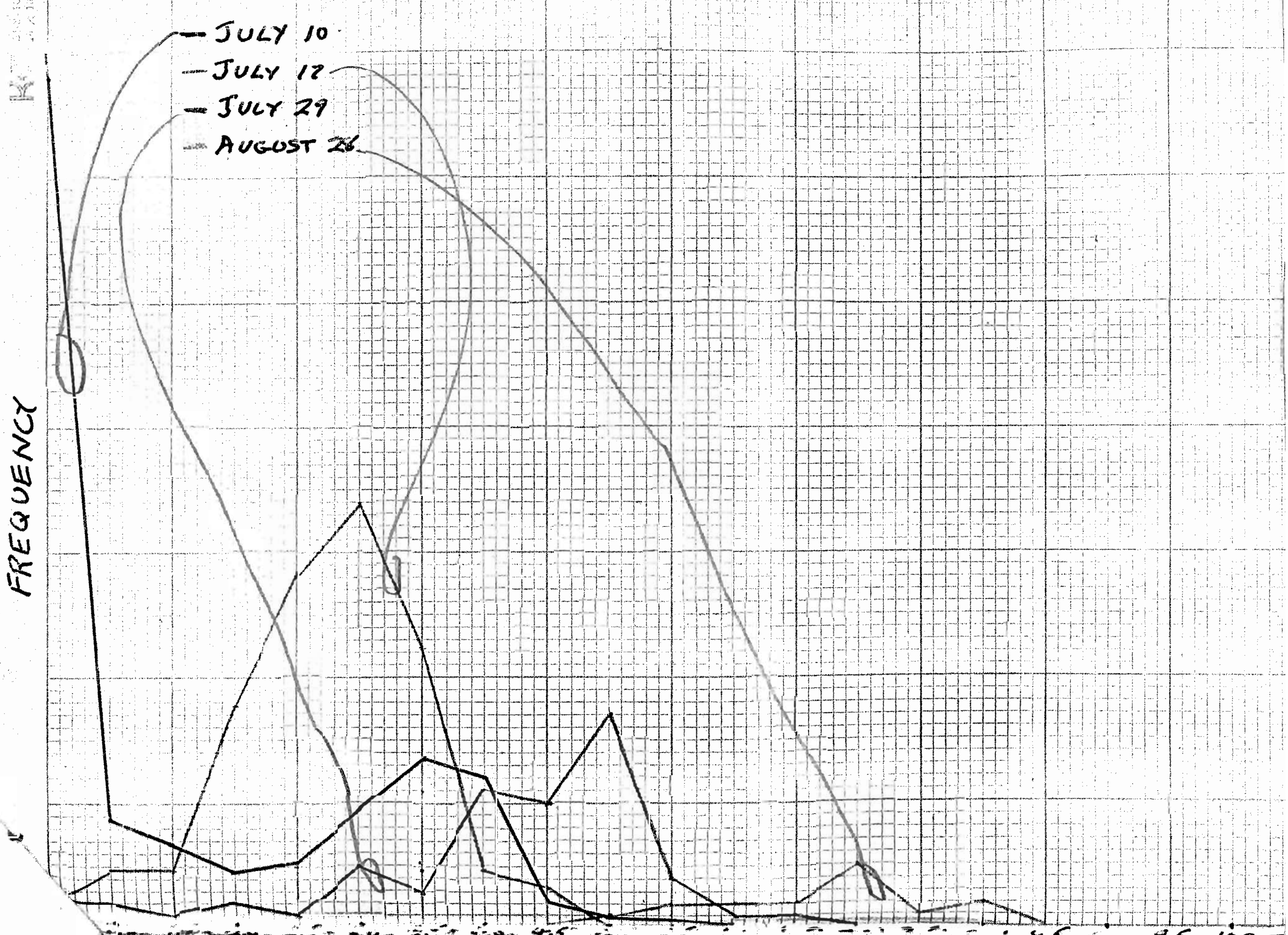
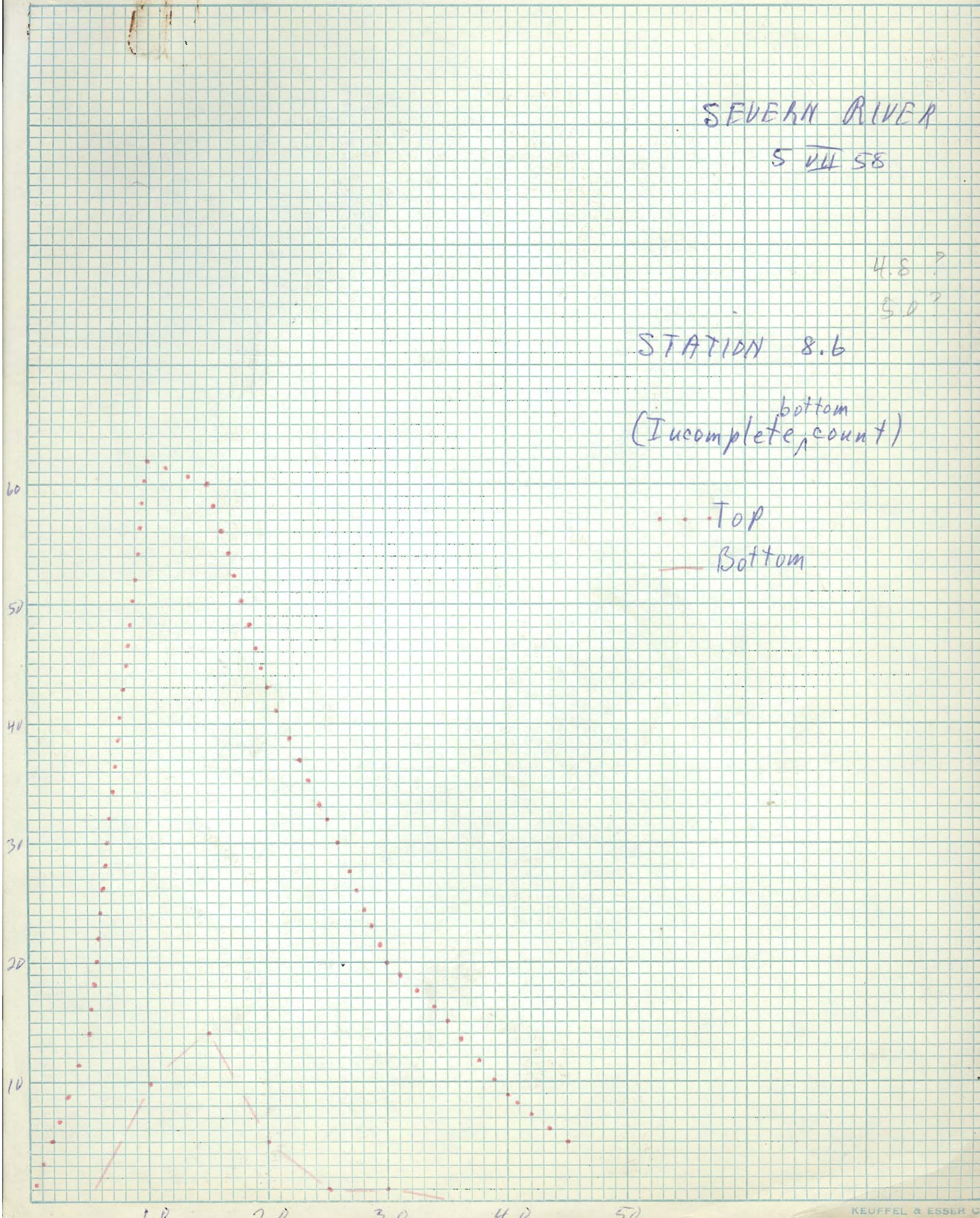
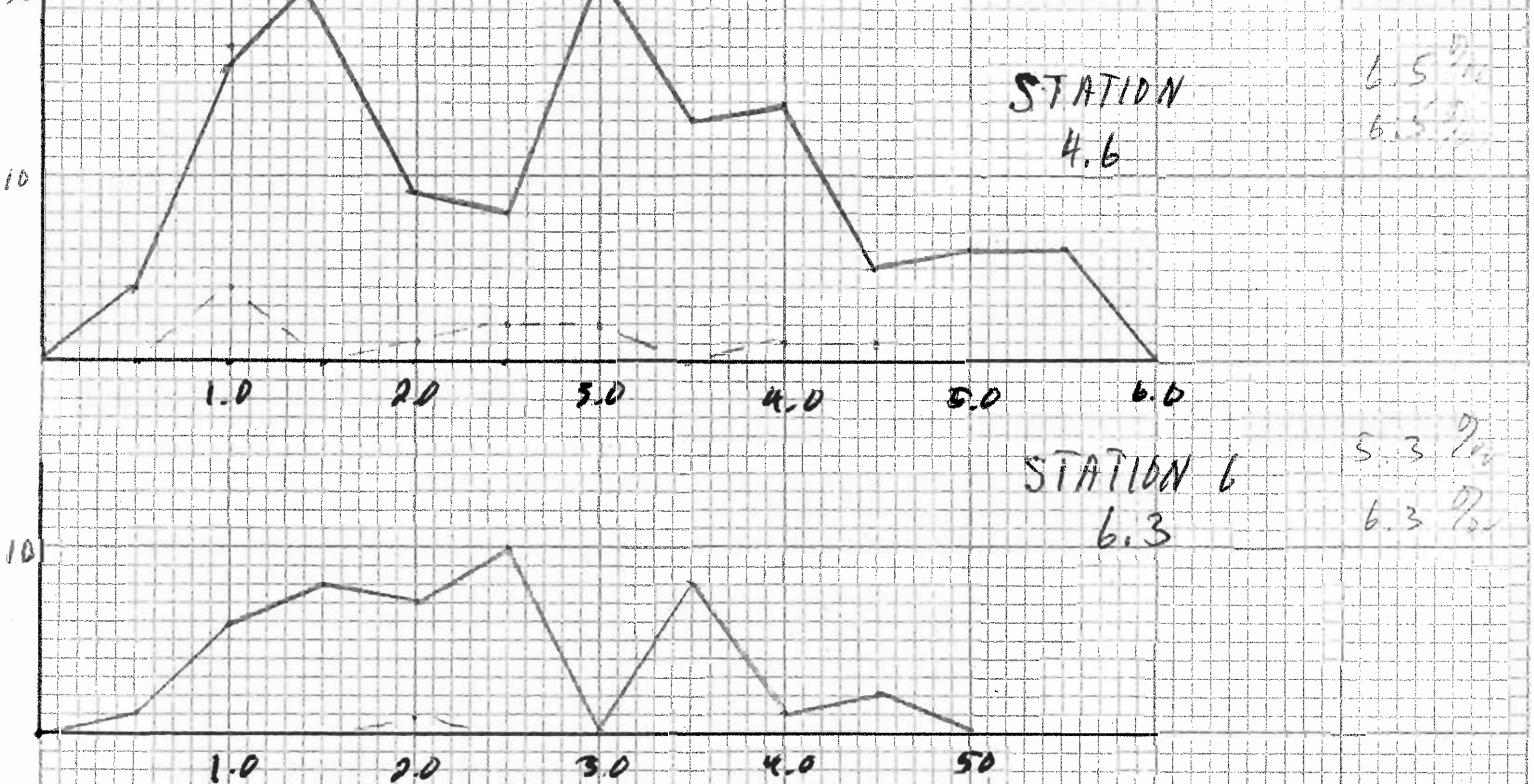


FIGURE XR
DIFFERENCE OF LENGTH-FREQUENCY DISTRIBUTION OVER A PERIOD AT A DOWNSTREAM STATION - (SCALES NOT SAME)

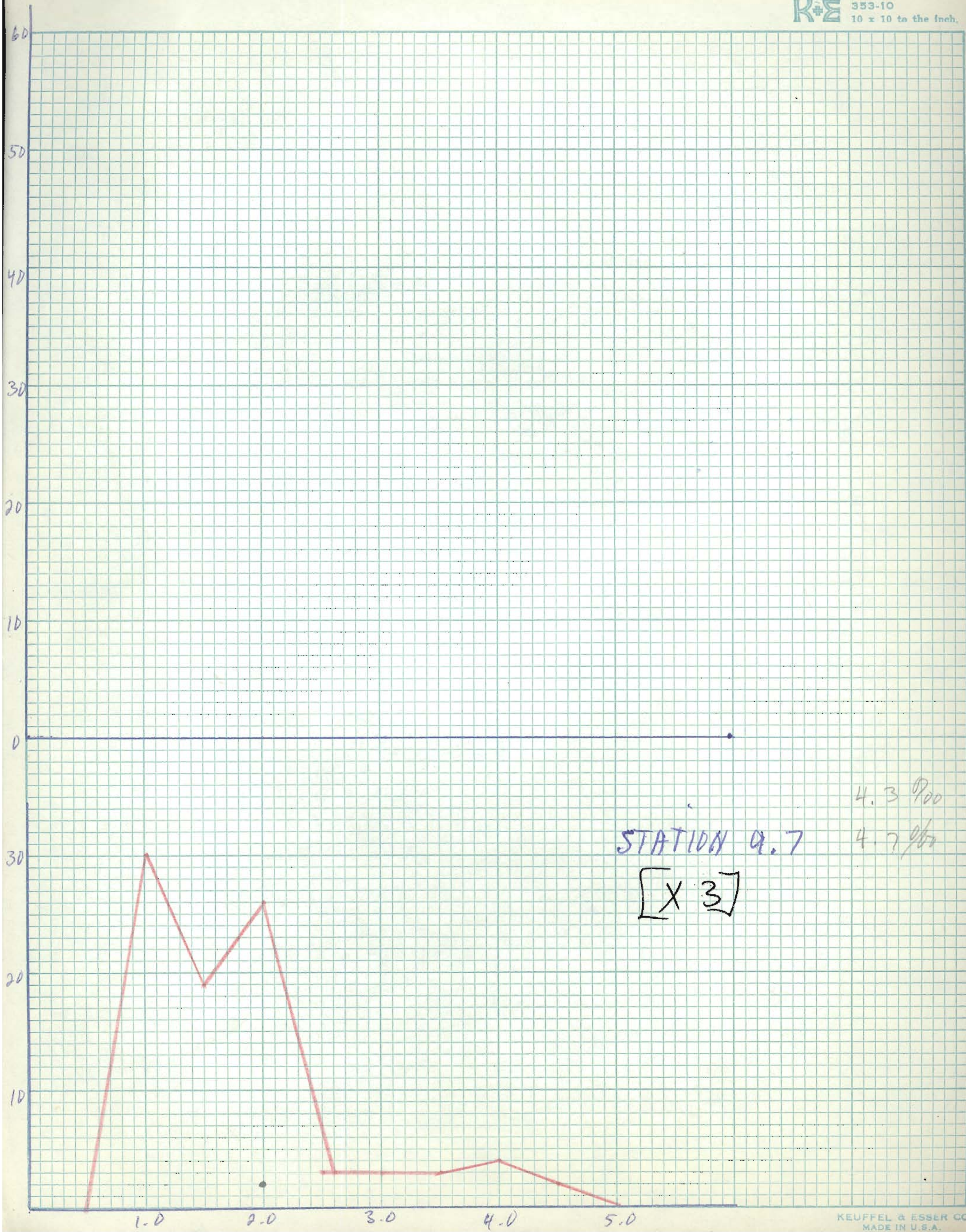



SEVERN RIVER
5 VII 58
4.8 ?
5.0 ?
STATION 8.6
(Incomplete bottom count)
Top
Bottom
60
50
40
30
20
10
1.0
2.0
3.0
4.0
5.0

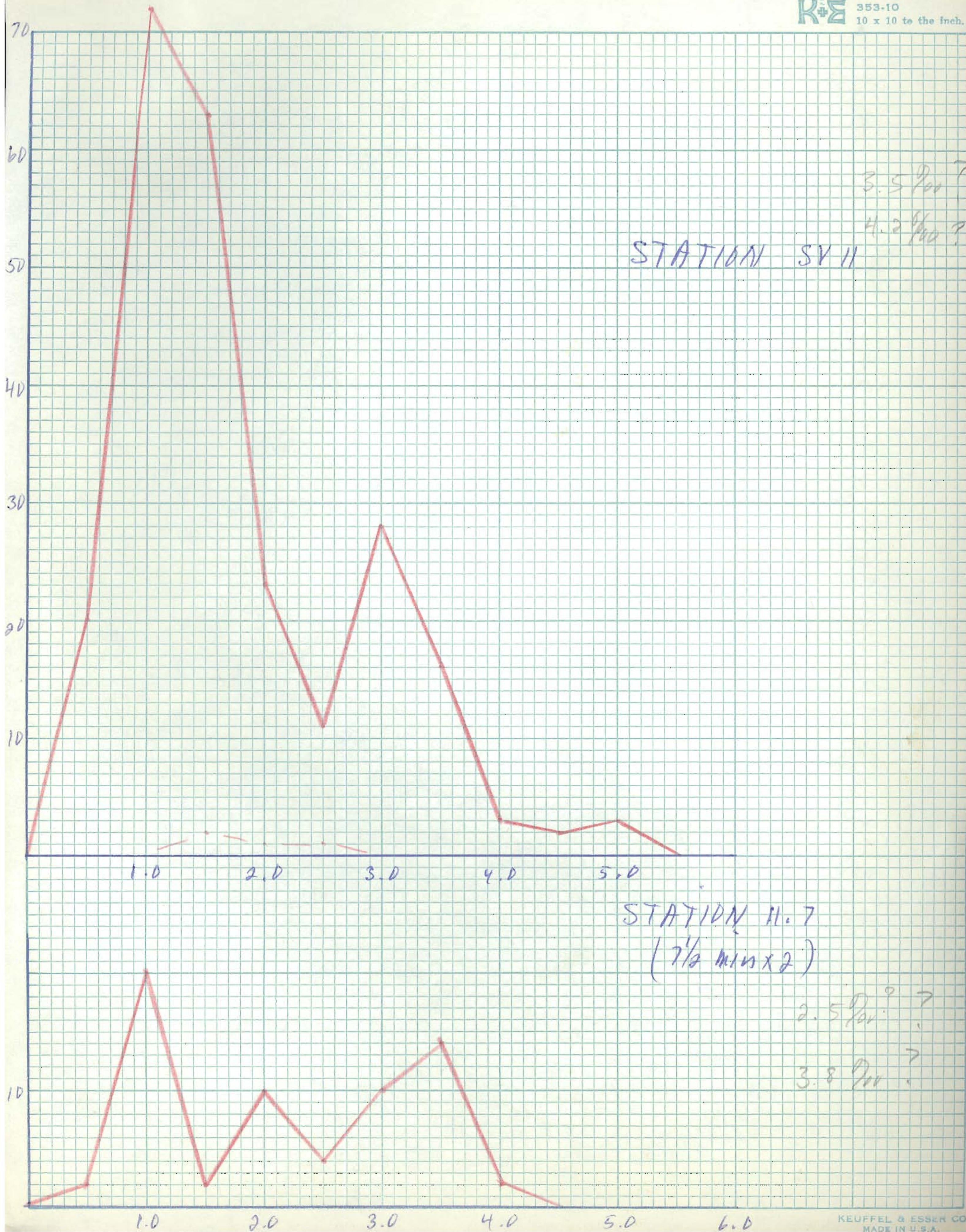
SEVERN RIVER
5 VII 58



5 VII 58



5 VII 58


STATION SV 11
3.5 ‰ ?
4.2 ‰ ?
70
60
50
40
30
20
10
1.0
2.0
3.0
4.0
5.0
STATION H. 7
(7½ min x 2)
2.5 ‰ ?
3.8 ‰ ?
10
1.0
2.0
3.0
4.0
5.0
6.0

Severn River
5 VII 58

Ctenophore

STATION SV 9.7

	Top (40cm - 15 min)	Bottom (30cm) 5 min)	Temp	Depth	‰
.5					
1.0		30		0'	
1.5		19			
2.0	2	26		5'	
2.5		3			
3.0		3		10'	
3.5		3			
4.0		4		15'	
4.5		2			
5.0				17'	

Severn River
5 VII 58

STATION SV 4.6 (New Bridge) - 15 min Ctenophore Sampling

Cm.	Top (40cm net)	Bottom (20') (30cm net)	Temp.	Depth	‰
.5		4	27.72°	0'	
1.0		16			
1.5		20	27.68	5'	
2.0	1	9			
2.5	2	8	27.59	10'	
3.0	2	21			
3.5		13	27.25	15'	
4.0	1	14			
4.5	1	5	27.16	20'	
5.0		6			
5.5		6			

STATION SV 6.3 15 min.

Cm.	Top (40cm)	Bottom - 25' (30cm)	Temp	Depth	‰
.5		1	27.89	0'	5.30
1.0		6			
1.5		8	27.64	5'	5.32
2.0	1	7			
2.5		10	27.57	10'	5.32
3.0					
3.5		8	26.46	15'	6.02
4.0		1			
4.5		2	24.66	20'	6.30
5.0					
			24.62	25'	6.35

STATION SV 8.6 - 15 min [Incomplete count] Cedar Pt.

Cm.	Top (40cm)	Bottom - 23' (30 cm)	Temp.	Depth	‰
.5		14	28.78	0'	
1.0	10	62			
1.5	14	60	26.95	5'	
2.0	5	43			
2.5	1	32	26.23	10'	
3.0	1	20			
3.5		15	24.57	15'	
4.0		9			
4.5		5	23.62	20'	
5.0					
			22.37	23'	