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The Ecology of the Navasota River, Texas

By:
William J. Clark

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Texas Water
Resources Institute
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RESEARCH PROJECT COMPLETION REPORT

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THE ECOLOGY OF THE NAVASOTA RIVER, TEXAS

Principal Investigator

William J. Clark

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ABSTRACT

A general Limnological Survey was made of the Navasota River, Texas, a tributary of the Brazos River, between February, 1968 and March, 1970. Five stations on the main channel were visited twice monthly from February, 1968 to January, 1970, and three major tributaries were visited twice monthly from April, 1969 to March, 1970, at a station near the mouth of each. In addition, collections of fishes and benthos were made from 144 sites distributed throughout the watershed. Data provided include; discharge, temperature, pH, specific conductance, chloride, sulfate, nitrate, hardness, organics, trace elements, bacteria, zooplankton, macro-drift, algae, benthos and fishes (with distribution maps of fish species).

ACKNOWLEDGEMENTS

The project has benefited from the efforts of many people. Thanks are due first of all, to Dr. Kirk Strawn, for his assistance as a co-investigator in the Fisheries area, and to Claron Bjork as the senior research assistant for three years, with major responsibility for the invertebrates. Edward Rozenberg and James Lasswell worked with the fishes, Paul Becker with the net plankton, Michael Champ with the organic carbon and Richard Vaughn with the microbiology. Walter Gallaher, Ray Telfair, Dewey Meyers, and James Ragan were Research Assistants. Also participating were Robert Phelps, Mrs. Sammy Phelps, Edmund Guidry and Mrs. Safia Nagi.

Many people assisted with identifications: Dr. Elenor Cox, algae; Dr. Merrill Sweet, Insects; Dr. Sewell Hopkins, Crustacea and Mollusca; Dr. E. P. Cheatum, Mollusca; Dr. Richard Baumann, Plecoptera; Dr. Richard W. Koss and Dr. Clifford Johnson, Ephemeroptera; Dr. Minter W. Westfall, Jr., Anisoptera; Dr. Rolan Rymer, Decapoda.

The U. S. Geological Survey, Water Resources Division, Austin, Texas, kindly supplied pre-publication data from stations on the Navasota.

And finally thanks are due to the many land owners along the Navasota and its tributaries for their unfailing kindness and cooperation in allowing us access.

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF FIGURES

Figure	Title	Page

LIST OF TABLES

INTRODUCTION

It is imperative that we construct a solid base of facts from which intelligent judgements can be made concerning the impact of water resources development. Unless we know the effects of impoundments we cannot rationally decide where to build them; or where not to build them; or how to construct and operate them so as to give the total maximum benefit to society and not just the maximum sustained yield in cubic feet per second.

In July 1967, a three year cooperative research project on the Navasota River, Texas, was funded by Texas A&M University and the Office of Water Resources Research, Department of the Interior, and administered through the Water Resources Institute, Texas A&M University.

The Navasota was chosen because of its manageable size, current lack of significant water resources development, and high probability of future development. This judgement was born out by the appropriation by the U.S. Congress in 1971, of funds for pre-construction planning for Millican Dam, at river mile 24.

The study covers only a small part of the total watershed ecosystem; it is confined to the physical, chemical and biological characteristics of the river and selected tributaries. It does not cover the flood plain, or the small lakes and numerous ponds in the watershed.

The coverage is uneven, reflecting constraints of budget, personnel, distance and the primitive state of aquatic ecology research in the area. The study is essentially a survey, with its greatest value coming when future work can be compared to it. The breadth of the coverage precludes in depth analysis of all subjects, and much of the data will be presented with minimal comments.

Where data are presented in figures the tabular data are not included, but are available in a Data Supplement upon request to the Texas Water Resources Institute.

An intensive study of the Fishes, (Rozenburg, Strawn and Clark 1972) covering the first years collections, has been published as an interim report, and the fish data included here will be an update of that report. Papers containing other more detailed analyses of important aspects will be published in appropriate scientific journals.

DESCRIPTION OF THE WATERSHED

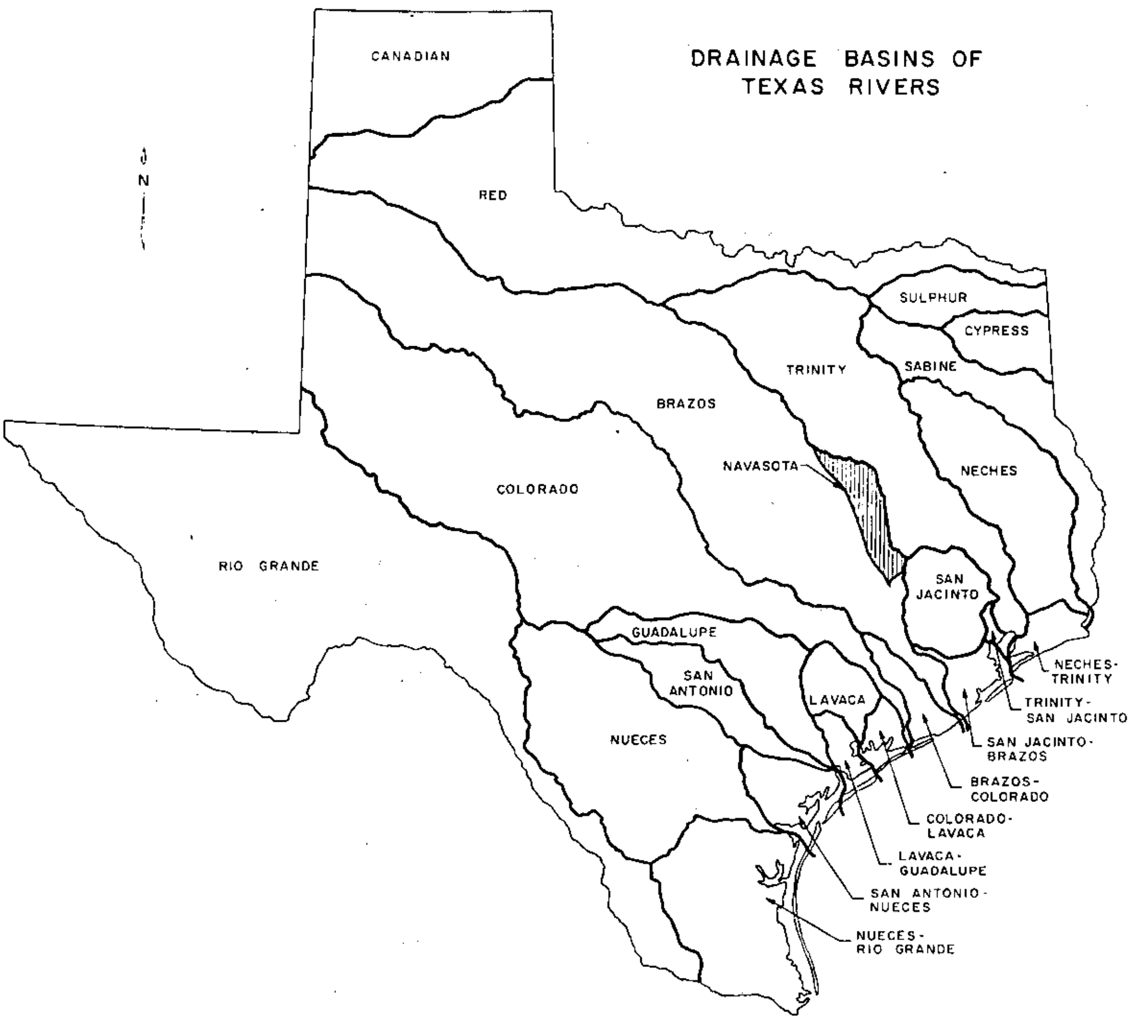
Geology and Geography

The Navasota is a tributary of the Lower Brazos and parallels the Brazos for much of its length (Fig. 1). The watershed has been described in some detail in reports prepared for the U. S. Corps of Engineers and compiled as House Document 341, 90th Congress (Anon 1968). The data reported here are abstracted from this report. The watershed is about 122 miles long and never more than 35 miles wide, with a drainage area of 2211 square miles. Channel length is about 200 miles. Average stream bed gradients are 1.2 to 1.4 feet per mile. The Navasota enters the Brazos at Brazos River mile 232, southwest of Navasota, Texas.

The uppermost part of the watershed is in Blackland Prairie, the remainder is in the East Texas Timber belt. Below river mile 125 (Fig. 2) the flood plain becomes very wide and the channel is meandering. The terrain bordering the flood plain is quite hilly in the lower two thirds of the watershed.

The river travels at right angles to the exposures of geological strata and traverses from top to bottom and in order of decreasing ages: the Taylor and Navarro Groups of the Upper Cretacious, the Midway, Wilcox Claiborne and Jackson Groups of the Eocene, the Catahoula of the Oligocene, and the Oakvill and Lagarto Groups of the Miocene. The outcrops consist of consolidated marls, soft limestones, sands, clays, silty clay, and sandy clays.

Only the uppermost and lowermost sections of the watershed are


DRAINAGE BASINS OF
TEXAS RIVERS
N
CANADIAN
RED
SULPHUR
CYPRESS
TRINITY
SABINE
BRAZOS
NAVASOTA
NECHES
COLORADO
RIO GRANDE
SAN
JACINTO
GUADALUPE
SAN
ANTONIO
LAVACA
NUECES
NECHES-
TRINITY
TRINITY-
SAN JACINTO
SAN JACINTO-
BRAZOS
BRAZOS-
COLORADO
COLORADO-
LAVACA
LAVACA-
GUADALUPE
SAN ANTONIO-
NUECES
NUECES-
RIO GRANDE

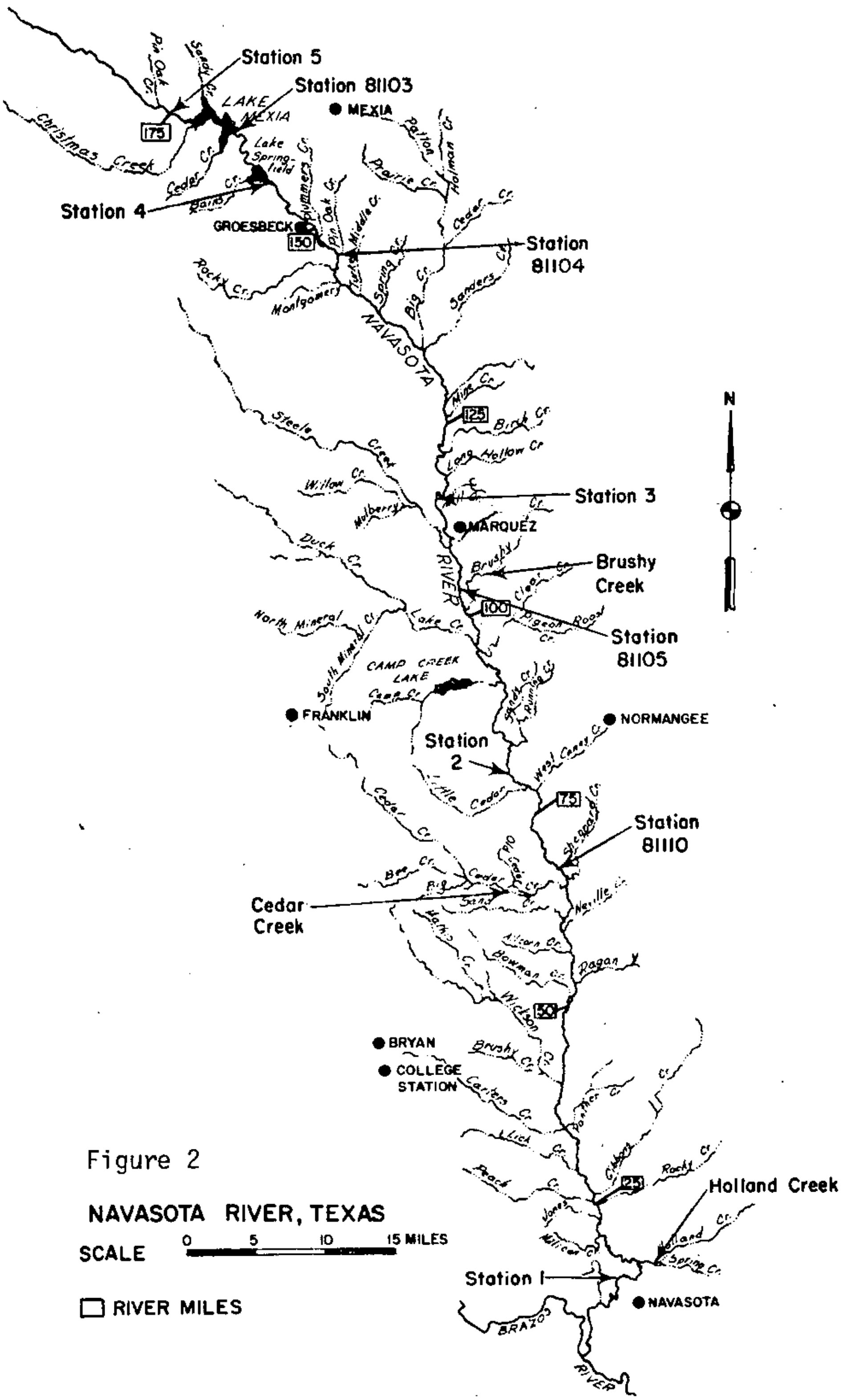


Figure 2

NAVASOTA RIVER, TEXAS

SCALE 0 5 10 15 MILES

☐ RIVER MILES

intensively farmed. Most of the watershed is in frequently flooded bottomland, forest, savannah, and unimproved and improved pasture.

The communities within the watershed are mostly small and with little or no industry, although there are oil and gas fields near Mexia. Communities with over 500 population (1971) are: (Figs. 3, 4, 5) Bryan-College Station (57,978 combined), Mexia (5,943), Groesbeck (2,396), Hearne (4,980), Navasota (5,111), Teague (2,867) and Normangee (657). Texas State Water Quality Board discharge permits for the Navasota watershed are given in Table 1, as of 1970. At about the time this list was completed the Texas State Railroad Commission directed that no oil well pits or discharges be permitted, with all saline water to be re-injected. A study by the Texas Water Commission (Burnett, Holloway and Thornhill 1962) outlines the problem of brine sepage and discharge from the pits.

Many of the communities are located on the ridge crest at the edge of the watershed. Of the communities listed, only Groesbeck is located completely within the watershed. In the Bryan-College Station area the sewage discharge is divided: Bryan and Texas A&M University discharge toward the Brazos, and College Station toward the Navasota.

In summary, the basin is an area of low population, little row crop farming, and little industry. One of the most important environmental aspects is the extent and complexity of the flood plain.

Climate

Summers are hot, with daytime temperatures often above 90^{o}F. and

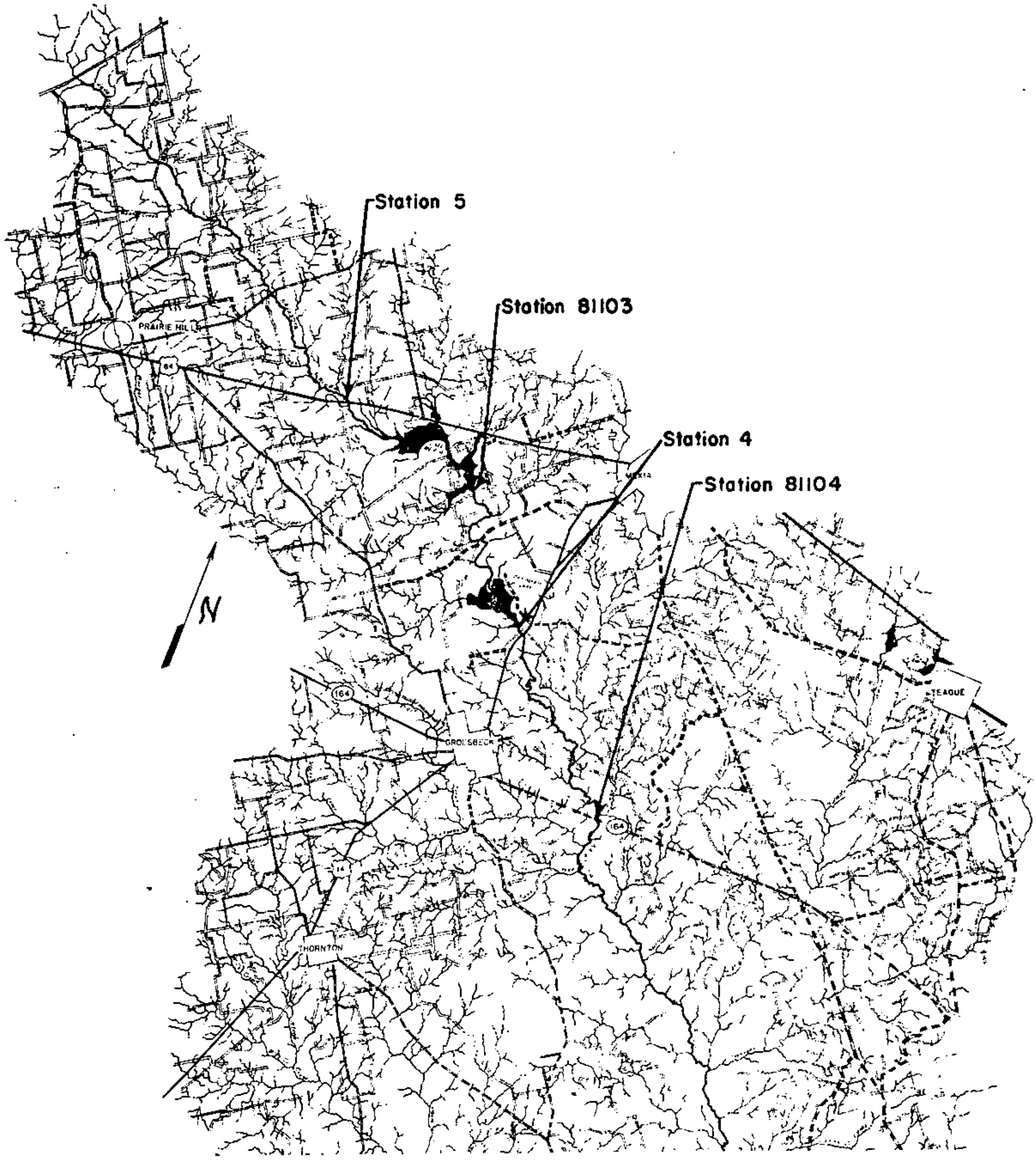


Figure 3

UPPER NAVASOTA RIVER, TEXAS

SCALE 4 MILES

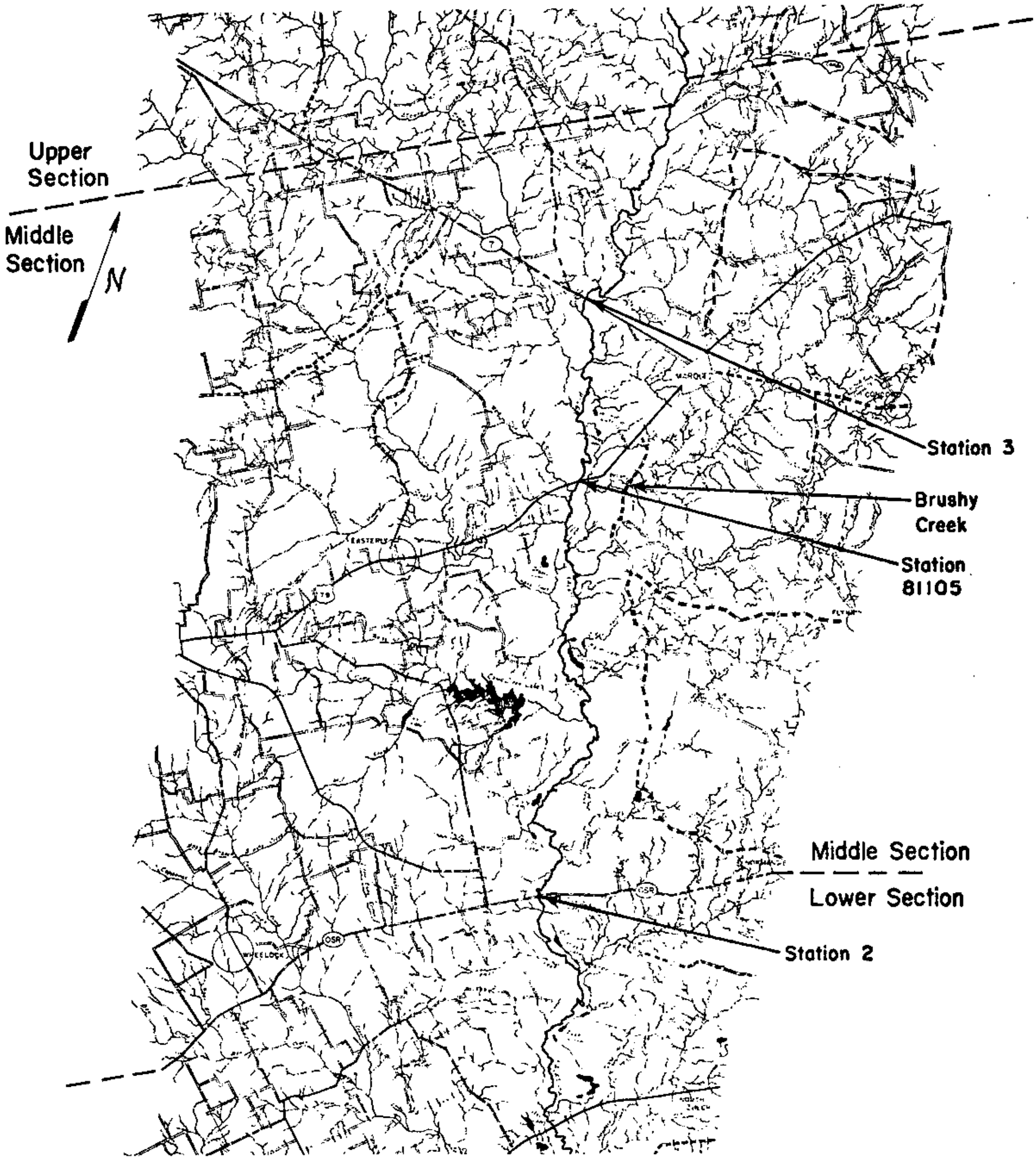


Figure 4

CENTRAL NAVASOTA RIVER, TEXAS

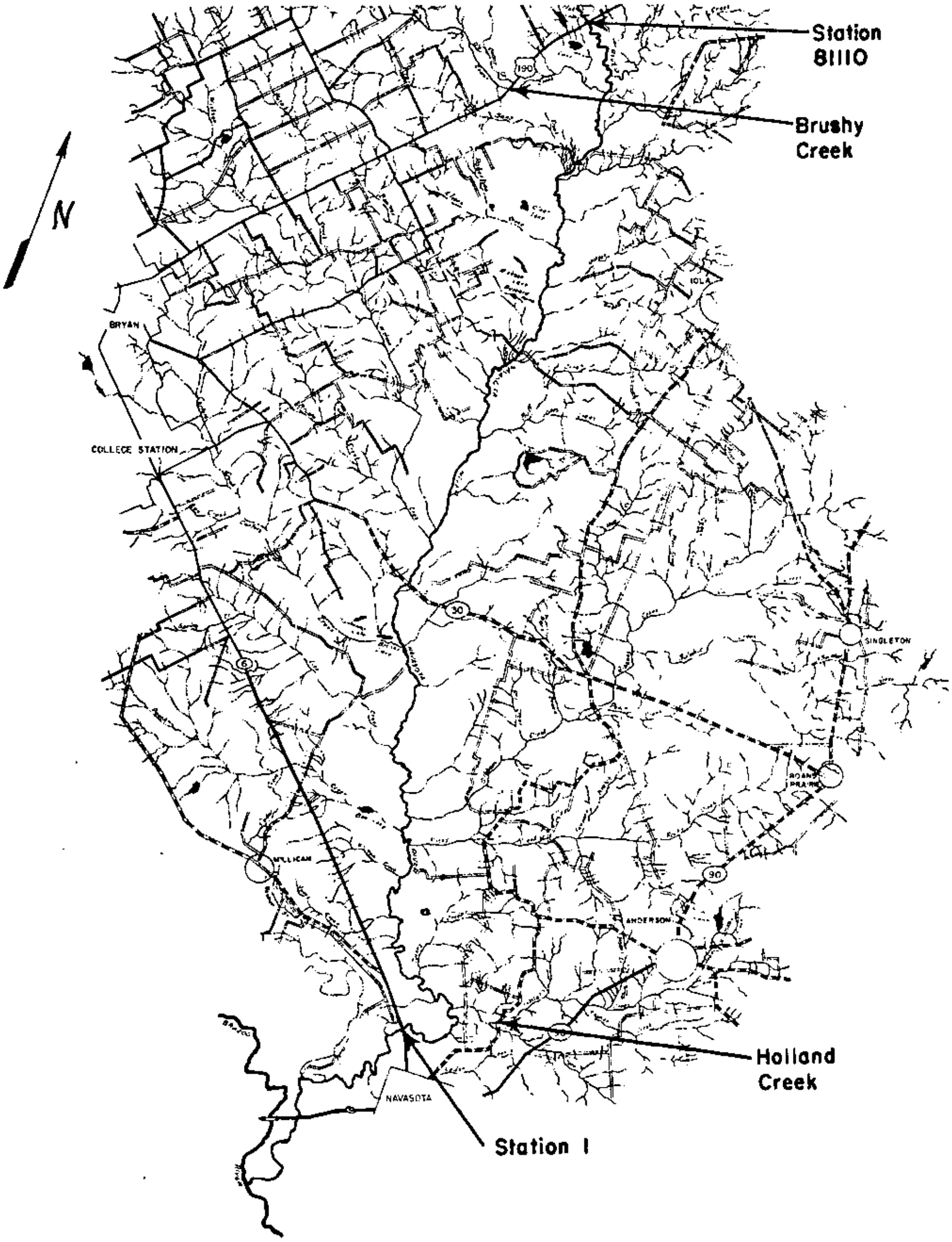


Figure 5

LOWER NAVASOTA RIVER, TEXAS

SCALE 0 1 2 3 4 MILES

Table 1

Texas State Water Quality Board Discharge Permits for the Navasota River as of 1970

Permit Holder	Permit Number	Discharge Route
Brazos County		
Bernath Concrete Co. (Industrial)	00650	Carter Creek & Navasota River
City of Bryan (Municipal & Domestic)	10426	Carter Creek & Navasota River
City of College Station (Municipal)	10024	Carter Creek & Navasota River
Lone Star Gas Co. Welborn Plant (Industrial)	01074	Retention Pit
Pennwalt Corp. (Industrial)	669	Carter Creek & Navasota River (Now using Retention Pit)
Texas International Speedway (Domestic)	11047	Lick Creek & Navasota River (Ponded overflow)
Limestone County		
City of Groesbeck (Domestic)	10182	Navasota River
Bistone Municipal Wtr. Supply Dist. (Municipal)	10387	Navasota River
Lone Star Gas Co. Barron Field (Industrial)	01116	Retention Pit
Lone Star Gas Co. Groesbeck Compressor Station (Industrial)	01066	Retention Pit
Magcobar Minerals Div. of Dresser Industries (Industrial)	01176	Steele Creek & Navasota River

Table 1. Continued

Permit Holder	Permit Number	Discharge Route
City of Mexia (Municipal)	10222	Navasota River
Mexia State School (Municipal)	10717	Navasota River
City of Thornton (Municipal)	10824	Navasota River
Grimes County		
City of Navasota (Domestic)	10231 (918)	Cedar Creek & Navasota River

sometimes over 100°F. Winters are mild, with freezing temperature occuring occasionally with passage of cold fronts and snow on rare occasions. The average length of the growing season between killing frosts is 250 days.

Mean annual precipitation is about 39 inches and has ranged at the Anderson gage from 65.46 inches in 1919 to 17.69 inches in 1917. The heaviest rainfall comes in the Spring; April, May, June.

GENERAL PROJECT DESIGN

Previous Work and Supporting Information

Physical-Chemical

The U. S. Geological Survey maintains a series of stations on the Navasota River. The Numbers, Locations, type of data collected and period of coverage are given in Table 2, and the locations are shown on the watershed maps (Figs. 2, 3, 4, 5).

The U. S. Geological Survey publishes two series of water supply papers containing these data. The series "Surface Water Supply of the United States" contains hydrological data such as discharge, gage height and reservoir storage volume. The other series "Quality of Surface Waters of the United States" contains mean discharge data along with temperature, suspended load and all physical and chemical data. The Navasota River data are found in parts 7 and 8 of these series.

Beginning with the 1961 water year the hydrological data were released on a state-wide basis in the series "Surface Water Records for Texas". Beginning with the 1964 water year the water quality data were also released in a state-wide series, and the general name of the series changed to "Water Resources Data for Texas" with Part 1, "Surface Water Records" and Part 2, "Water Quality Records". Copies of these reports may be obtained form the District Chief, Water Resources Division, U. S. Geological Survey, Federal Building, 300 East 8th Street, Austin, Texas 78701.

All U. S. Geological Survey data used in this report have been taken from these state series unless otherwise cited.

Table 2

U. S. Geological Survey
Stations on the Navasota River

No.	Name	Location	Type of Data	Year Began
8-1110	Bryan	U. S. Highway 190 (St. Highway 21)	Discharge	1950
			Temperature	1950
			Chemical Quality	1958
8-1105	Easterly	U. S. Highway 79	Discharge	1924
			Sediment	1942
			Temperature	1948
			Chemical Quality	1968
8-1104	Groesbeck	St. Highway 164 E.	Discharge	1965
			Chemical Quality	1967
			Temperature	1967
8-1103	Lake Mexia	At dam	Reservior gage height	1961

A large series of special publications on Texas waters is available through the Texas Water Development Board, P. O. Box 12386, Capitol Station, Austin, Texas 78711. They will supply an index to available publications upon request. Circulars 62-04 and 64-03 of the Texas Water Commission, an older name for the Water Development Board, are indexes which list many additional publications. Those out of print are usually available at the Water Development Board Library.

There is one Texas A&M University Masters Thesis (Cowan 1933) on Rainfall and Stream flow in the Navasota.

Biological

There are no checklists, keys, or publications of any kind on the algae or invertebrates of the Navasota River basin, nor do any general works exist for the state of Texas or the general Gulf Coast region. (Clark 1969)

There is a Texas A&M University Masters Thesis (Massey 1965) on aquatic vascular plants which covers much of the watershed and should be applicable to the remainder.

The fishes are better known (Rozenburg 1970, Rozenburg et al, 1972). Check lists and keys to Texas fishes are available and good collections exist at Texas A&M University and the University of Texas.

Sampling Procedures

Two types of data collection procedures were adopted. (1) fixed stations visited on a regular basis, and (2) random collections at as many sites on the river and tributaries as time and logistics would allow.

Table 3

Regular Project Sampling Stations on the Navasota River and Tributaries

Station	Location	Sampling Period
Station 1	Crossing of Texas Highway 6 Near Navasota	Feb. 1968-Jan. 1970
Station 2	Crossing of Old San Antonio Road Near Normangee	Feb. 1968-Jan. 1970
Station 3	Crossing of State Highway 7 Near Marquez	Feb. 1968-Jan. 1970
Station 4	Below Lake Spring-field Dam Near Groesbeck	Feb. 1968-Jan. 1970
Station 5	Grossing of US Highway 84 Near Mexia	Feb. 1968-Jan. 1970
Holland Creek	Crossing of Farm-to-Market Road 244 Near Navasota	April 1969-March 1970
Cedar Creek	Crossing of US Highway 190 Near North Zulch	April 1969-March 1970
Brushy Creek	Crossing of Farm-to-Market Road 977 Near Marquez	April 1969-March 1970

The fixed stations are listed in Table 3 and shown on the watershed maps (Figs. 2, 3, 4, 5).

Reliable access to the river is limited to crossings of surfaced roads, and we could only handle five main channel stations in a single days collecting trip. We also wanted to avoid duplicating the USGS stations, and to have stations above and below probable reservoir sites.

The tributary stations were chosen from those with reliable access, and to give one permanent flow tributary below the Millican dam (Holland Creek), one permanent flow tributary above the Millican reservoir (Cedar Creek) and one intermittent flow tributary (Brushy Creek). When the reservoir is very full, Cedar Creek will probably enter the upper headwaters.

Locations of random stations at which fish were collected are given in the data supplement. Locations for algae and invertebrate collections are more numerous and are not listed.

Physical-Chemical

Unless otherwise noted the physical-chemical data reported were collected during twice monthly runs of the regular stations. When only the five main channel stations were used, they were run all on the same day and on alternate weeks. After the tributary stations were added they were also run on a single day, alternating weeks with the main channel stations. That is; one week the main channel stations would be run and the next week the tributary stations would be run, each run being completed in a single day.

Physical and Chemical data collected at random sampling stations are reported in tables in the data supplement.

Biological

Zooplankton collections were made as part of the runs of the regular sampling stations, and algae collections were often made at the same time. Lack of time precluded benthic or fish collections during the regular station runs.

Field trips for biological collections tended to be either for fishes or for benthos. From a practical standpoint it turned out to be very ineffecient to try to do both on the same trip.

The watershed was divided roughly into thirds (Figs. 3, 4, 5) and trips were rotated to prevent concentration of effort in interesting or more accessible areas.

The dividing line between the lower and middle sections is the Old San Antonio Road (OSR) which is the dividing line between Brazos and Robertson Counties on the west side of the river and between Madison and Leon Counties on the east side of the river.

The dividing line between the middle and upper sections is the county line between Limestone and Robertson Counties on the west side of the river and between Freeston and Leon Counties on the east side of the river.

PHYSICAL

Discharge

Methods

USGS data are from recording gages at carefully calibrated stations.

Project data are much less accurate. We constructed cross sections, at all stations except No. 4, by measuring to the substrate from a reference line on the bridge structure. Measurements were by weighted metal sounding line at one foot intervals. Velocity estimates were made by the float method at several water levels, and discharge calculated. (The maximum velocity measured was 4.2 ft/sec.) A plot of water level against gage height (distance from the bridge reference point to the water surface) was made and a curve fitted by eye. Gage height was read at every sampling visit and later discharge was estimated using the rating curve.

Results and Discussion

Uneven distribution of precipitation and the long narrow shape of the watershed combine to produce extreme variations in runoff. Annual discharge in acre feet for the period 1924-1968 at USGS Station 81105, Easterly, is shown in Figure 6. The Easterly Station is near the midpoint of the watershed, and the low flows might be increased by the contributions of additional tributaries in the lower part of the river, but the range is never-the-less spectacular, and is one of the fundamental controlling phenomena of the Navasota ecosystem.

When the mean discharge for each month is averaged over a number of

USGS STATION 81105 EASTERLY ANNUAL DISCHARGE

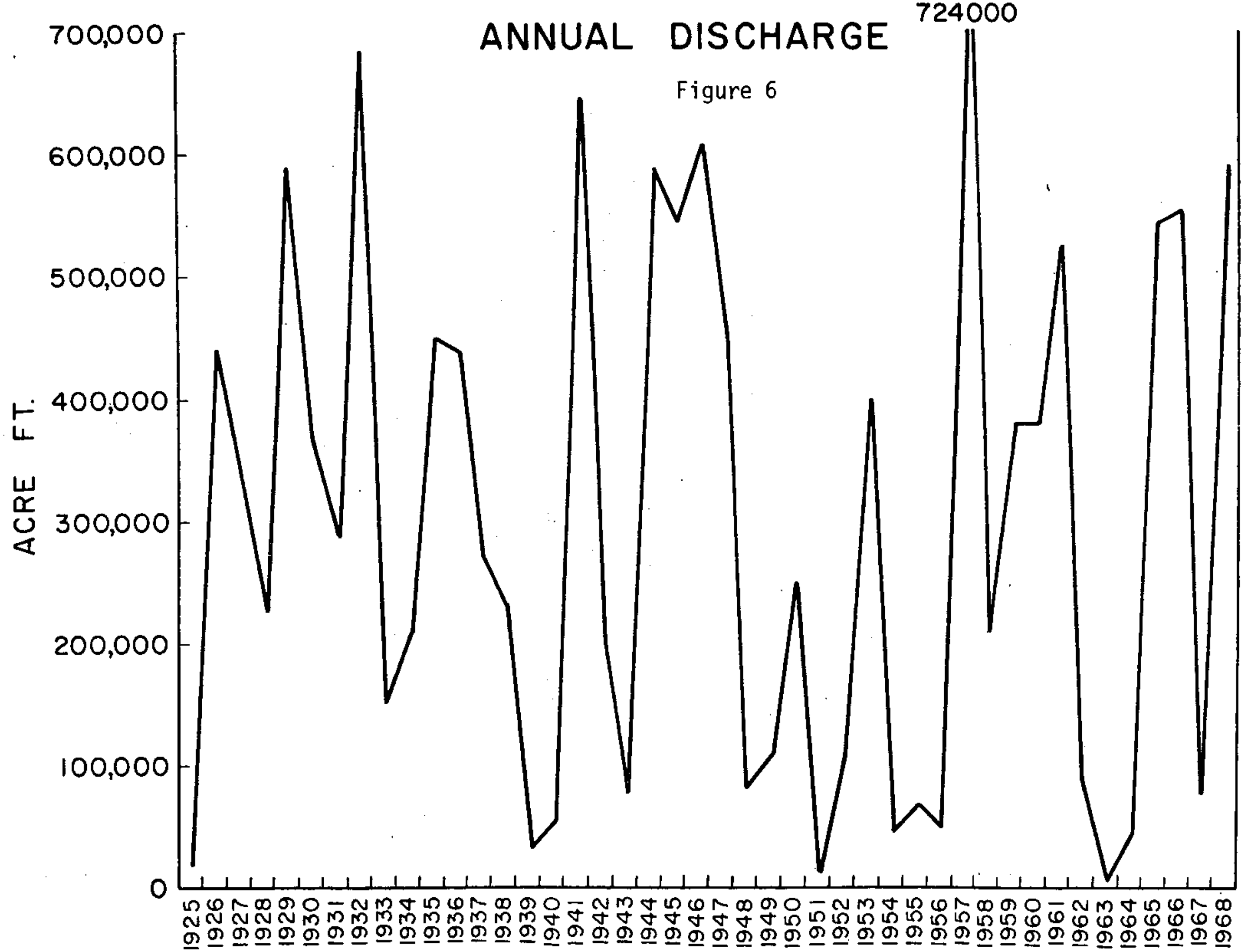


Figure 6

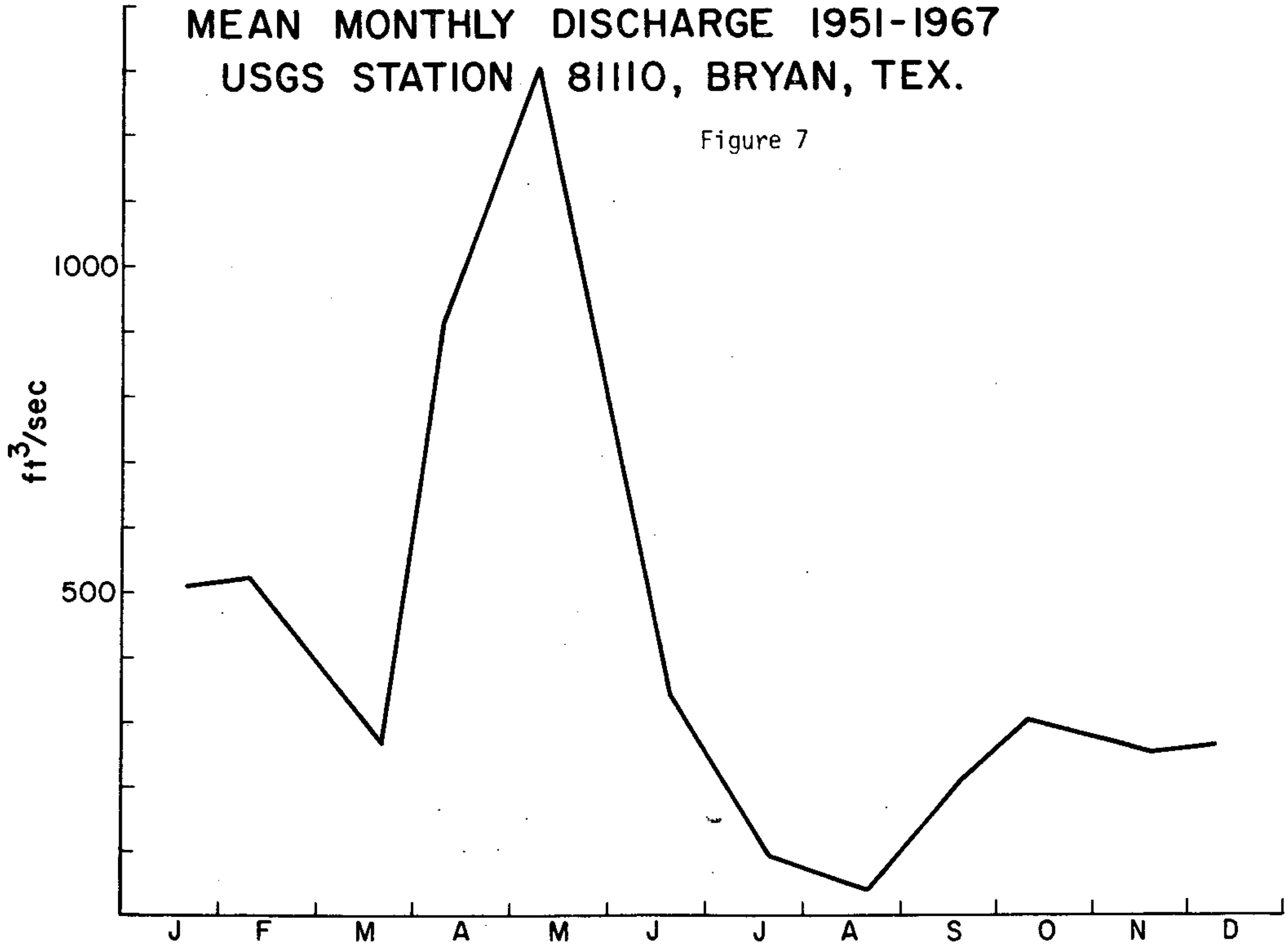
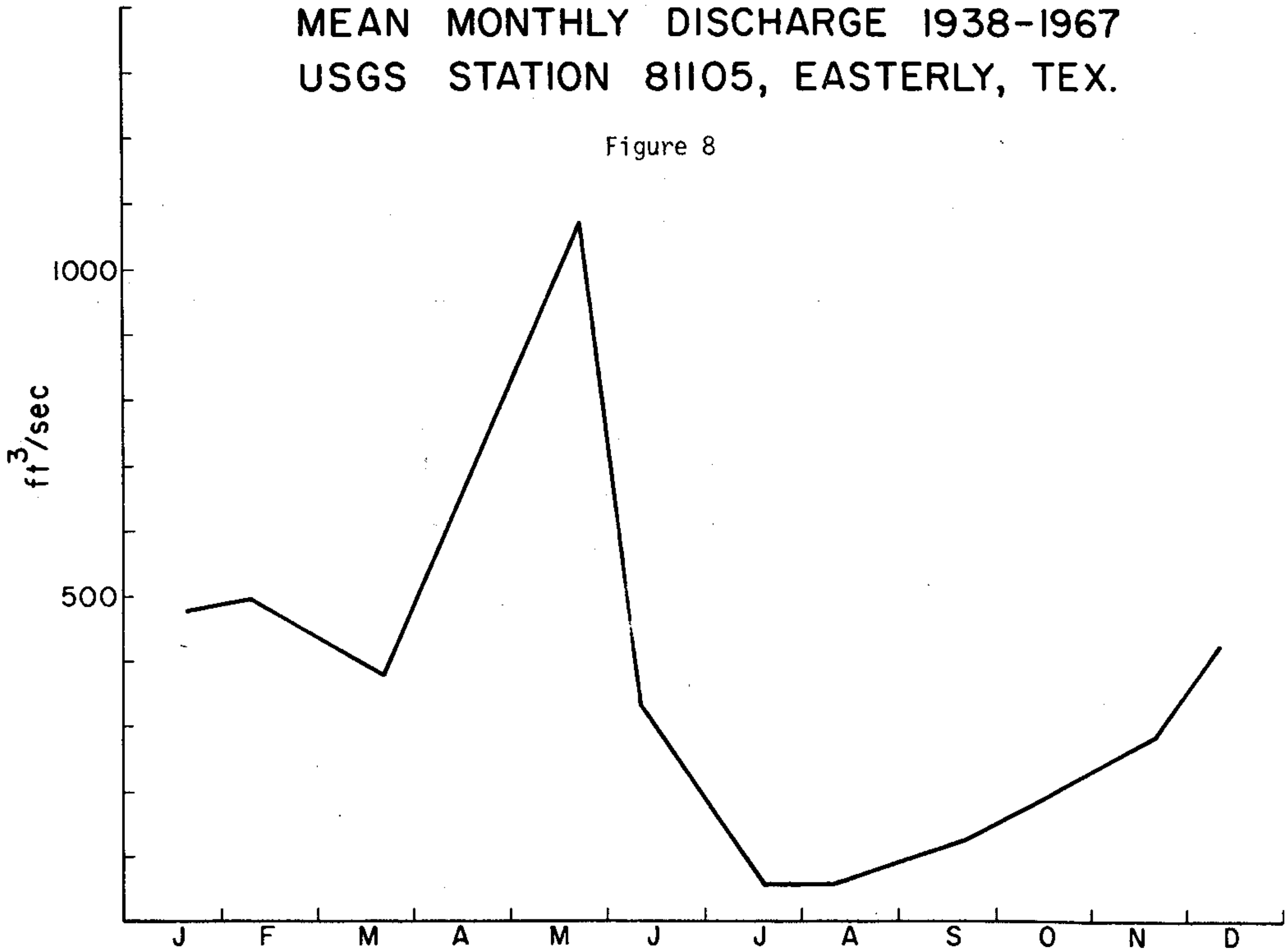

MEAN MONTHLY DISCHARGE 1951-1967
USGS STATION 81110, BRYAN, TEX.
ft³/sec
1000
500
J
F
M
A
M
J
J
A
S
O
N
D

Figure 7

MEAN MONTHLY DISCHARGE 1938-1967
USGS STATION 81105, EASTERLY, TEX.

Figure 8



years, more order results (Figs. 7 & 8). The curves for the two stations are similar in shape, maximum in the spring, minimum in summer, and moderate during the winter.

Discharge data for the project period are shown in Figures 9 through 17.

The erratic nature of the main channel discharge is evident. The differences in pattern between the USGS data and project data reflect the difference in method of data collection. The continuous recording of the USGS gives good definition of the spates (floods) while the twice monthly readings of project stations result in a smoothed curve in which some spates can be missed entirely. Another result is that while individual spates can be traced from one USGS station to the other, this is not possible with project data. For example, if rainfall in the upper watershed caused a spate which reached its peak at station 3 on collection day, it would not be evident at station 2 and 1 on that same day, but would have largely progressed into the Brazos before the next collection trip and thus might never show up at the lower stations. The individuality of the record at a given station is exemplified by the major flood of late April 1969 at 81110, which was not significantly greater than several others at station 81104. The major portion of the precipitation which caused the flood apparently fell in the central part of the watershed. Discharge data for the tributaries reflects the characteristics for which they were chosen. Holland Creek (Figure 15) has a small watershed with several springs, giving it a more stable flow. Cedar Creek (Fig.16) has a large watershed and had no flow only in October 1969. Brushy Creek (Fig. 17) is an intermittent stream, representative of the majority of

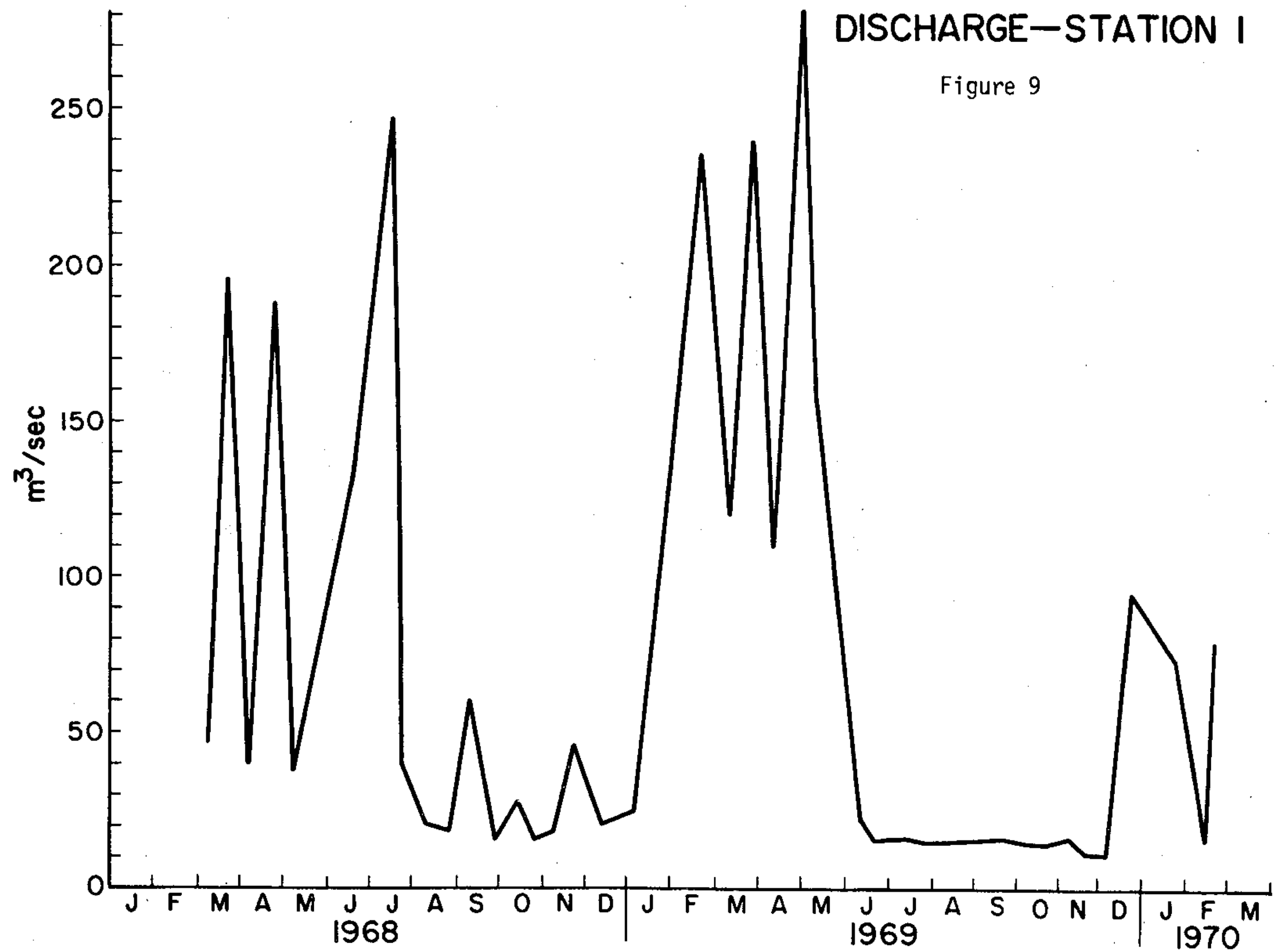
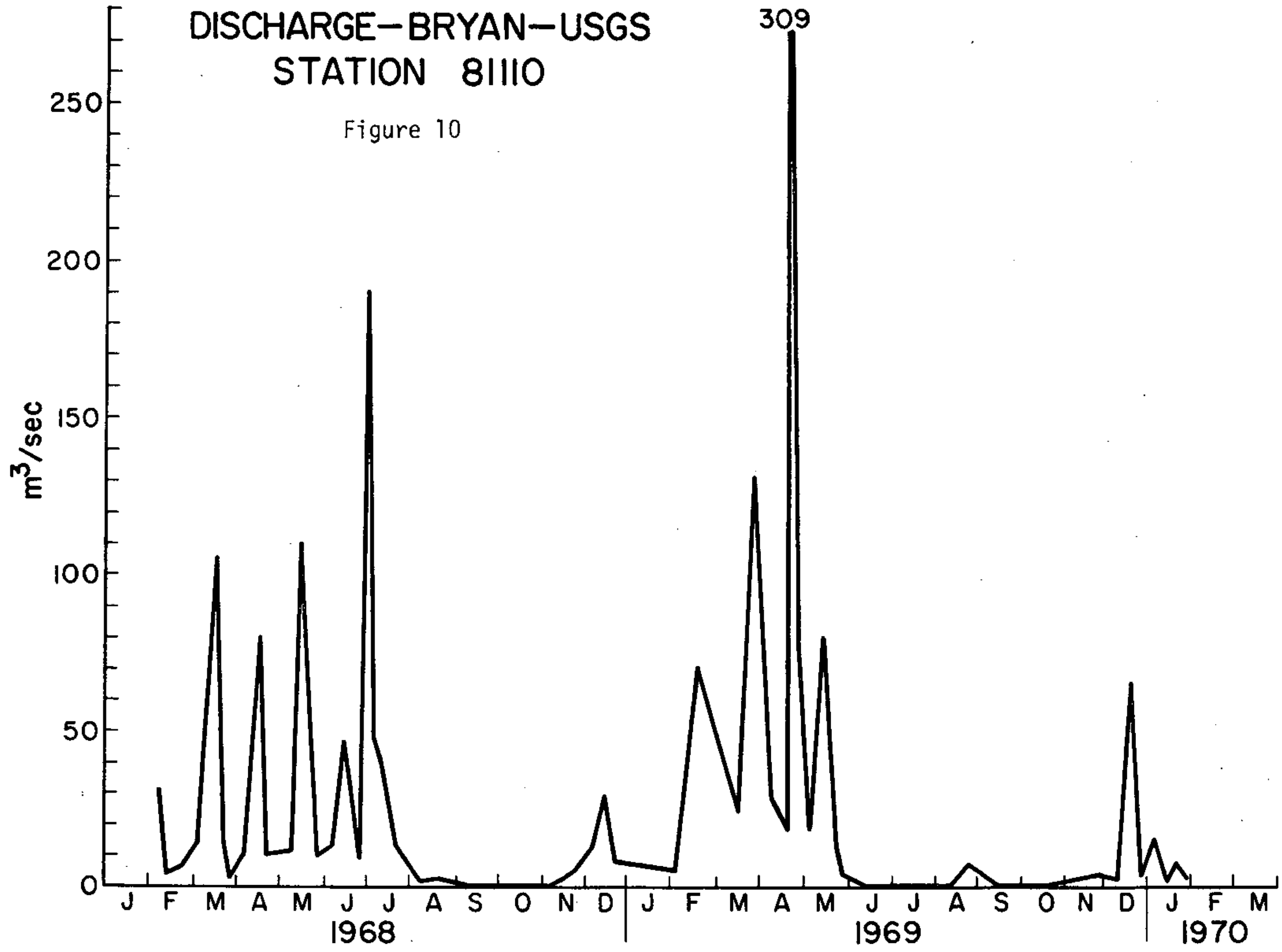

DISCHARGE—STATION I
m3/sec
0
50
100
150
200
250
J F M A M J J A S O N D
1968
J F M A M J J A S O N D
1969
J F M
1970

Figure 9

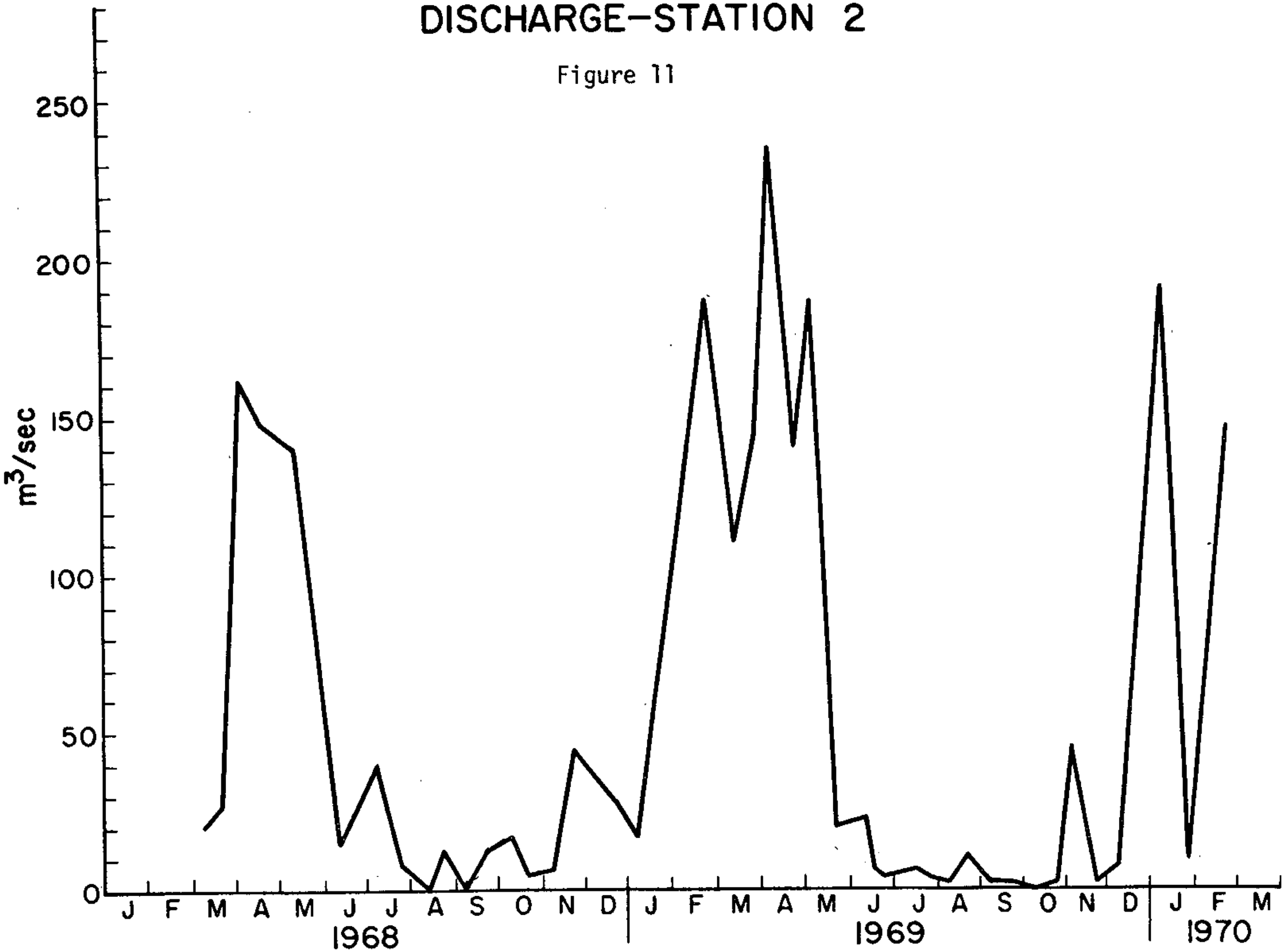
DISCHARGE—BRYAN—USGS STATION 81110

Figure 10



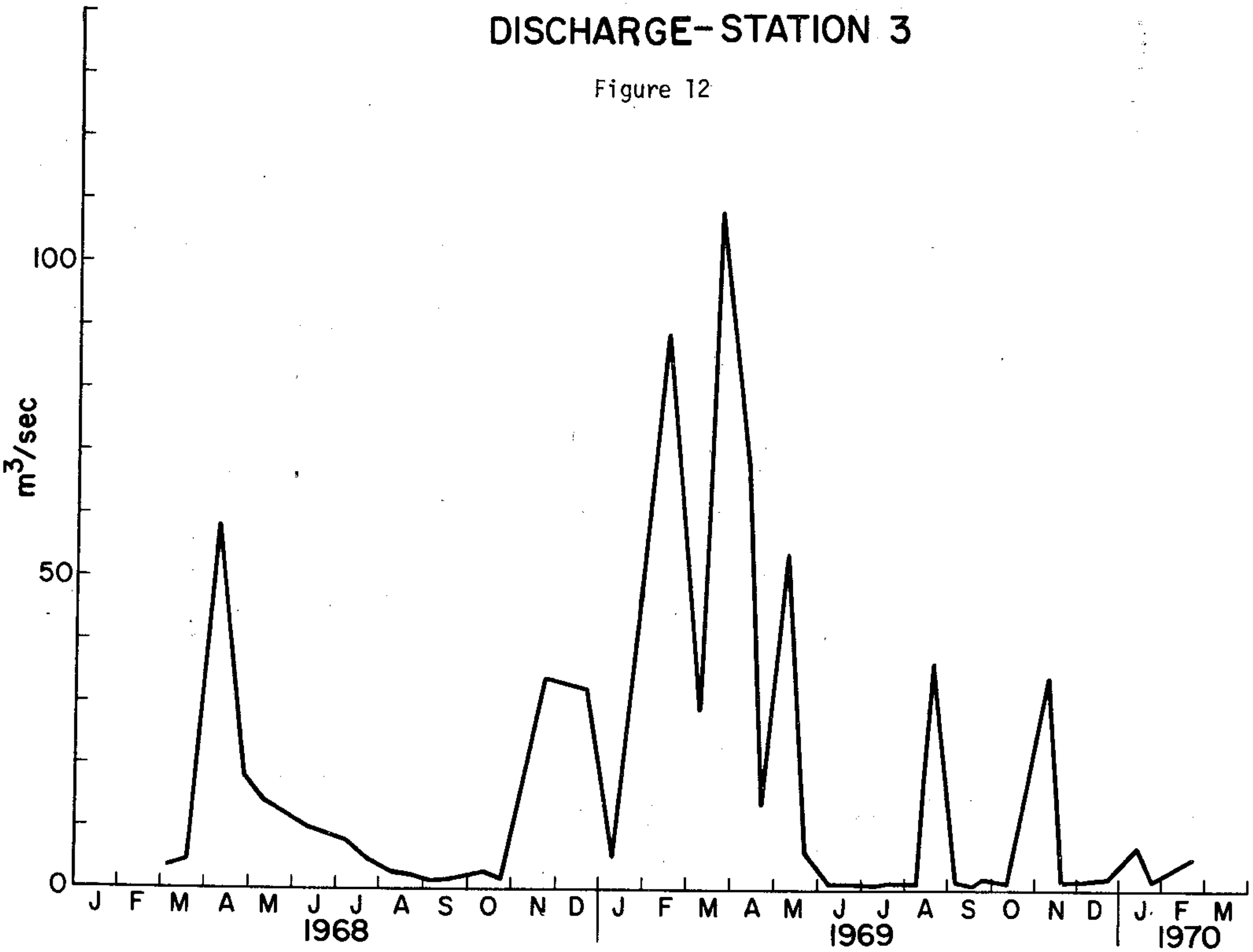
DISCHARGE–STATION 2

Figure 11



DISCHARGE–STATION 3

Figure 12



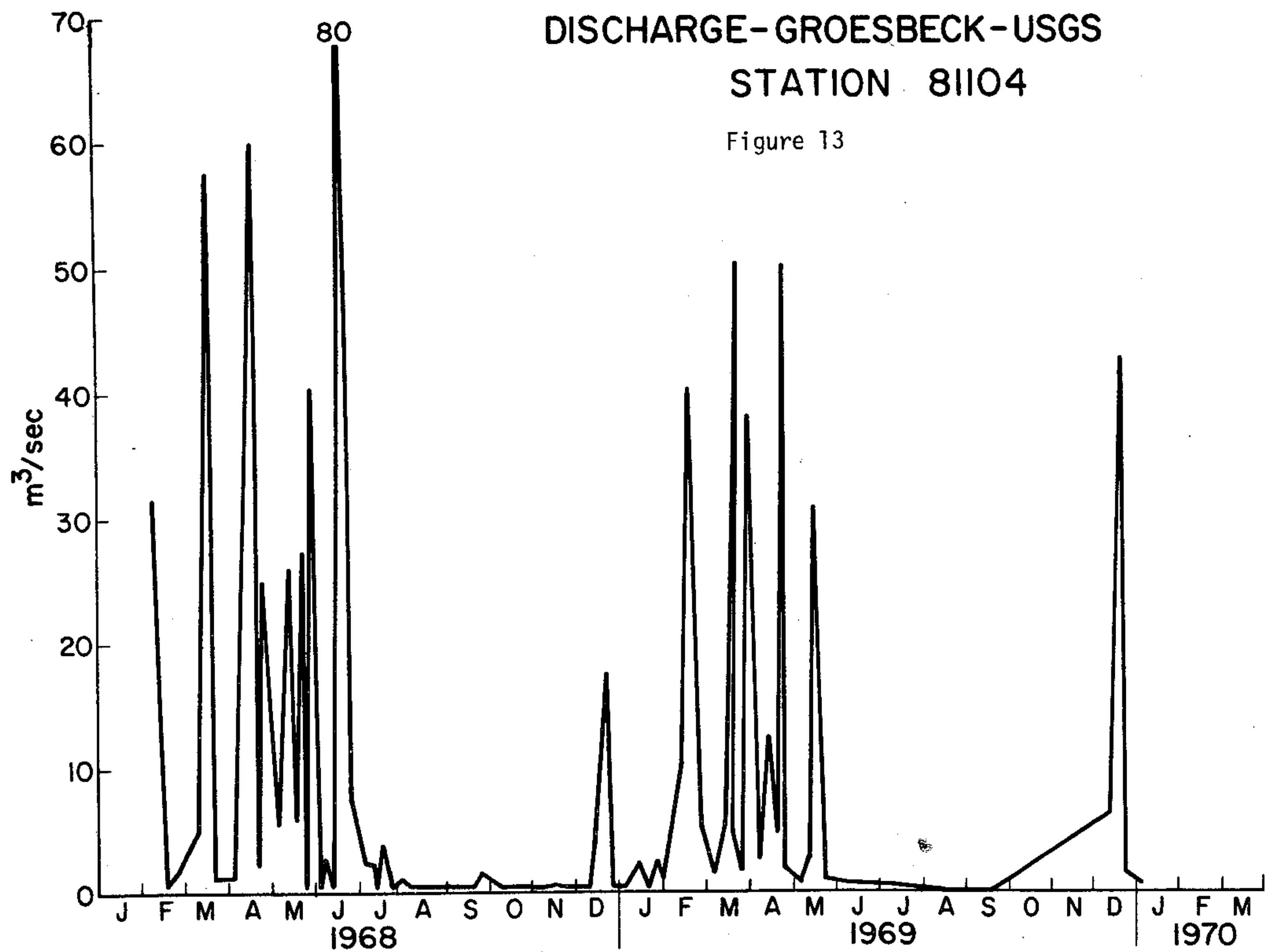
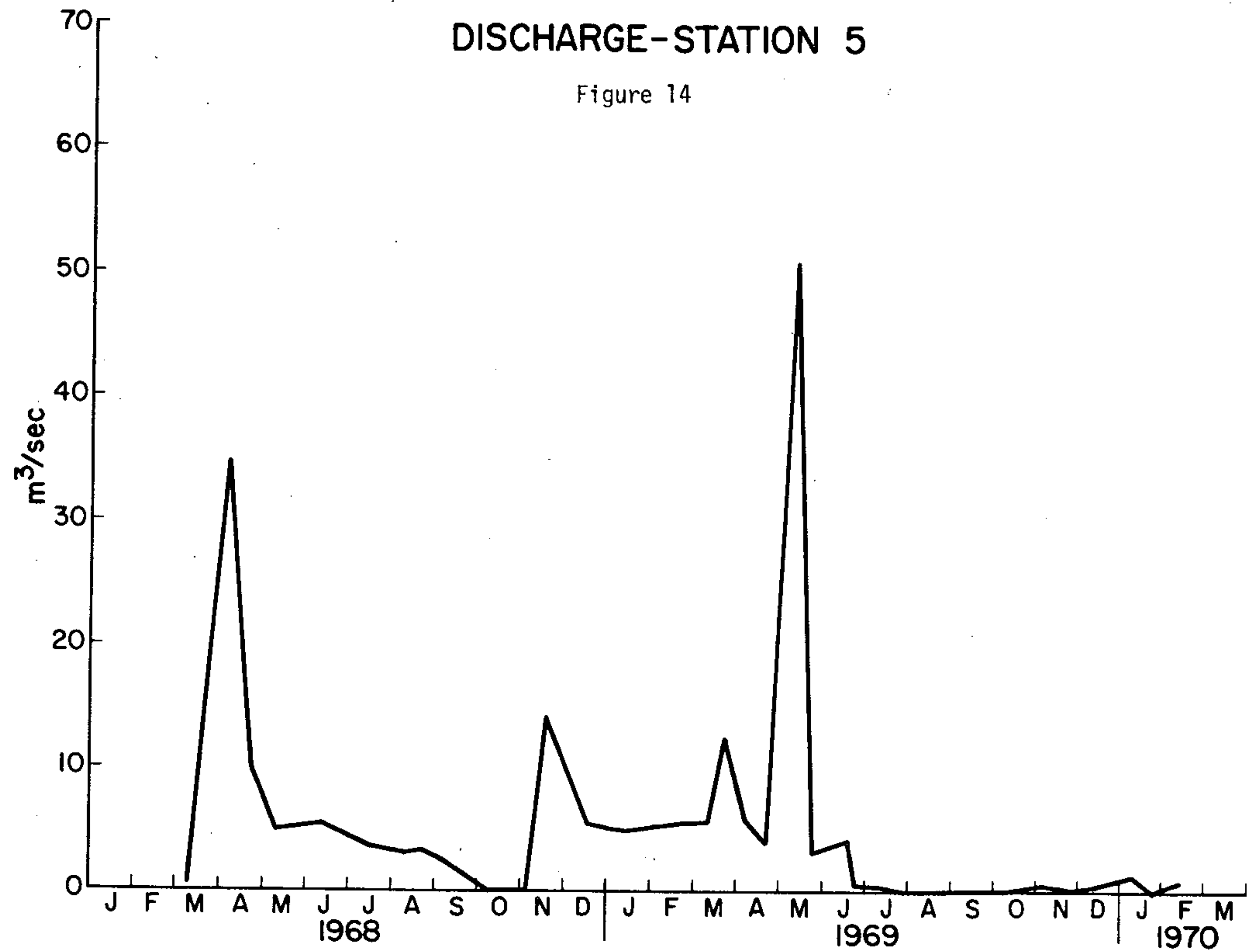

DISCHARGE-GROESBECK-USGS
STATION 81104
m3/sec
70
60
50
40
30
20
10
0
80
J F M A M J J A S O N D
1968
J F M A M J J A S O N D
1969
J F M
1970

Figure 13

DISCHARGE-STATION 5

Figure 14



DISCHARGE–HOLLAND CREEK

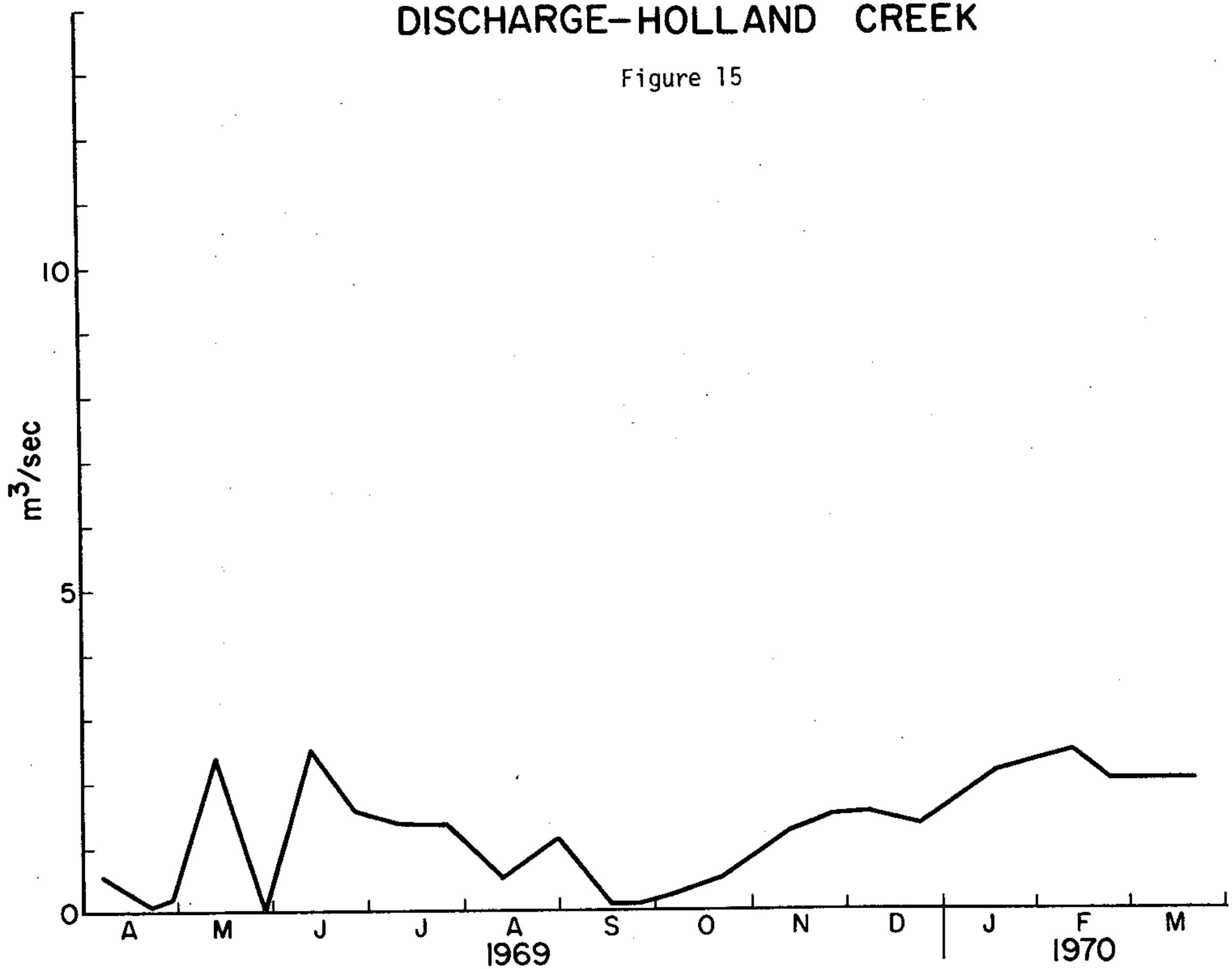
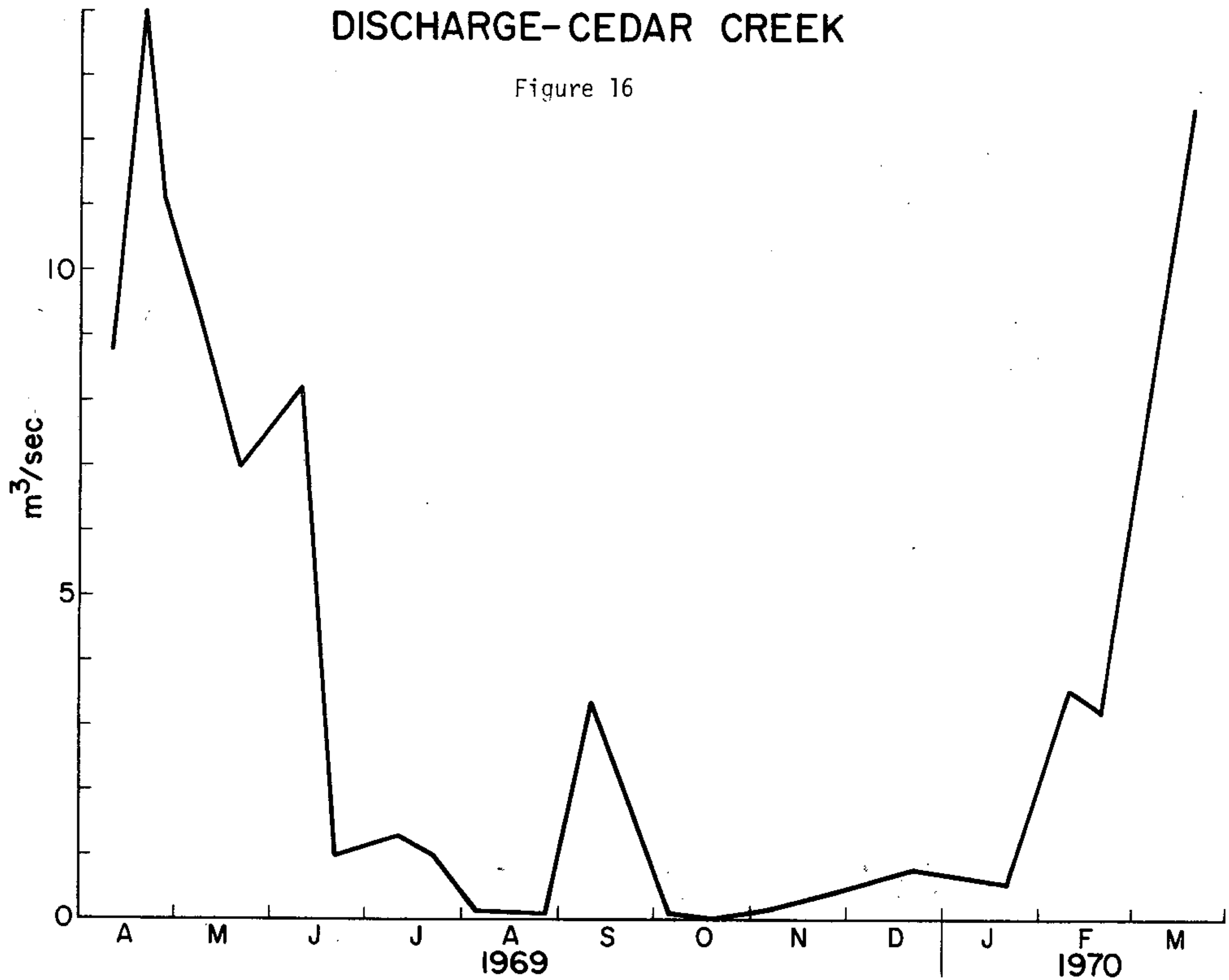


Figure 15

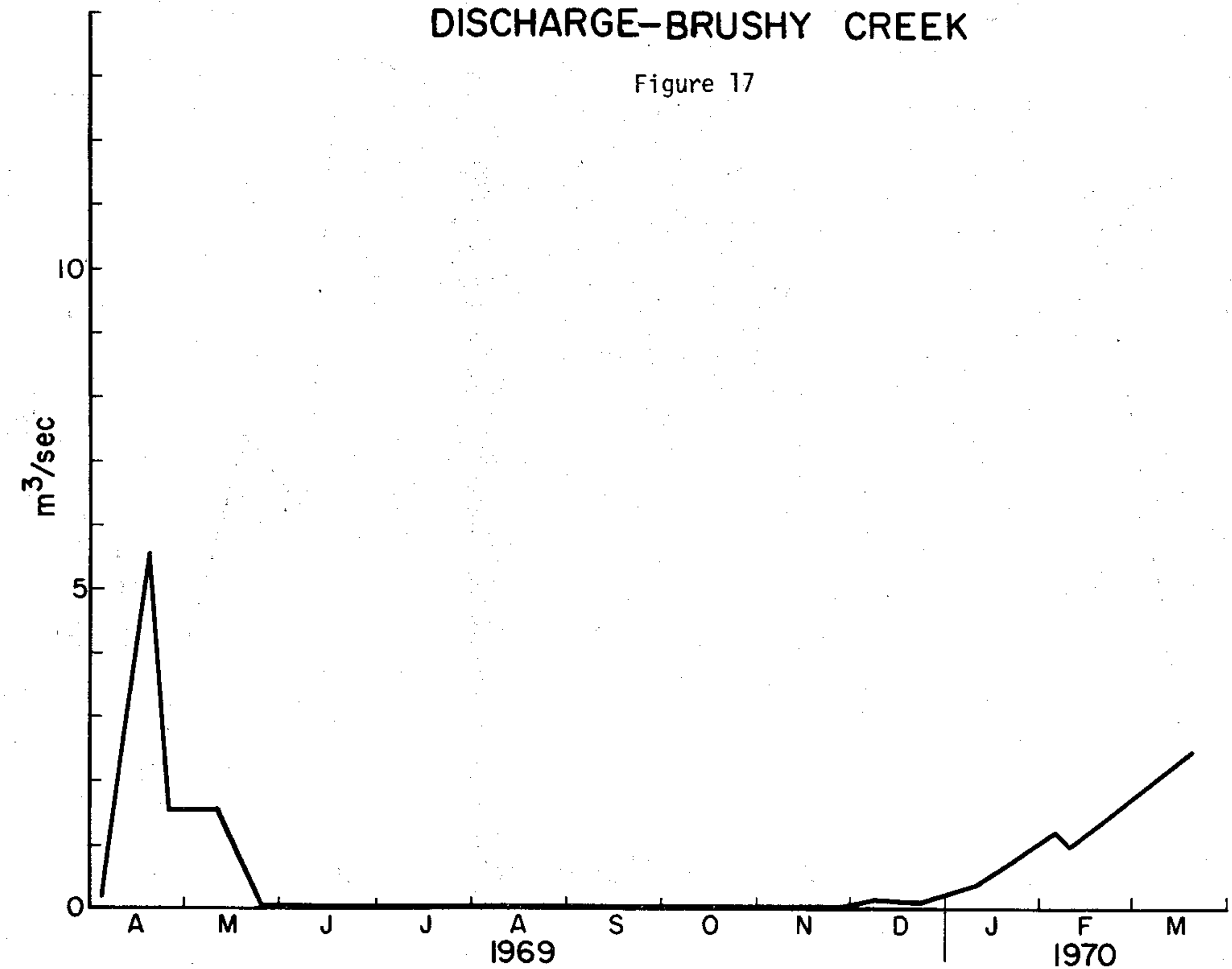
DISCHARGE-CEDAR CREEK

Figure 16



DISCHARGE–BRUSHY CREEK

Figure 17



the tributaries to the Navasota. The actual number of tributaries showing continuous flow during a year would vary with the rainfall pattern. In drouth conditions, probably not more than 8 or 10 would maintain flow. For most of the channels in the watershed, water flows only following a rain, with pools persisting for varying periods of time depending on their depth and protection. The hydrological picture is one of extreme fluctuations, both seasonally and from year to year. Periodic flooding is the natural state for the Navasota.

Temperature

U. S. Geological Survey temperature data for Station 81110 on the Navasota and for Station 81095 on the Brazos River near Bryan along with project data, are given in Table 4. The trends and ranges for the two USGS stations are similar, despite the considerable difference in the size of the streams. The USGS data were taken once a day at the time of collection of the water samples. Similar data taken during project collections show no significant deviations from the USGS data so far as minimum temperatures are concerned, but show higher summer maxima. We deliberately took temperatures in the shallow water, however, since this is the habitat of many aquatic organisms of interest.

We attempted to use maximum-minimum thermometers, but could never develop installation methods which could withstand the twin problems of spates and vandalism. The limited data collected show no extensions for the minimum temperatures, but give two maximums of 37^{0} from an isolated pool on Holland Creek in August and September, 1969. Rivers and streams are shallow, well-mixed systems which adjust quickly to local weather

Table 4

Water temperatures in degrees C, Navasota and Brazos Rivers
Project Temperatures
(April 1969 - February 1970)

Location	Temperatures at Collection times	Max. - Min. Thermometers
Station 1	7-33	
Station 2	4-32	
Station 3	3.5-35	
Station 4	4-32	
Station 5	2.5-35	
Cedar Creek	8-28	7-36
Brushy Creek	4-30	6-31
Holland Creek	3.5-35	2.5-37

USGS Temperature data, water year 1970

Month	Station					
	Navasota 81110			Brazos 81095		
	Min.	Max.	Avg.	Min.	Max.	Avg.
October 1969	16.0	24.5	20.5	14.0	25.5	20.0
November	12.0	16.0	----	10.0	20.0	16.5
December	9.0	16.0	12.5	9.0	14.5	12.5
January 1970	6.0	14.0	----	6.0	15.5	11.5
February	8.0	13.0	11.0	9.0	14.5	12.5
March	11.0	18.0	14.5	9.0	17.0	13.5
April		incl. data		14.0	20.0	18.5
May	19.0	25.0	22.5	14.0	24.5	20.5
June	22.0	30.0	26.5	10.5	33.5	21.0
July	26.0	30.0	28.5	24.4	31.5	28.5
August	26.0	31.0	28.5	27.0	31.5	29.5
September	28.0	20.0	26.0	20.5	31.5	38.0

changes.

Turbidity and Suspended Load

Turbidity was measured on a Hach colorimeter calibrated in Jackson Turbidity Units.

The Navasota is a turbid stream (Figures 18-25). Main channel turbidities were often over 100 Jackson Turbidity Units (JTU), and reached 400 to 500 JTU's during spates. In general turbidity decreased upstream, with station 4 showing the settling which occurred in Lakes Mexia and Springfield. The Tributary turbidities were lower than those of the main channel, with Holland Creek the lowest. A general rain in early November 1969 is reflected in turbidity peaks at all stations except No. 4. The peak in August at station 3 comes from a local rainstorm. The consistent high turbidity at station 1 during low flow in August and September is the result of construction of a new bridge just upstream from the sampling station, during which considerable dirt was pushed into the river and much raw earth exposed.

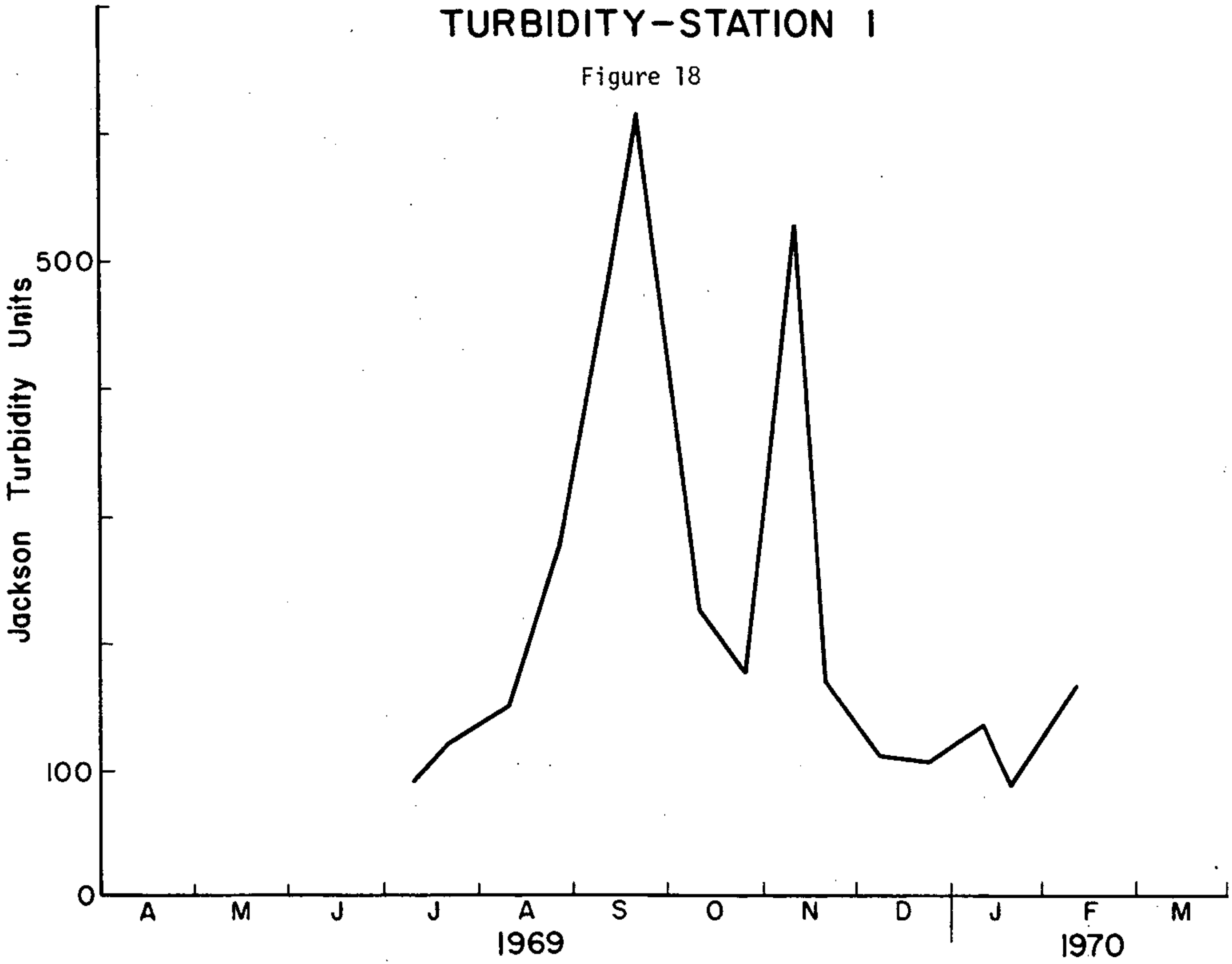
Annual suspended load data for USGS station 81104 are shown in figure 26. (Texas Board of Water Engineers 1961, Texas Water Development Board 1967, 1970) The range is spectacular, and in general parallels the annual discharge data shown in figure 6, as would be expected.

Bottom Types

No intensive survey was made. Bottom types were evaluated by observation. There were very few naturally occurring boulder, rock, or gravel substrates on the main river channel. Most of the bottom

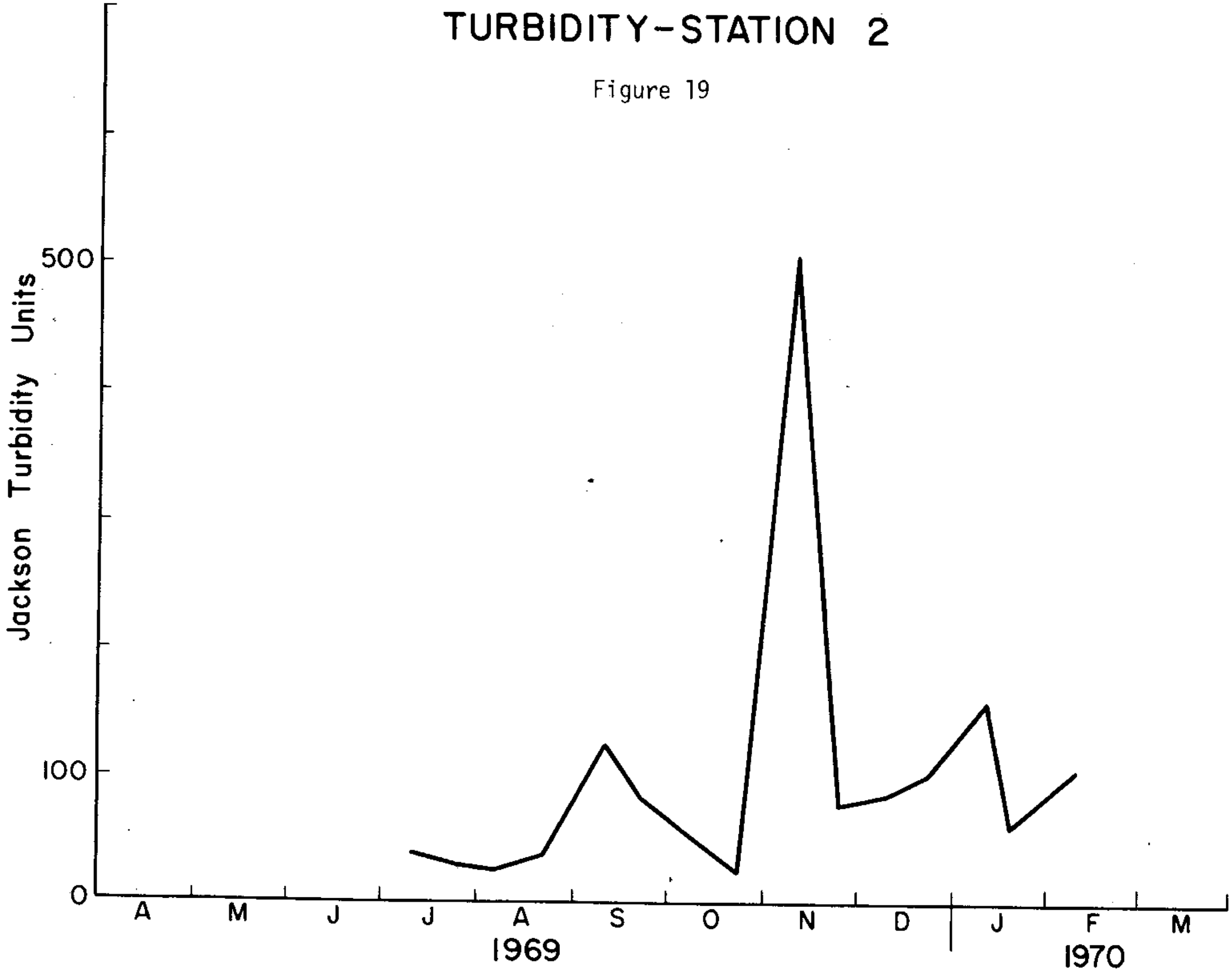
TURBIDITY–STATION I

Figure 18



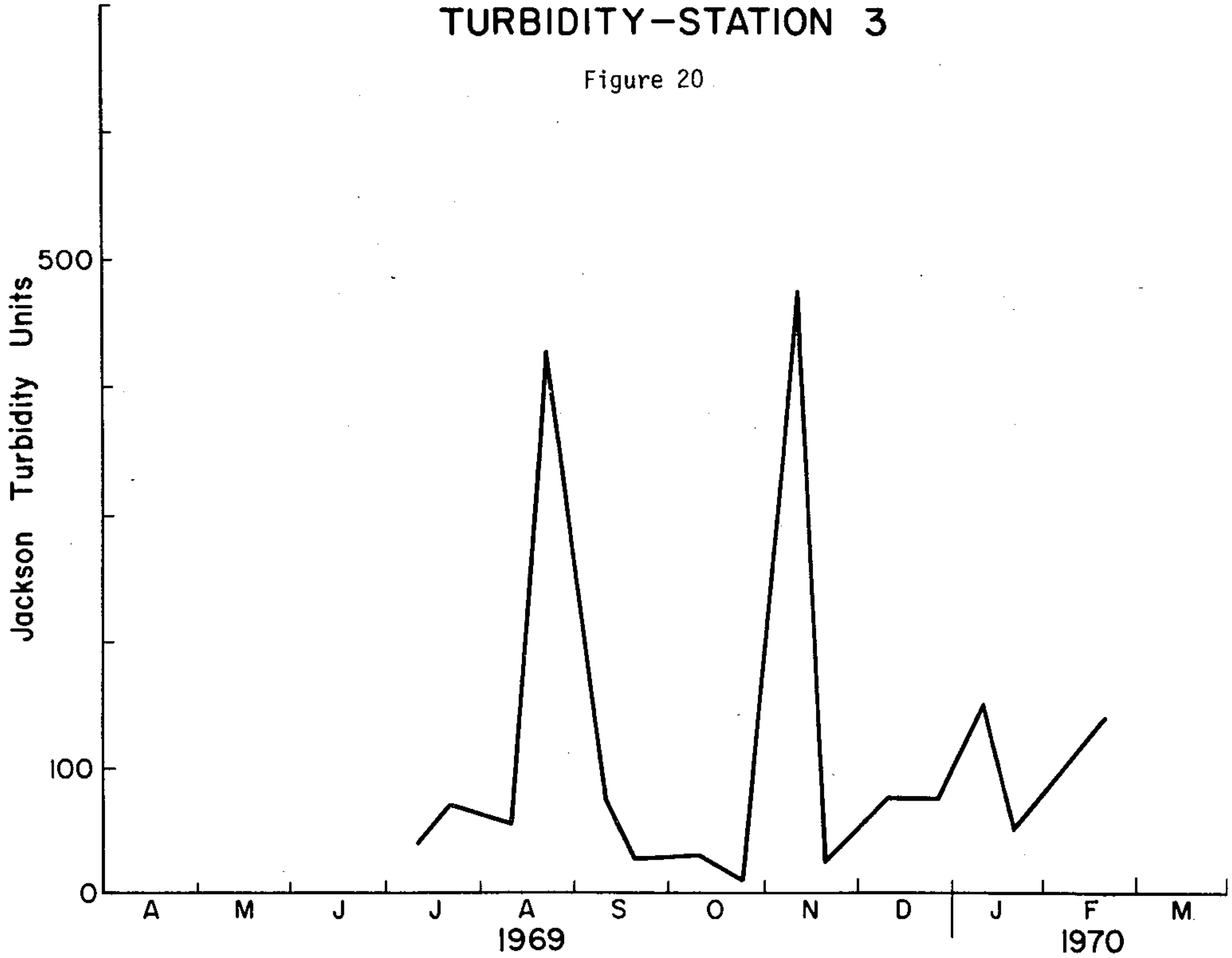
TURBIDITY-STATION 2

Figure 19



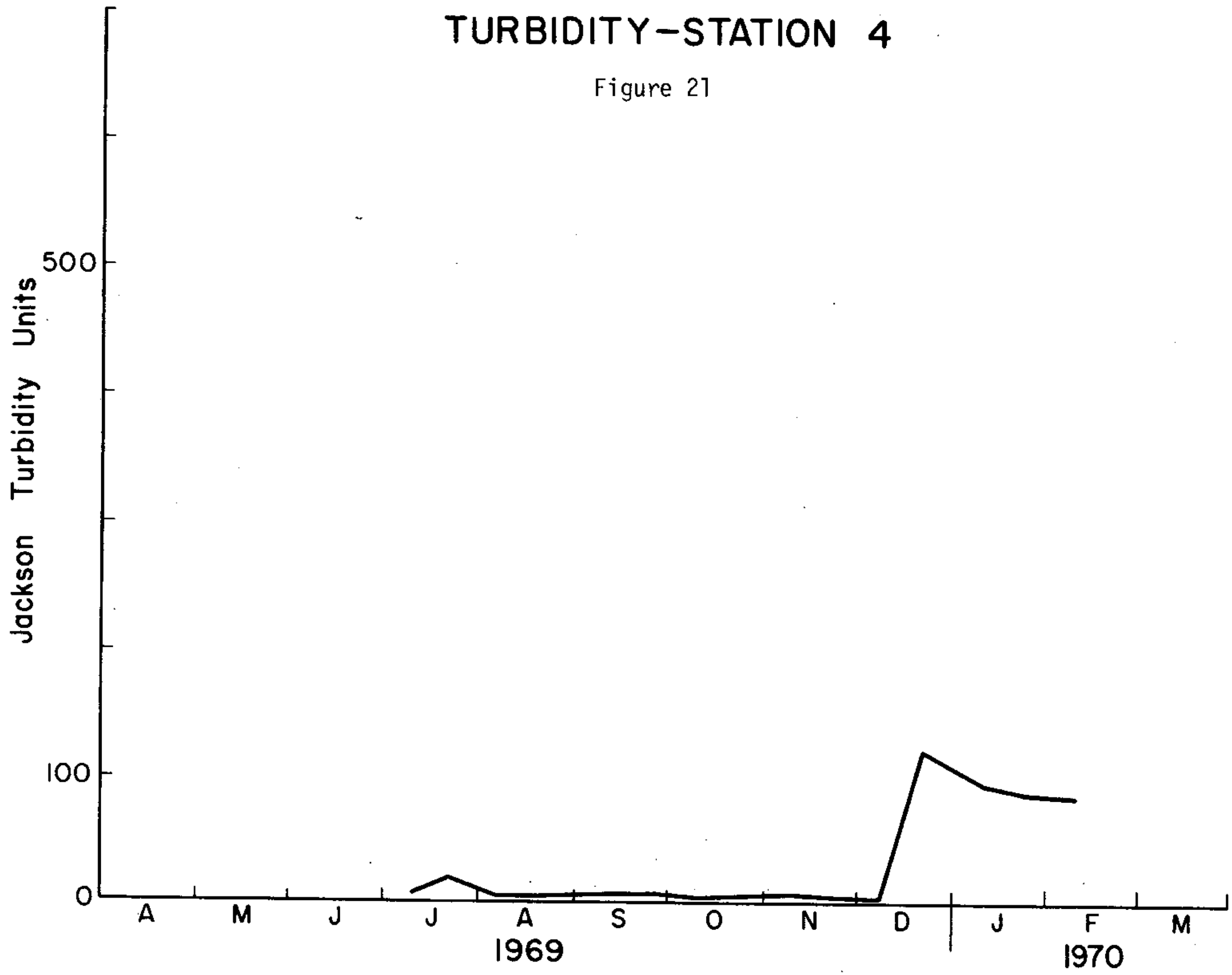
TURBIDITY—STATION 3

Figure 20



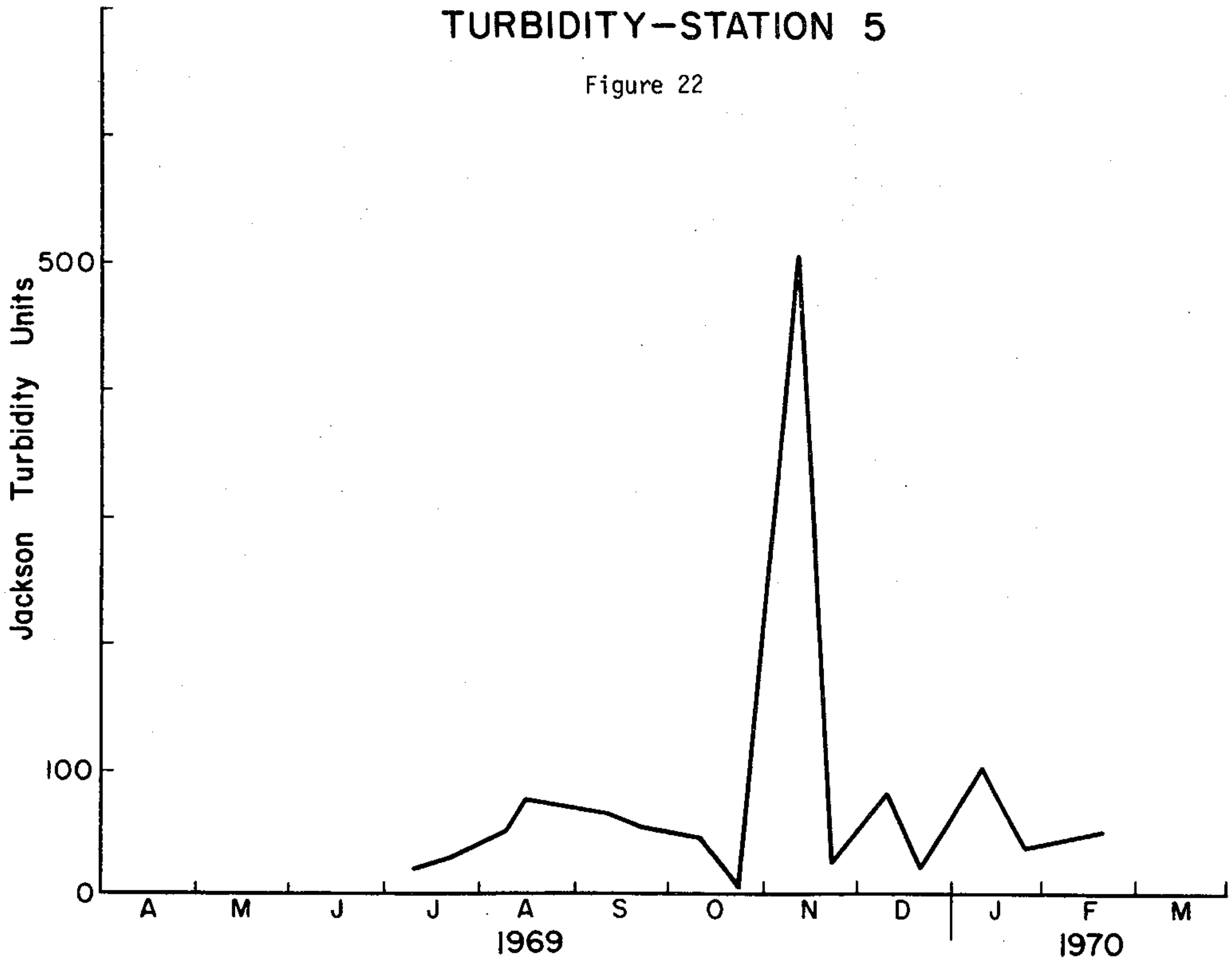
TURBIDITY-STATION 4

Figure 21



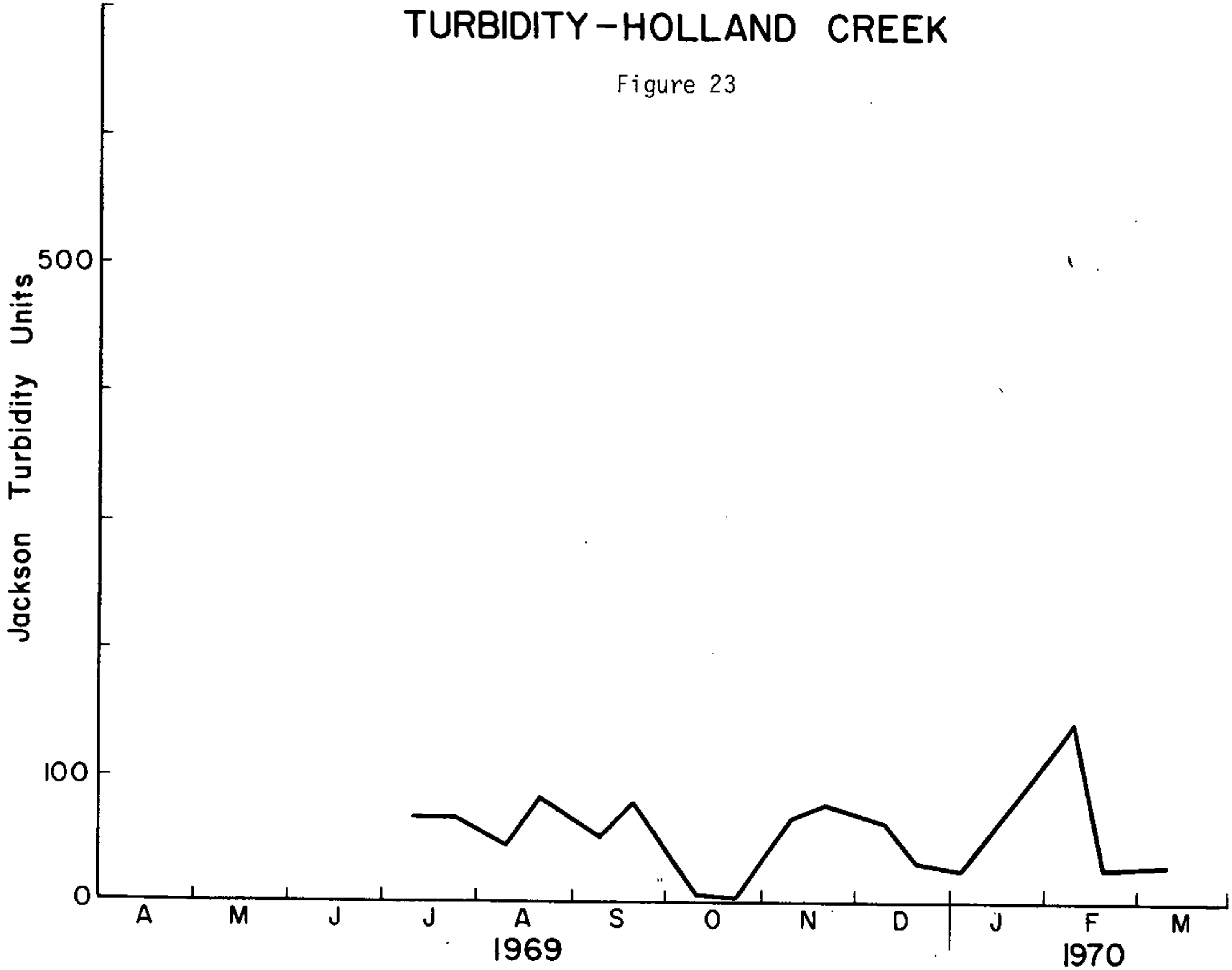
TURBIDITY-STATION 5

Figure 22



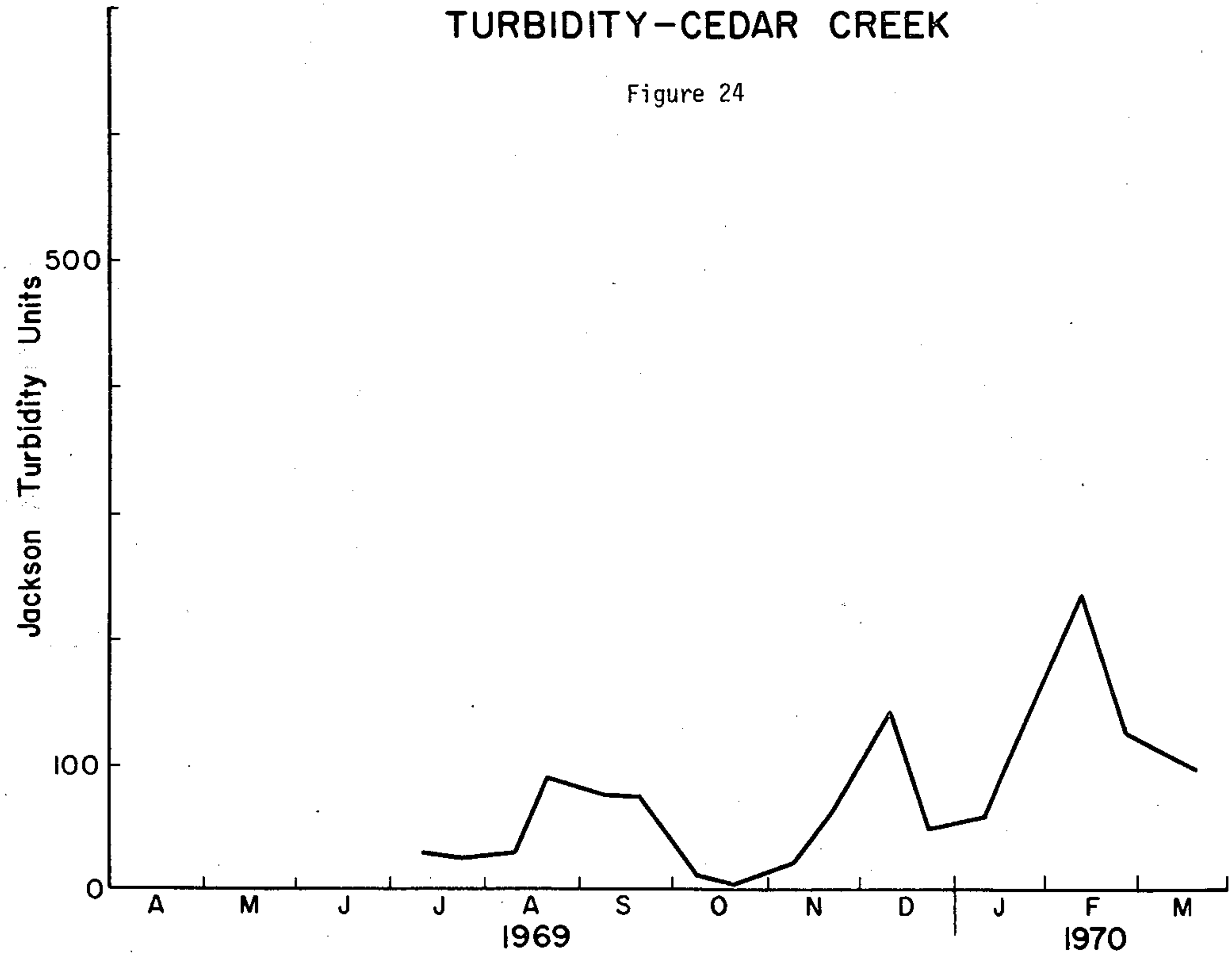
TURBIDITY-HOLLAND CREEK

Figure 23



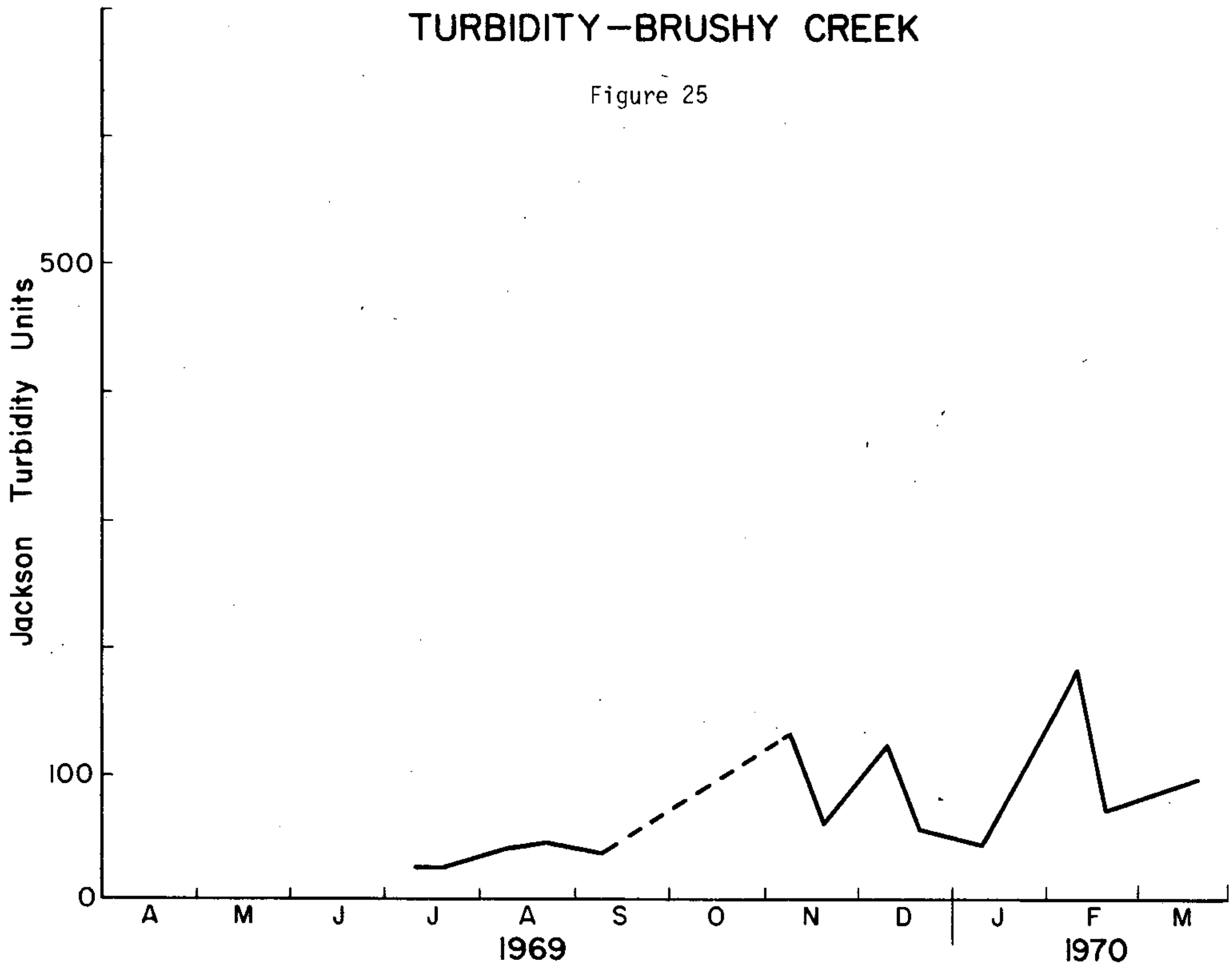
TURBIDITY-CEDAR CREEK

Figure 24



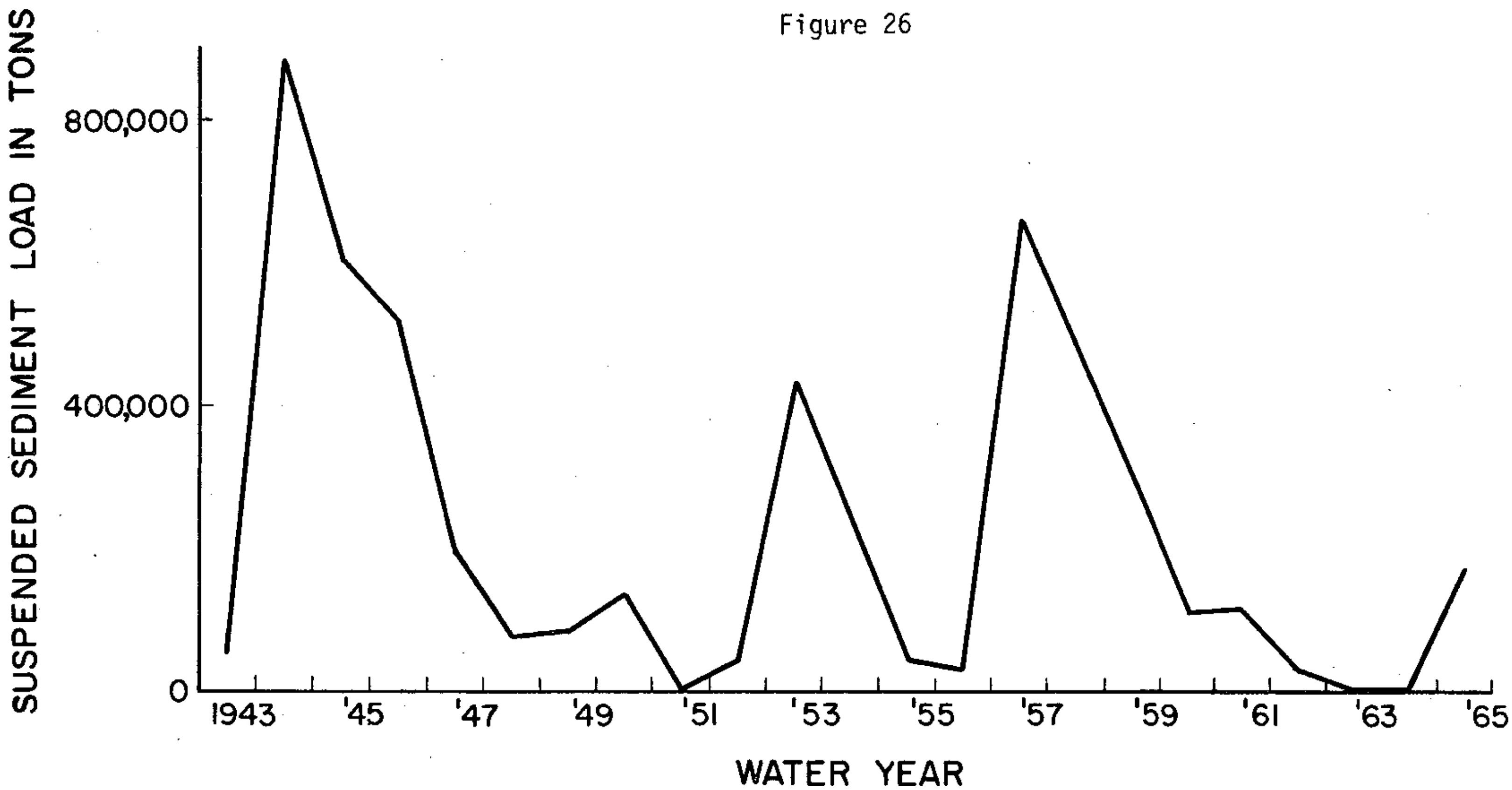
TURBIDITY—BRUSHY CREEK

Figure 25



USGS STATION 81104-SUSPENDED SEDIMENT LOAD

Figure 26



consisted of various combinations of silt and clay. Often the clay was scoured clean and was quite firm.

Sheltered bottom areas, pool bottoms and backwaters often had deep accumulations of organic debris, sometimes up to 6 inches deep.

The main channel always contained many down trees and drifting logs. Some of these came from bank cutting at high water, but many came from clearing operations. The logs made many stretches of the river very difficult to navigate by boat, and a few areas were essentially impassible. However, the logs did provide a significant amount of solid substrate for organisms.

Except for Rocky Creek, Holland Creek and one or two other tributaries in the south east part of the watershed which contained more rocky material, the bottom material of the tributaries was similar to that of the main channel.

CHEMICAL

Introduction

Detailed U. S. Geological Survey chemical analyses were available at one station on the Navasota when the project was submitted, and became available at other stations before field work began. The project chemical analyses were designed to supplement the USGS data, and were limited to those analyses of interest that could be accurately accomplished with the personnel and analytical facilities available.

General Methods and Procedures

pH was measured with a Coleman 37A Laboratory meter, specific conductance with an Electronic Switchgear LTD. Mark IV null point instrument. Chloride was determined by the Mercuric Nitrate method, total Hardness by the EDTA method, Nitrate by the Cadmium reduction method and Sulfate by the Barium Chloride turbidimetric method. Hardness, Chloride, Sulfate and Nitrate were run on a Hach Direct Reading Colorimeter. Aliquots for dry-weight ash weight were dried to constant weight at 100C and ashed at 550C, with weights determined on a Sartorius analytical balance. Carbon determinations were made in a Beckman Total Carbon Analyzer.

Field procedures involved collecting main current samples with a plastic bucket and line and storing the samples in polyethylene bottles. Analyses were run in the laboratory on the day of collection.

Initially pH and specific conductance were determined in the field, but test runs revealed no significant change upon re-reading in the laboratory on the same day, and field readings were discontinued.

General Chemical Characteristics

Data on the mean Chemical composition of North American rivers are given in Table 5 (Livingston 1963). Comparable USGS data, along with some additional categories, are given in Table 6 for the three major Texas rivers near the Navasota; the Trinity to the east, the Brazos, (into which the Navasota empties) and the Colorado to the west.

The three rivers are consistently at or above the average North American concentrations for the categories listed. Only the Silica values for the Trinity and Brazos are below the average value. Sodium, Chloride, Sulfate and Potassium values are at least three times the average. One Brazos river reading of Sulfate is six times, of Sodium nine times and of Chloride fifteen times the North American average.

The Brazos also shows consistently higher values for dissolved solids, hardness and conductivity. This general condition is due largely to the geology of the upper watershed where extensive saline strata are naturally exposed. The chemical quality of the Brazos has been analyzed in detail by Ireland and Mendieta (1964).

The general chemical characteristics of the Navasota as measured at the lowest USGS Station (Table 7, 81110-Bryan) are closer to those of the Trinity and Colorado than to the Brazos.

Table 5

Mean Chemical Composition of North American Rivers, (Livingston, 1963) mg/L

Silica	9	Bicarbonate	68
Calcium	21	Sulfate	20
Magnesium	5	Chloride	8
Sodium	9	Nitrate	1
Potassium	1.4		

Table 6

U. S. Geological Survey Chemical Data For selected Stations on the Trinity, Brazos and Colorado Rivers, water year 1969. Specific Conductance in micro-mhos, pH in pH Units, other Valves in mg/L.

	Trinity River Station 80665			Brazos River Station 81095			Colorado River Station 81620		
	Minimum	Maximun	Weighted Average	Minimum	Maximum	Weighted Average	Minimum	Maximum	Weighted Average
Silica	2.3	12	7.8	4.3	10	8.3	8.4	14	9.6
Calcium	21	56	36	48	86	72	39	76	49
Magnesium	2.5	6.4	5.5	4.7	18	11	4.2	17	10
Sodium	11	164	34	14	183	31	8.4	40	23
Potassium	3.6	6.1	---	3.8	4.4	---	3.4	3.7	---
Bicarbonate	52	182	103	146	238	184	117	255	165
Carbonate	0	0	0	0	0	0	0	0	0
Sulfate	17	69	30	26	130	75	17	41	31
Chloride	15	193	25	32	280	120	9.8	53	32
Fluoride	0.2	2.0	0.3	0.2	0.5	---	0	0.3	---
Nitrate	0.2	11	2.7	1.2	8.0	3.2	0.2	5.4	2.1
Dissolved Solids	103	617	180	202	783	462	159	314	238

Table 6. Continued

	Trinity River Station 80665			Brozos River Station 81095			Colorado River Station 81620		
	Minimun	Maximum	Weighted Average	Minimum	Maximum	Weighted Average	Minimum	Maximum	Weighted Average
Ca & Mg Hardness	63	162	104	151	280	224	115	228	164
Non-Carbonate Hardness	10	48	20	20	135	72	14	44	29
Specific Conductance	182	1090	314	348	1380	810	280	642	421
pH	7.0	8.0	7.4	7.3	8.3	7.6	7.0	8.2	7.7

Table 7

U. S. Geological Survey Chemical Data from Station 81110 on the Navasota River, water years 1968 and 1969. Specific Conductance in micro-mhos, pH in pH Units, other Valves in mg/L except daily totals in tons.

	Water Year 1968				Water Year 1969			
	Minimum	Maximum	Weighted Average	Tons per Day	Minimum	Maximum	Weighted Average	Tons per Day
Silica	4.2	12	8.5	23	7.2	16	9.1	20
Calcium	7.5	51	19	50	9.5	69	18	41
Magnesium	1.6	14	3.8	10	2.6	18	4.6	10
Sodium	5.7	82	18	47	7.4	113	19	42
Potassium	3.7	5.2	---	---	3.6	4.7	---	---
Bicarbonate	25	144	54	144	27	136	47	105
Carbonate	0	0	0	0	0	0	0	0
SO_4	5.4	77	20	54	22	103	26	59
Chloride	12	154	25	68	9.4	258	28	62
Fluoride	0.1	0.4	---	---	0.1	0.3	---	---
Nitrate	0.1	2.5	0.8	2.0	0	3.2	0.7	1.6
Dissolved Solids	47	429	122	---	62	632	129	---

Table 7. Continued

	Water Year 1968				Water Year 1969			
	Minimum	Maximum	Weighted Average	Tons per Day	Minimum	Maximum	Weighted Average	Tons per Day
Ca & Mg Hardness	25	184	62	---	34	264	64	---
Non-Carbonate Hardness	4	118	18	---	8	180	26	---
Specific Conductance	88	649	222	---	108	1020	228	---
pH	6.7	8.2	7.3	---	6.6	7.7	6.9	---

Table 8

U. S. Geological Survey Chemical Data from Station 81104 on the Navasota River, water years 1968 and 1969. Specific Conductance in micro-mhos, pH in pH Units, other Valves in mg/L except daily totals in tons.

	Water Year 1968				Water Year 1969			
	Minimum	Maximum	Weighted Average	Tons per Day	Minimum	Maximum	Weighted Average	Tons per Day
Silica	7.0	11	8.8	8.5	6.1	12	8.4	3.2
Calcium	22	160	29	28	20	270	36	14
Magnesium	1.9	28	3.0	2.9	2.8	56	4.1	1.6
Sodium	8.2	466	19	19	15	815	26	10
Potassium	3.2	3.8	---	---	3.7	6.2	---	---
Bicarbonate	64	199	90	87	57	256	104	40
Carbonate	3	6	0	0	0	0	0	0
Sulfate	7.2	130	14	14	12	269	21	8.1
Chloride	7.4	860	26	25	18	1620	39	15
Fluoride	0.3	0.8	---	---	0.2	1.4	---	---
Nitrate	0.1	11	1.1	1.1	0.4	17	1.9	0.7
Solids Dissolved	96	1770	145	---	132	3110	188	---

Table 8. Continued

	Water Year 1968				Water Year 1969			
	Minimum	Maximum	Weighted Average	Tons per Day	Minimum	Maximum	Weighted Average	Tons per Day
Ca & Mg Hardness	60	514	84	---	65	904	106	---
Non-Carbonate Hardness	3	341	11	---	8	798	21	---
Specific Conductance	169	3380	265	---	239	5500	342	---
pH	6.7	7.4	7.5	---	7.0	8.1	7.3	---

It is pertinent to reiterate the differences in collection and analysis methods for project and USGS data. Water samples for the USGS are taken daily, but during periods of little change are reported as average values covering two to several days. During periods of rapid fluctuation, daily values are reported, so that where necessary the system has good definition.

Water samples from project stations were taken every two weeks and thus should not be relied upon for more than evidence of general trends, since fluctuations of short duration could be missed entirely and coincidence of sampling and actual maxima and minima would be fortuitous.

Chemical data are often reported only in units of concentration, but for river systems this conceals much information of interest, since the variations in discharge coupled with the nature of the source of the material causes characteristic variations in the total amount per unit time passing a point.

One can hypotheisize some theoretical relationships.

If there is a finite source of material the total load should stay fairly constant and the concentration should vary with the discharge.

If the material is generally and widely distributed the concentration should stay constant and the total load should vary with the discharge.

If concentration and total load increase without significant increase in discharge, man caused effluent is probable.

Where discharge data are available, the chemical data from the Navasota are presented as total load in gms/second passing the collection point, as well as in concentration units.

Conditions at station 4 precluded accurate discharge measurement and data for that station are reported only in concentration units. Discharge was occasionally zero at the upper stations and on some of the tributaries, but some standing water was always present. In these cases concentration data are reported but the total load is shown as zero.

Oxygen

Oxygen readings were taken on a random basis, and oxygen was never below 5 mg/l with flowing waters. When main channel discharge was near zero, oxygen valves near the bottom at pools went below 2ppm for short periods.

Phosphorus

The phosphorus analysis method available would not perform reliably, and rather than put poor data into print, phosphorus is not reported. Some data from a subsequent study (Gallaher 1974) show orthophosphate values during low flow periods of from 0.02 to 0.05 mg/l and values during a spate of 0.09 to 0.14 mg/l. Comparable total phosphorus values were 0.03 to 0.07 at low flow 0.10 to 0.19 during a spate. The phosphorus peaked in concentration during the very early part of the rise in flow, and had begun to decline by the time the river overflowed onto the flood plain.

Pesticides

Kramer and Plapp (1972) found that DDT and its metabolites (DDD, DDE) were the only insecticides present in measurable quantities in muscle tissue of fish from the Brazos and Navasota Rivers. However, dieldren and toxaphene were found in fat samples from fish collected at the same sites.

Of the fish taken from the Navasota only Gar showed measurable total DDT (0.118-0.468ppm); with Channel catfish showing trace amounts and Carp, Buffalo, Blue catfish and White crapie showing no detectable levels.

The fish from the Brazos all showed measurable total DDT's with channel catfish giving the highest single value and average value (.930ppm, .611ppm) followed by Flathead catfish (.468ppm, .277ppm), Freshwater drum (.356ppm, .296ppm), Carp (.712ppm, .238ppm) and Carp-sucker (.163ppm).

The values reflect the basic differences in land use practices; pasture for the Navasota and an intensively cultivated flood plain for the Brazos.

Chloride

The data are presented in figures 27 through 36, concentrations were never high in the tributaries with Holland Creek significantly lower than the other two. Cedar and Brushy Creeks showed increases in total load associated with increased discharge, but Holland Creek showed only slight increases in total load even with large changes in discharge.

Values at Station 5 are erratic, reflecting the intermittent nature of the stream and heavy cattle use.

Data from Station 4 show a general decrease in concentration plus a considerable smoothing of the peaks. There is no apparent explanations for the peak in September, 1968. The same peak appears in the conductivity data, indicating that analysis error is not the probable cause. Collection notes show no flow over the dam for at least a month prior to collection, with the water in the channel coming from seepage around the dam and from overflow from a small nearby pond. It is improbable that the peak resulted from passage of a slug of more saline water through Springfield Lake. The most probable causes are local dumping or mis-identification of the samples.

Station 81104 shows very high chloride levels, and extreme fluctuations. Often concentration and total load increased together; sometimes, as in the peaks of July, 1968 and January, 1969, when there was very little increase in discharge. There are obviously intermittent intrusions of concentrated salt solution between stations 4 and USGS 81104. Burnitt et al (1962) reported on salt water pollution from oil and gas fields which entered the Navasota via Plummer Creek. This creek enters between our station 4 and USGS 81104.

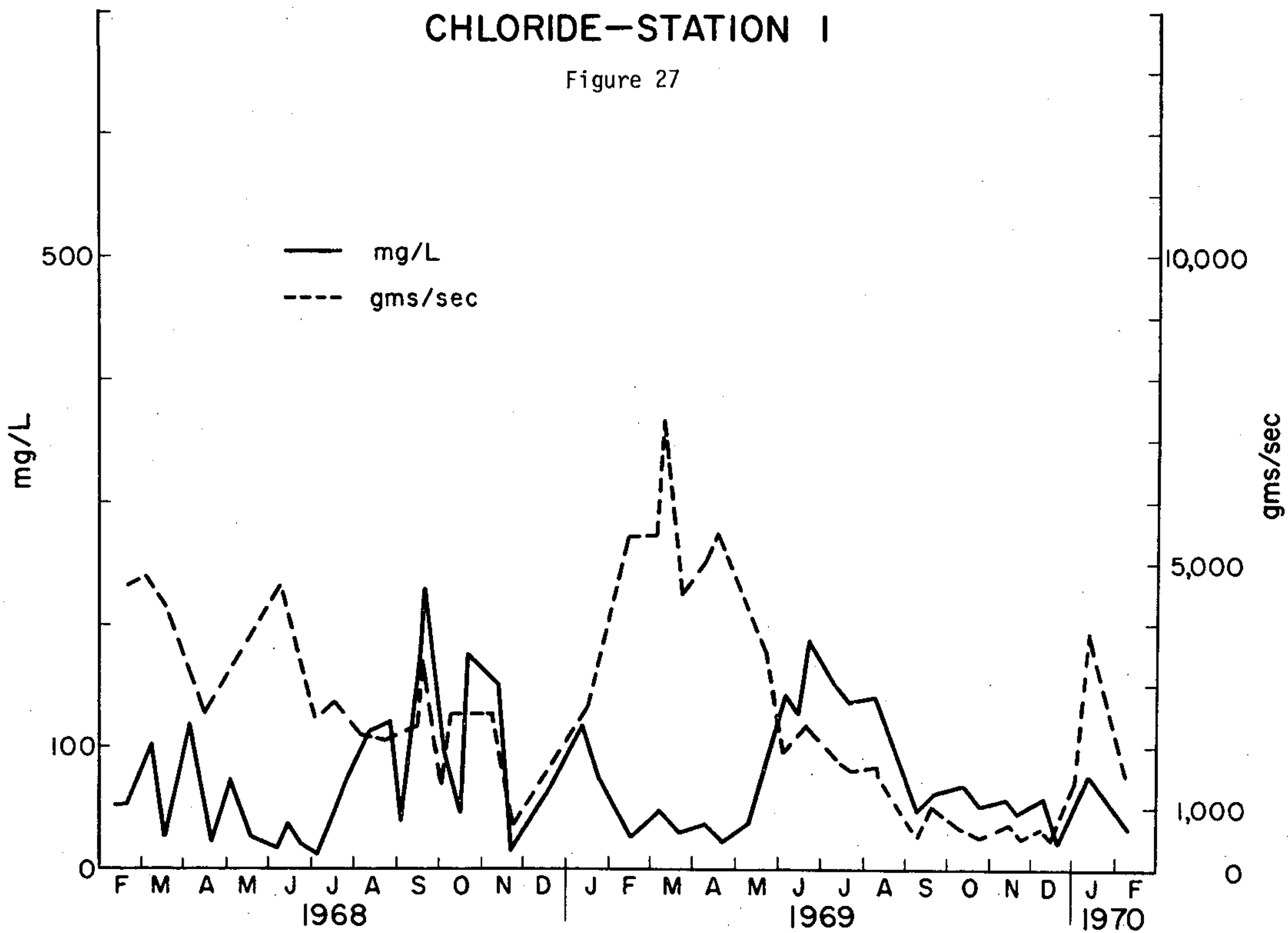
Sulfate

The data are presented in Figures 37 through 46.

Holland Creek is very low in both concentration and total load. The other two tributaries are higher in average concentration than any river station except 5, which itself more like a tributary than like

CHLORIDE—STATION I

Figure 27



CHLORIDE - USGS STATION 8110 BRYAN

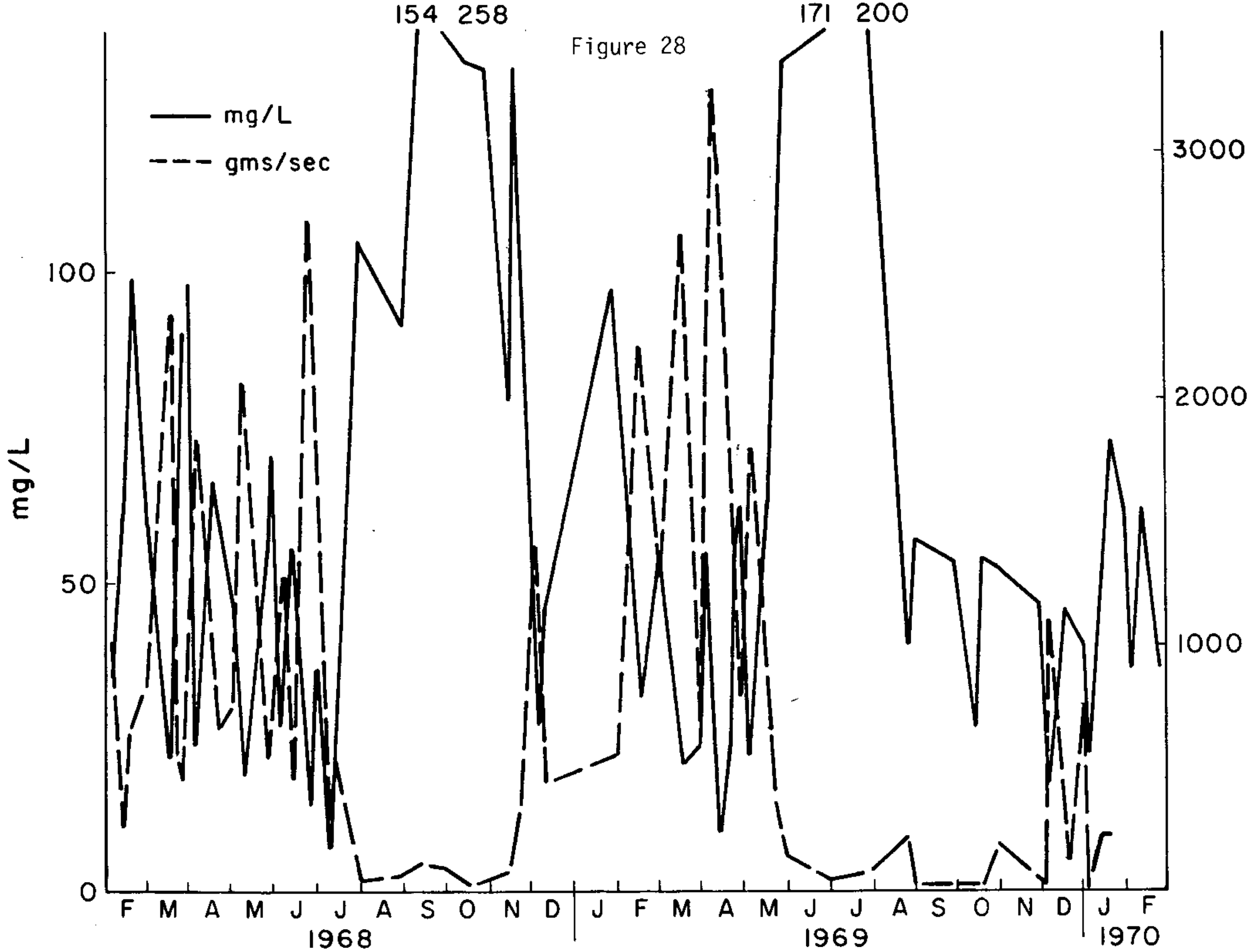
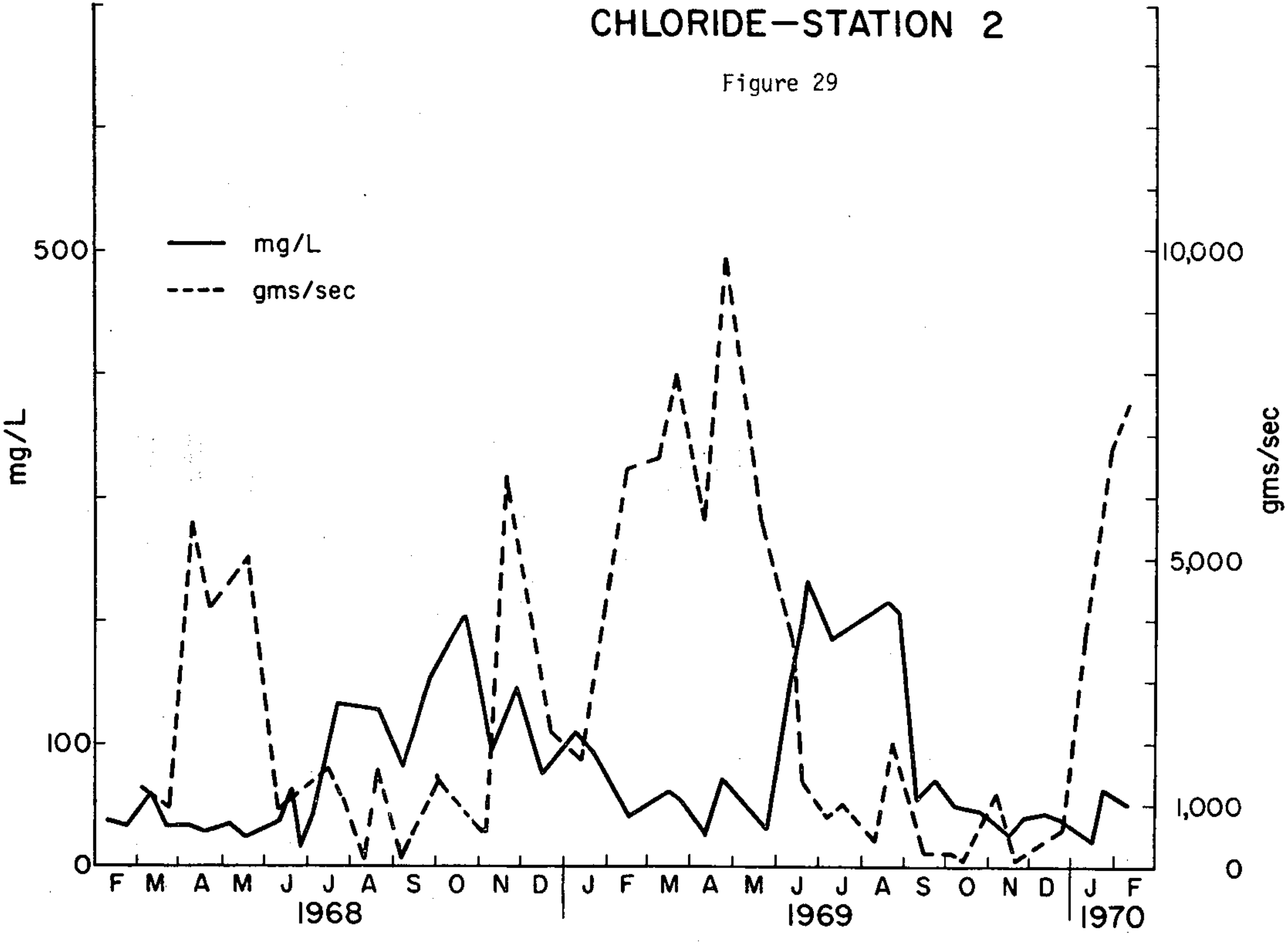
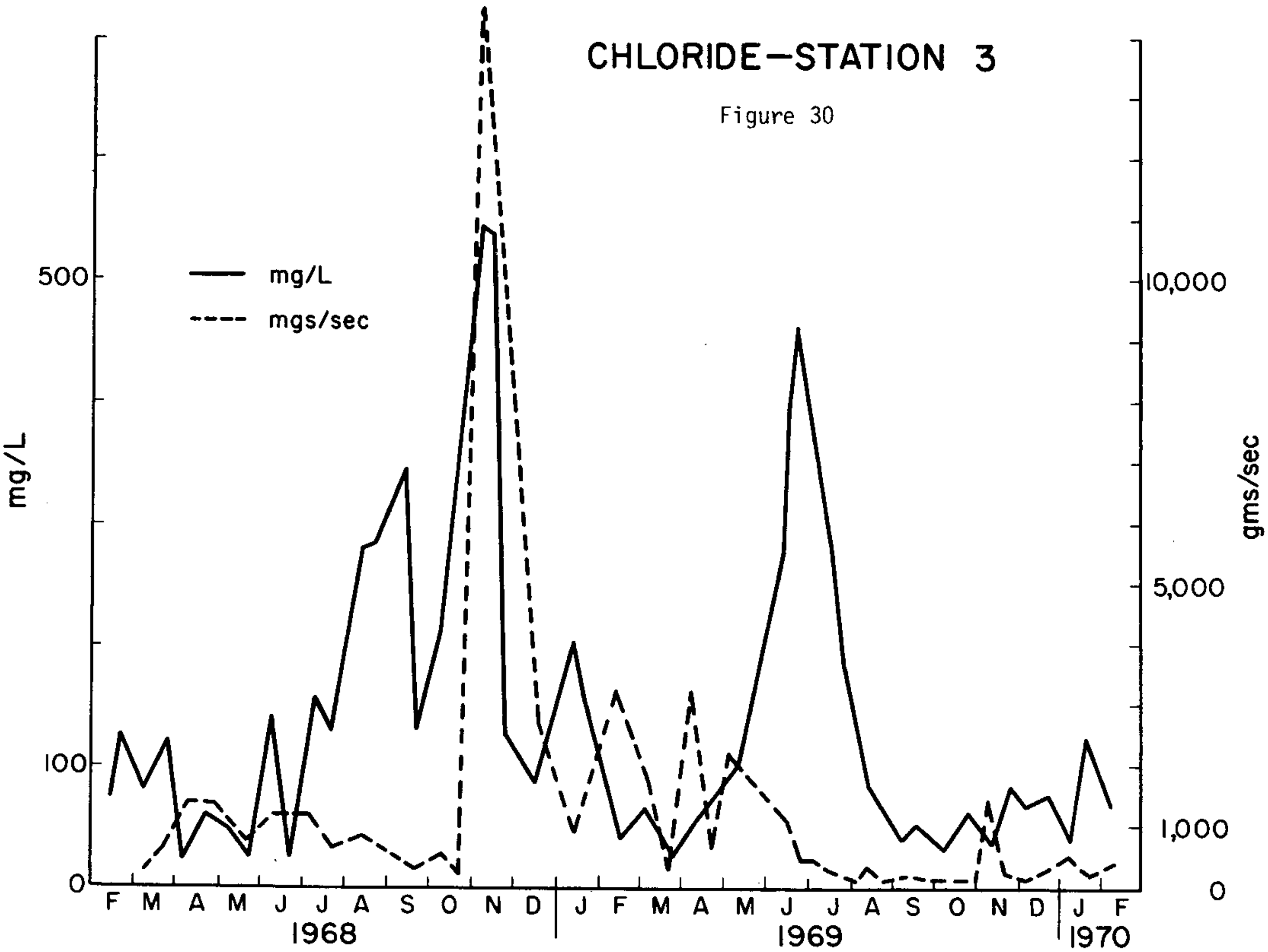


Figure 28

CHLORIDE—STATION 2

Figure 29





CHLORIDE—STATION 3

Figure 30

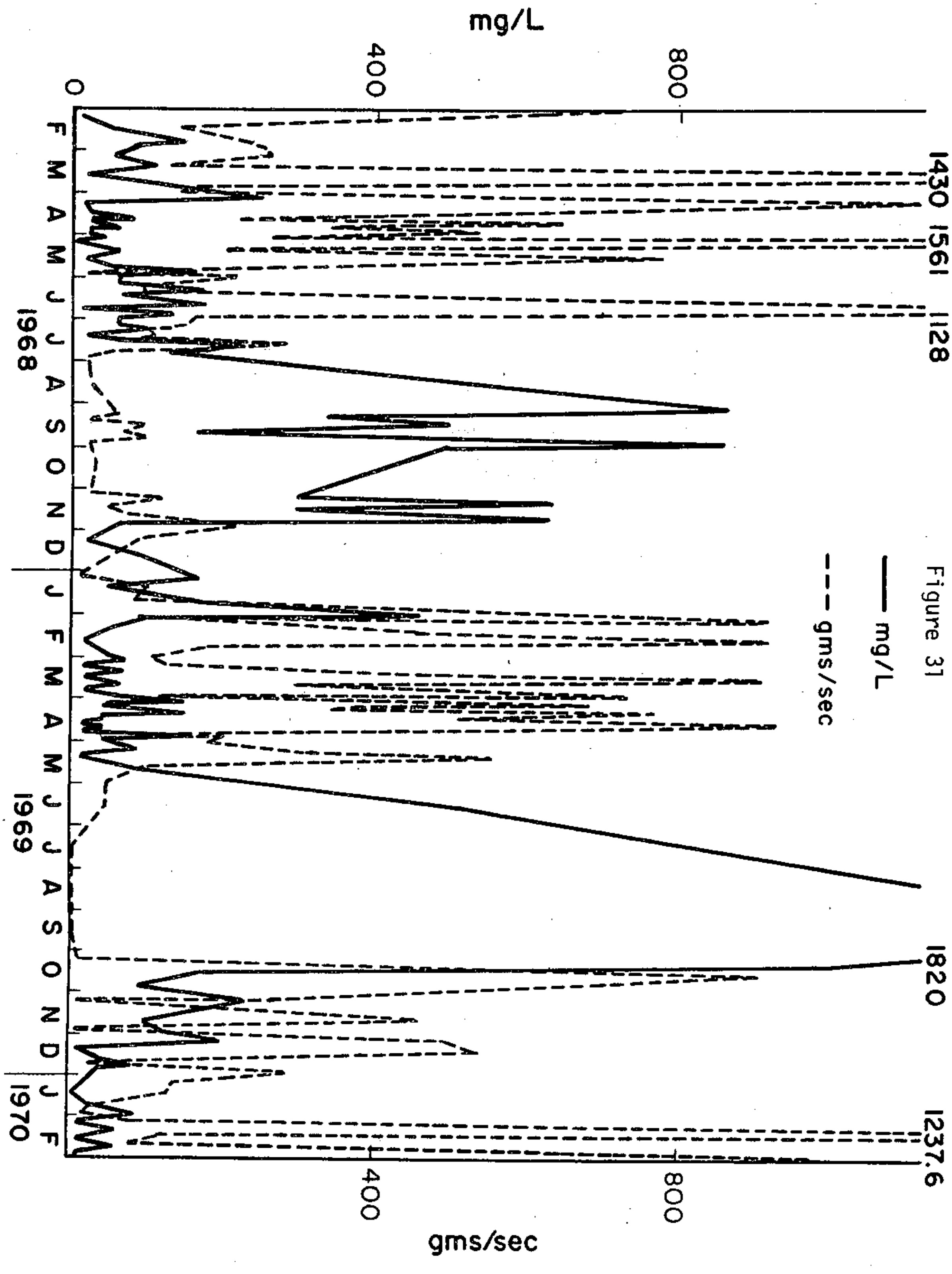
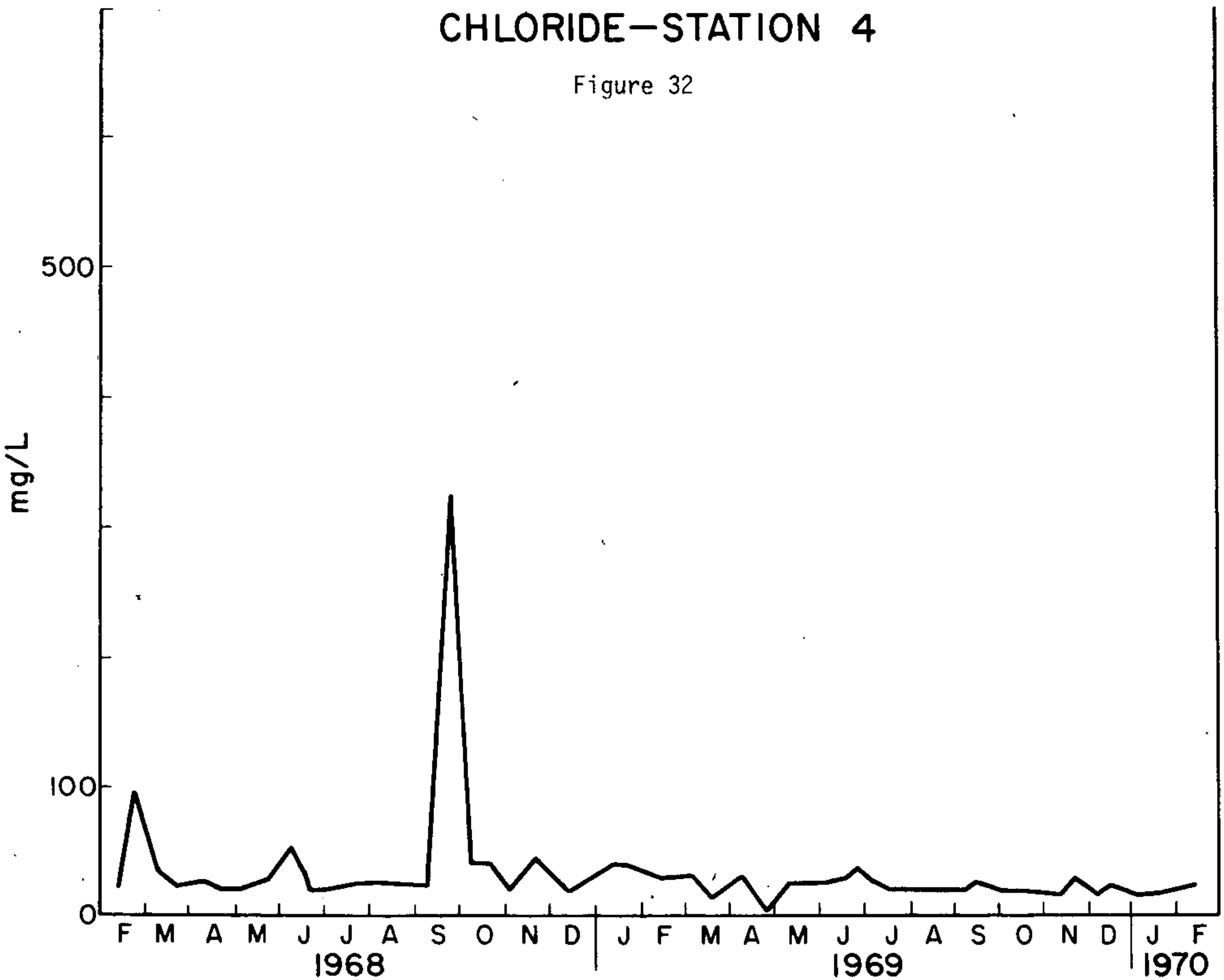


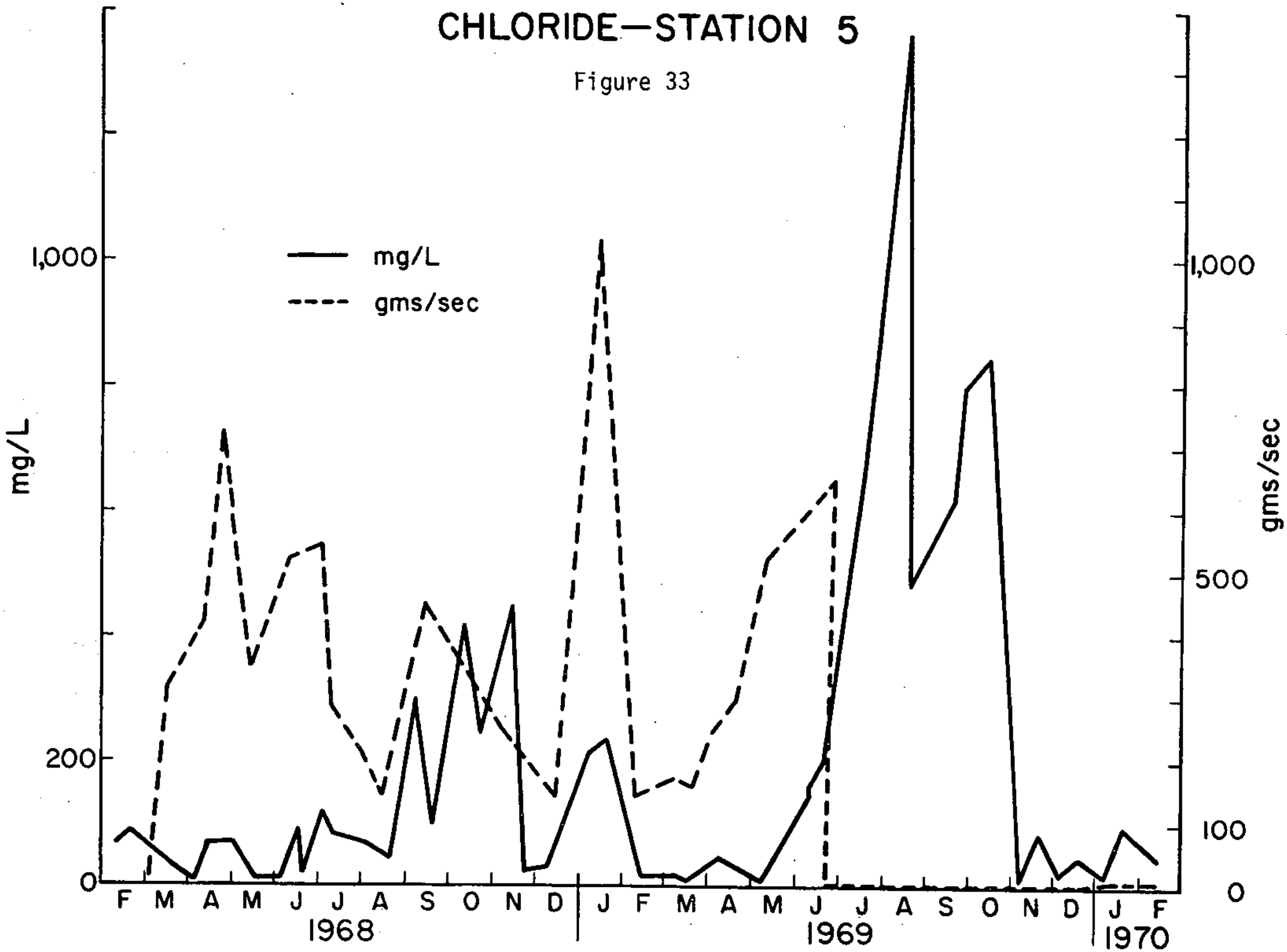
Figure 31

USGS STATION 81104 GROSBECK-CHLORIDE

CHLORIDE—STATION 4

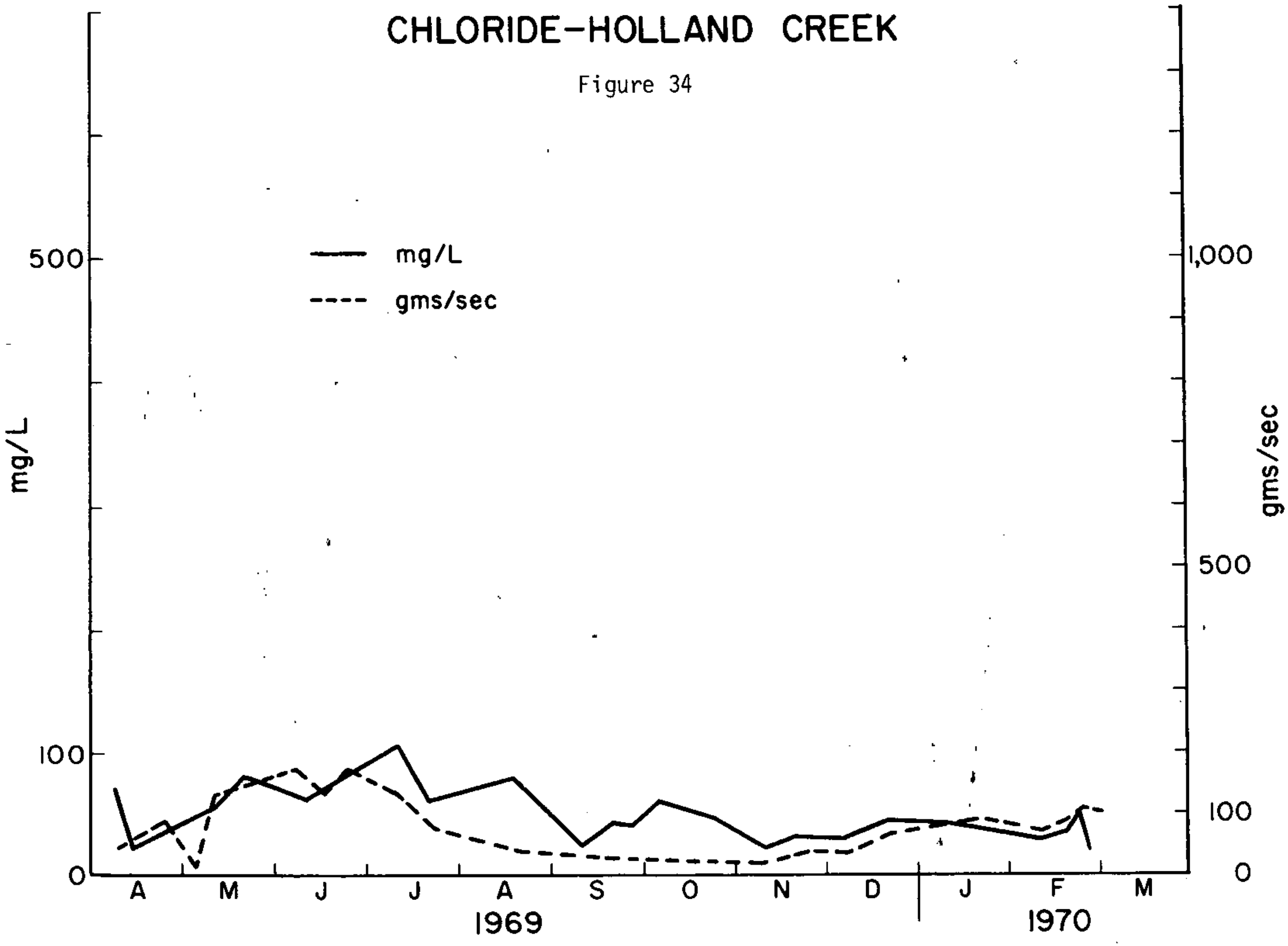
Figure 32

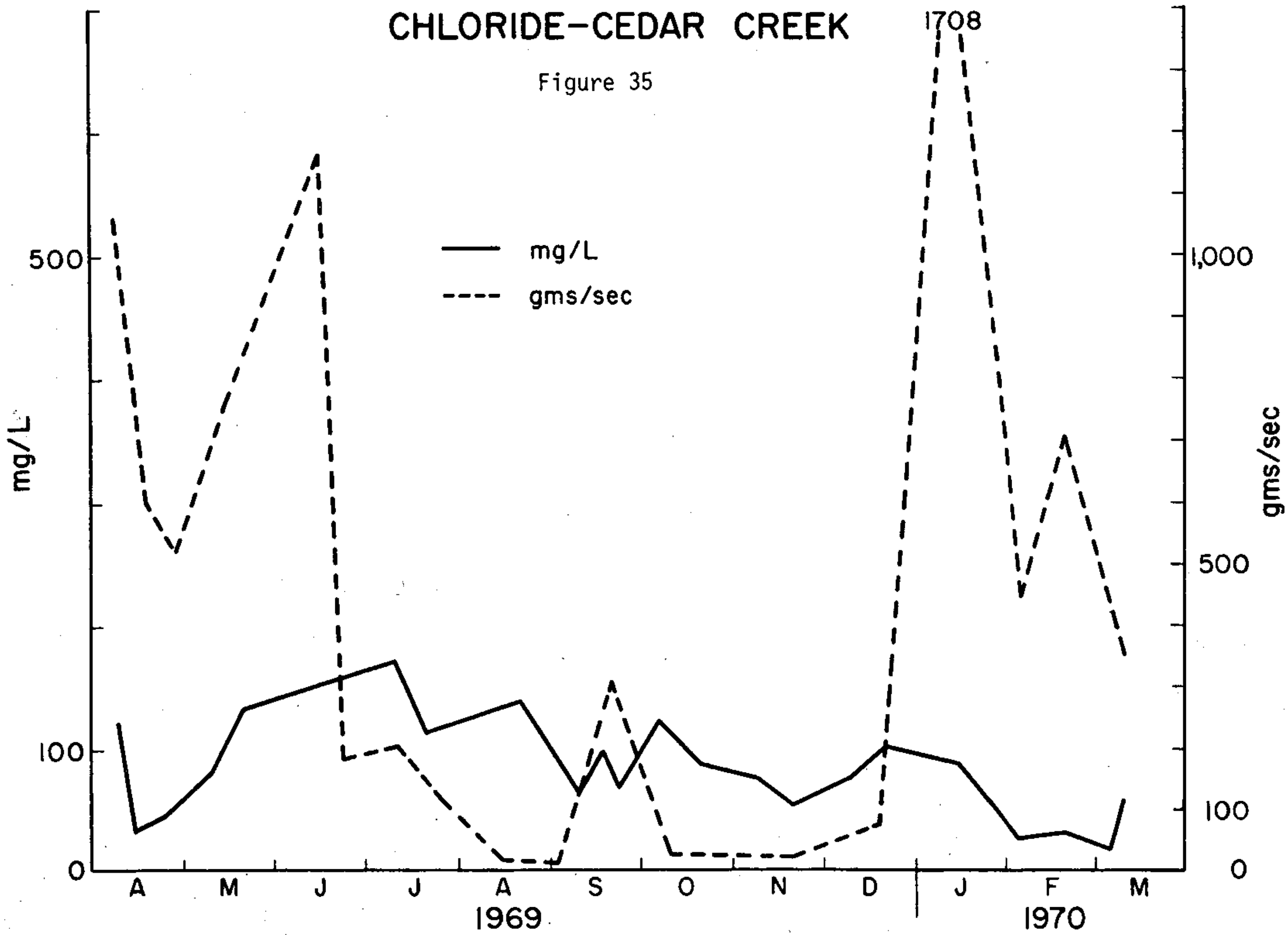


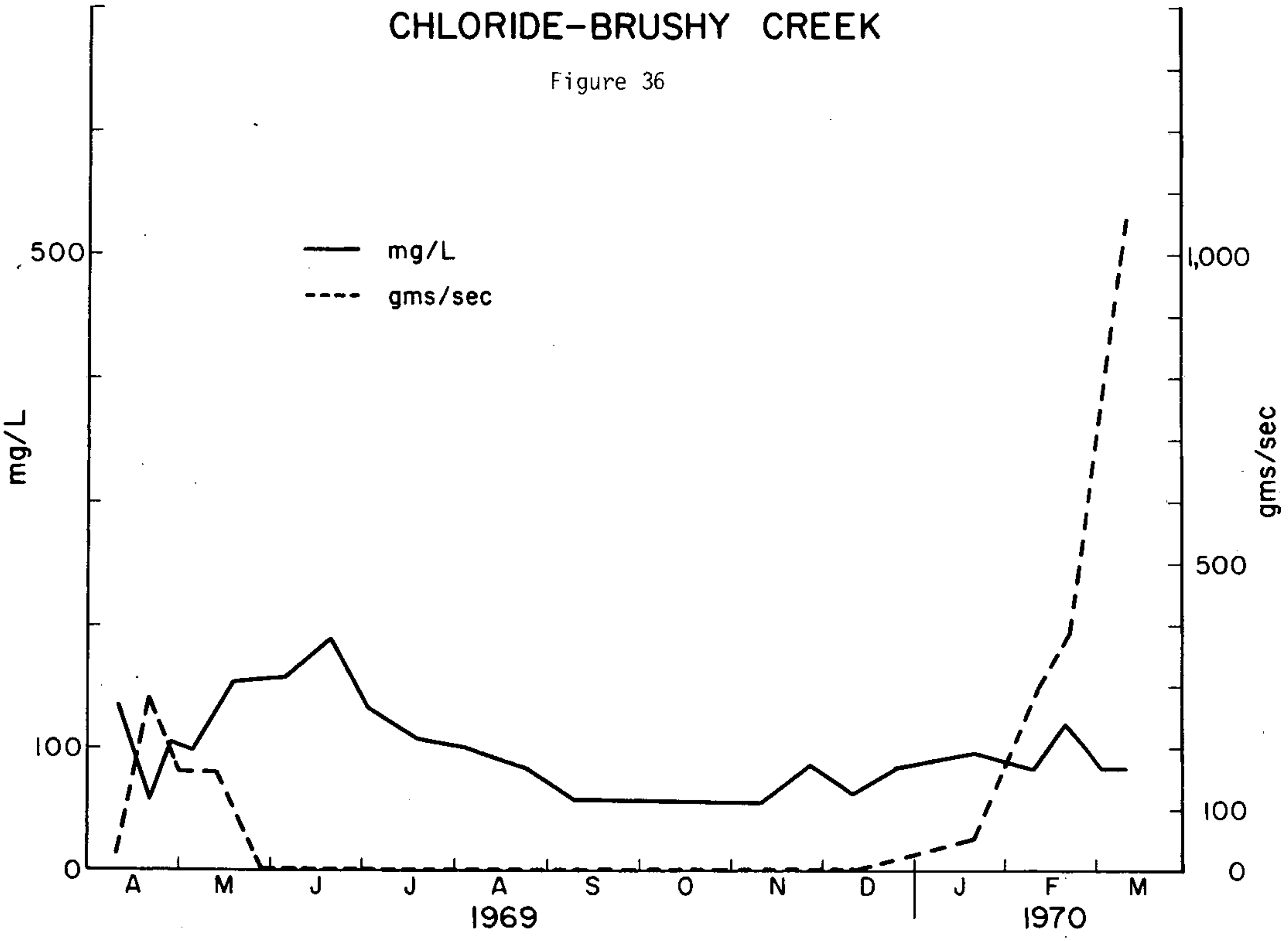

CHLORIDE—STATION 5
Figure 33
mg/L
gms/sec
mg/L
1,000
200
0
gms/sec
1,000
500
100
0
F M A M J J A S O N D
1968
J F M A M J J A S O N D
1969
J F
1970

CHLORIDE-HOLLAND CREEK

Figure 34




CHLORIDE-CEDAR CREEK
Figure 35
mg/L
gms/sec
1708
500
100
0
1,000
500
100
0
A
M
J
J
A
S
O
N
D
J
F
M
1969
1970



CHLORIDE-BRUSHY CREEK

Figure 36

the main river channel. Total load maxima for Cedar Creek approach those for the upper river stations, but loads for Brushy Creek are considerably lower.

Station 4 reflects a considerable decrease in concentration below the lakes. Levels at station 81104 are high again, but not as high as at station 5; and unlike Chloride, the picture downstream from 81104 shows an increase in Sulfate rather than a dillution effect. There are apparently significant sources of sulfate in the lower half of the watershed.

The peaks in both concentration and load of September, 1968 and October, 1969, at Station 1, with little or no increase in flow, argue for a fairly concentrated local source.

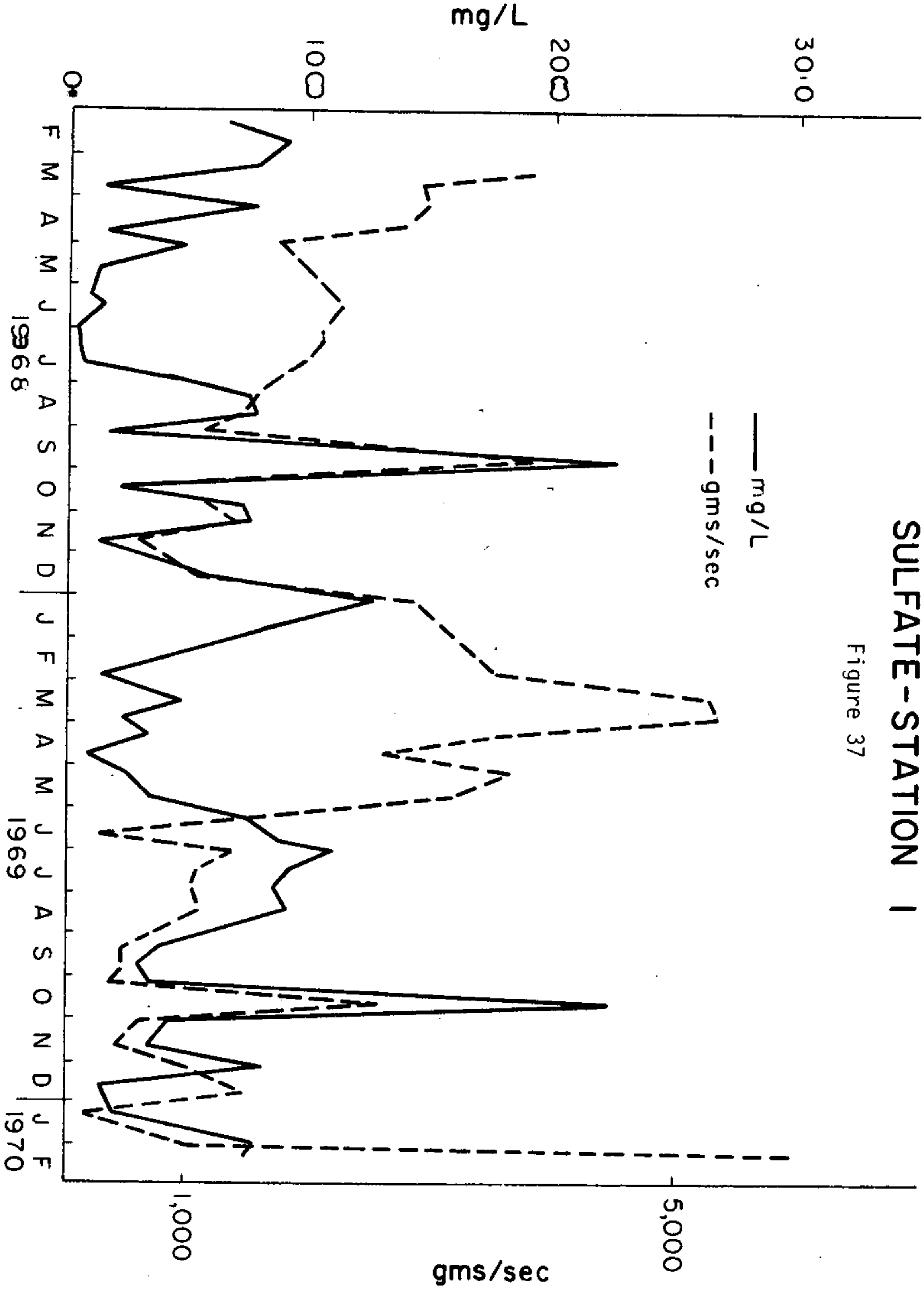
Nitrate

The data are presented in Figures 47 through 56.

The data are erratic. The factors of solubility, rapid utilization, and possible local fixation all act to make nitrate concentrations very much a product of local conditions. It is obviously impossible for any one station to reflect the nitrate status of the river.

The July-August peak in concentration on Brushy Creek and the September peak at Station 81104, both at times of very low or no flow, and with no known pollution sources, are suggestive of local fixation.

The very high values at station 81104 are probably from municipal sewage from the towns of Mexia and Groesbeck. The values have dropped dramatically by station 3, 30 river miles downstream.


SULFATE-STATION I
Figure 37
—— mg/L
- - - gms/sec
mg/L
0
100
200
300
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970
1,000
5,000
gms/sec

SULFATE-USGS STATION 8III0 BRYAN

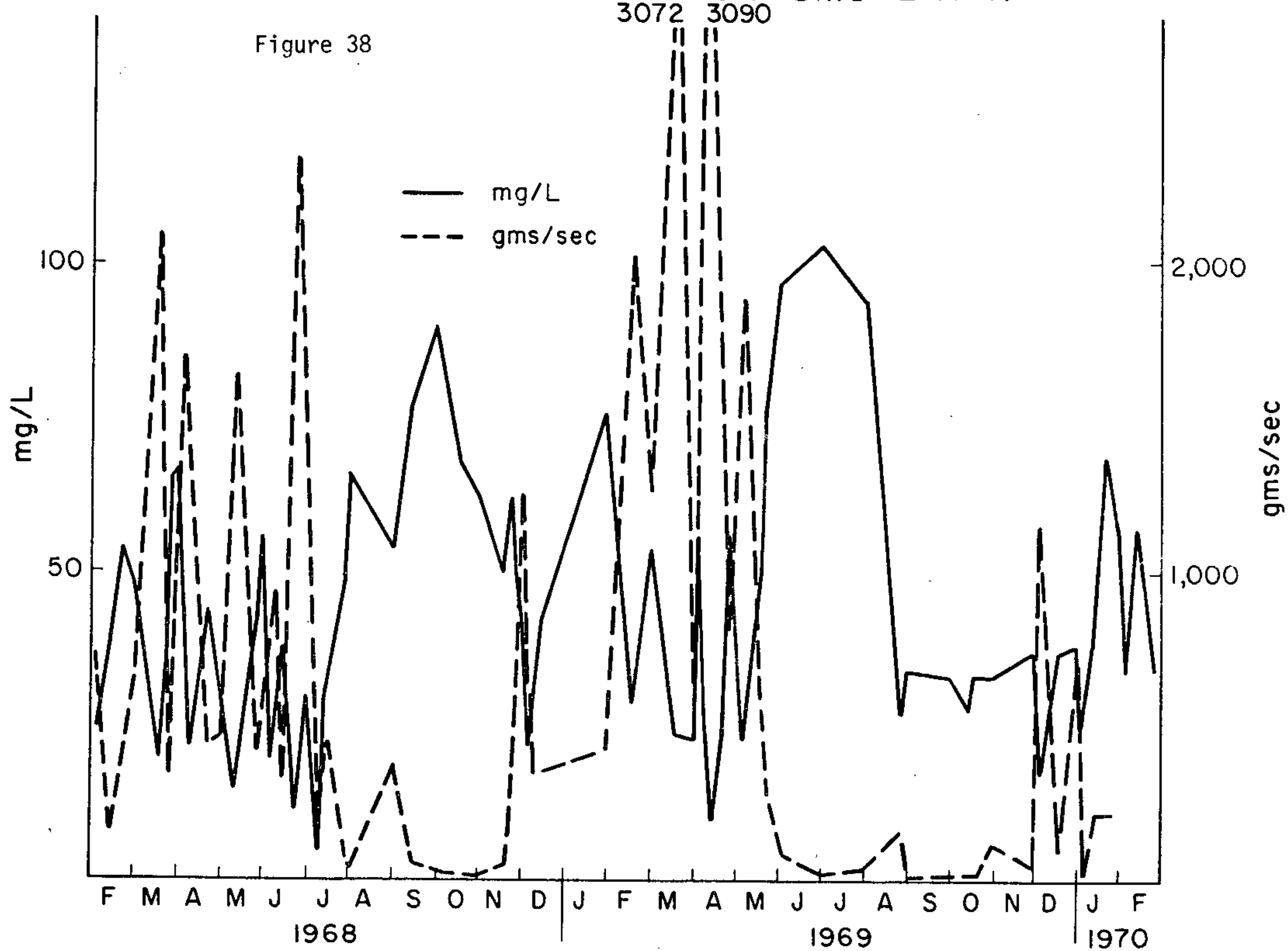
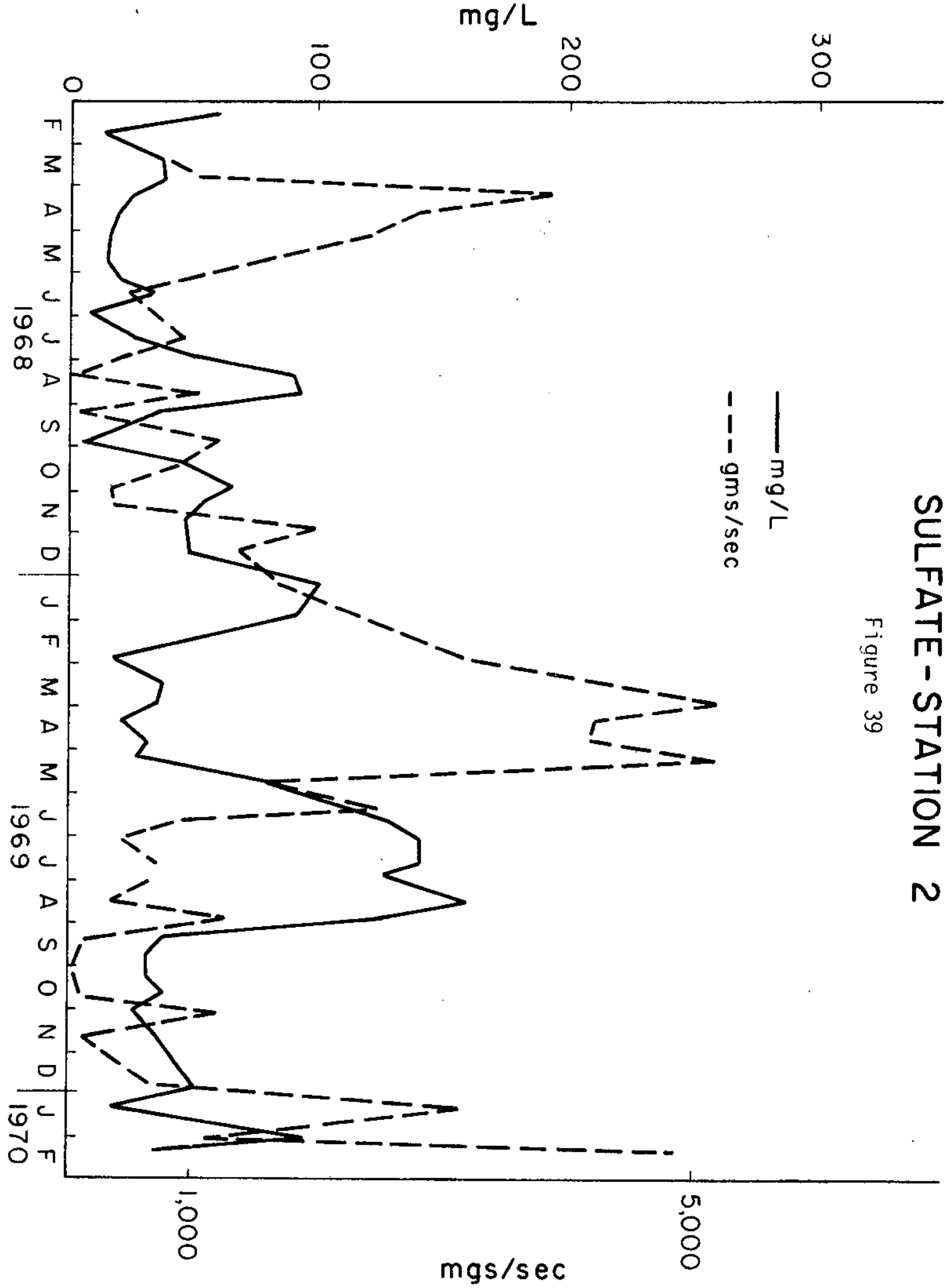
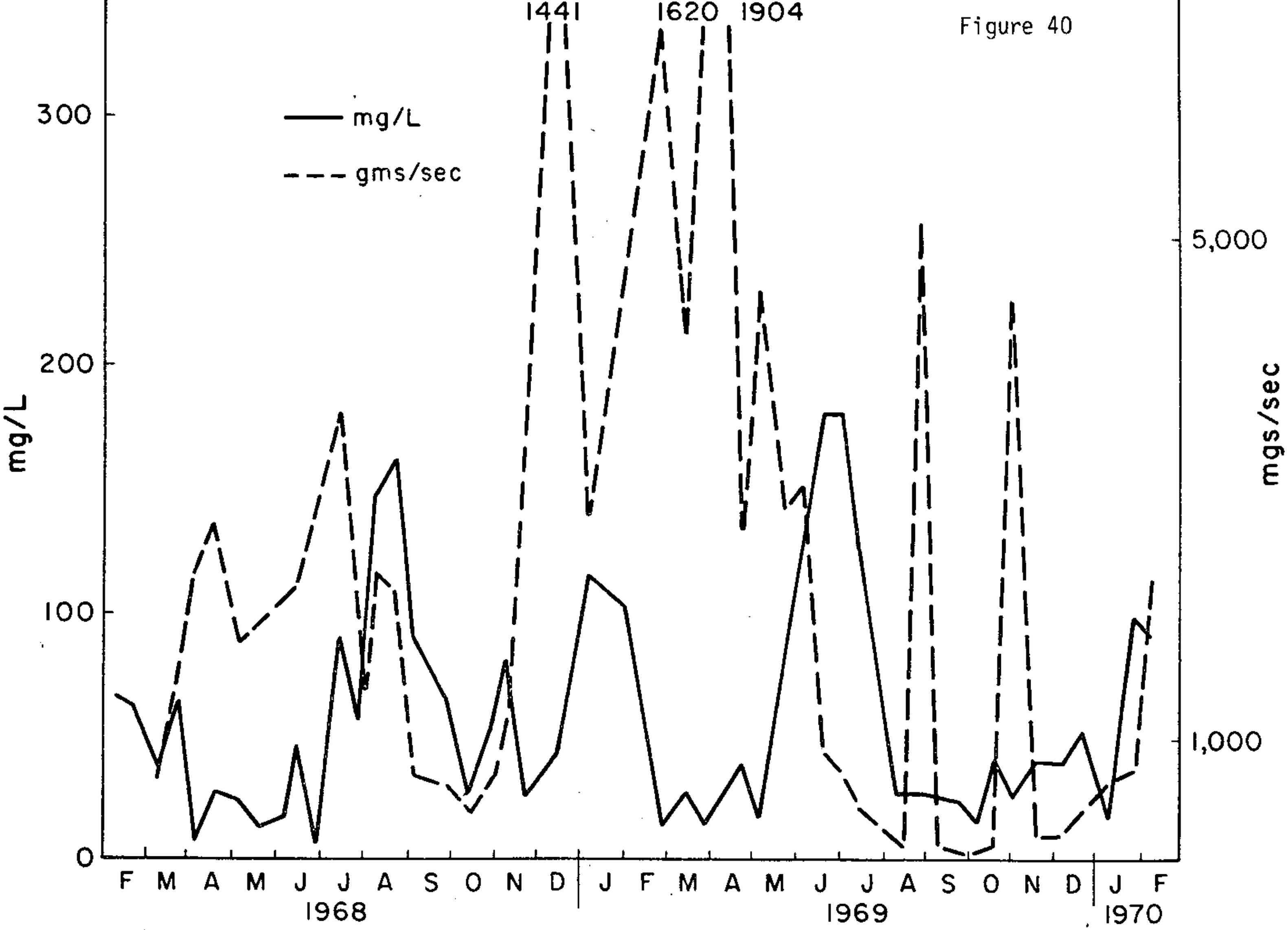


Figure 38


SULFATE-STATION 2
Figure 39
mg/L
gms/sec
mg/L
0
100
200
300
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970
1,000
5,000
mgs/sec

SULFATE-STATION 3

Figure 40



USGS STATION 81104 GROESBECK — SULFATE

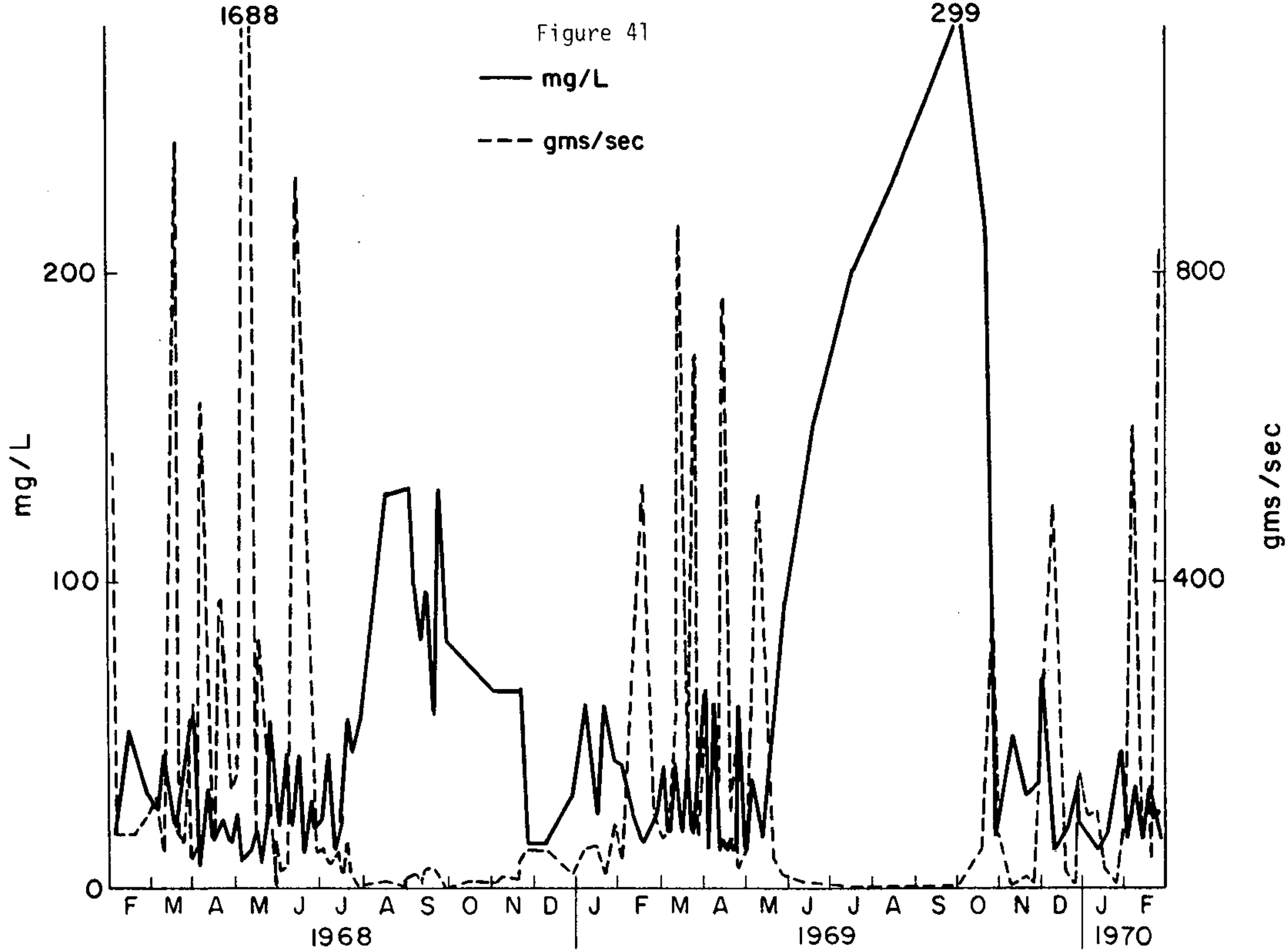
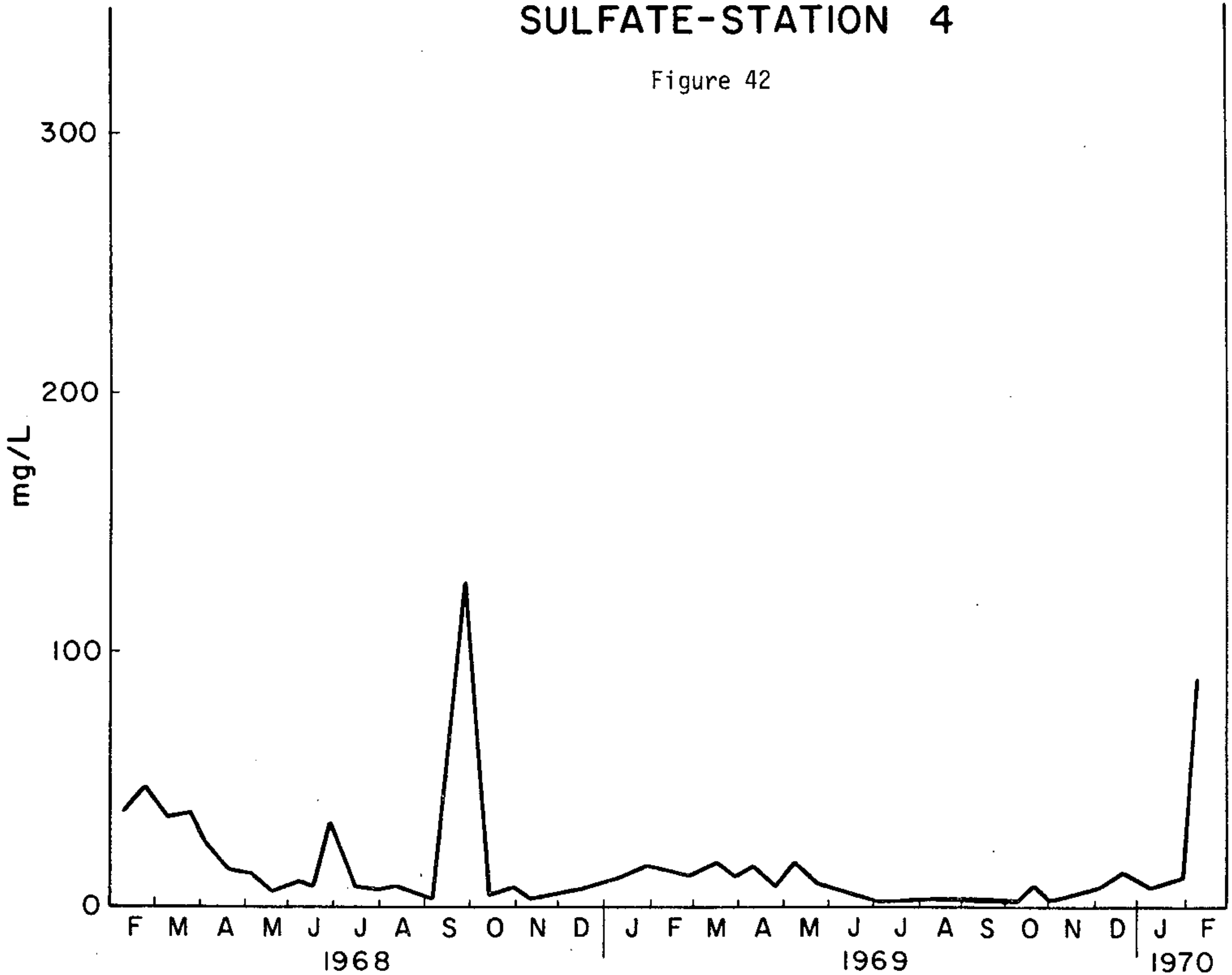


Figure 41

SULFATE-STATION 4

Figure 42



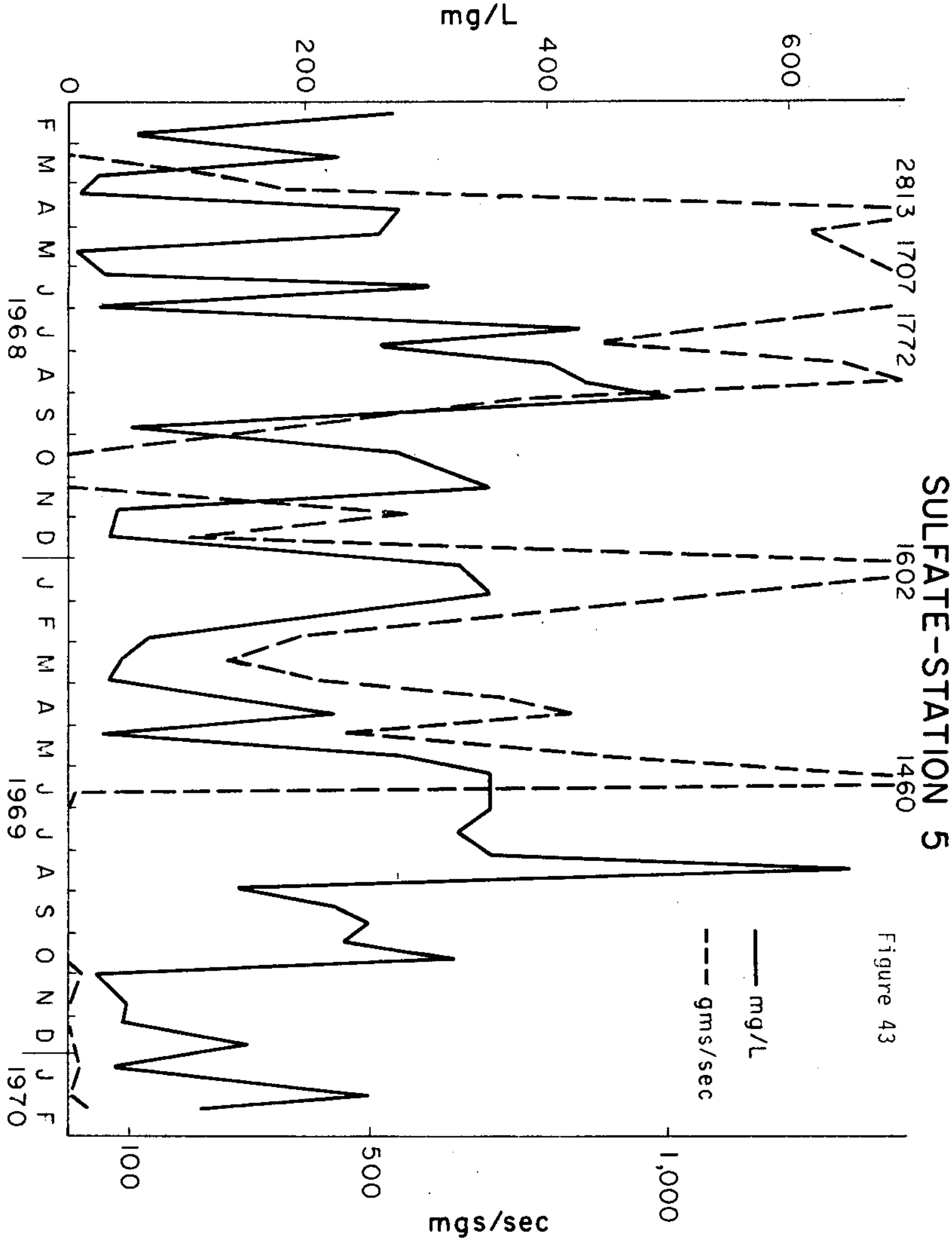
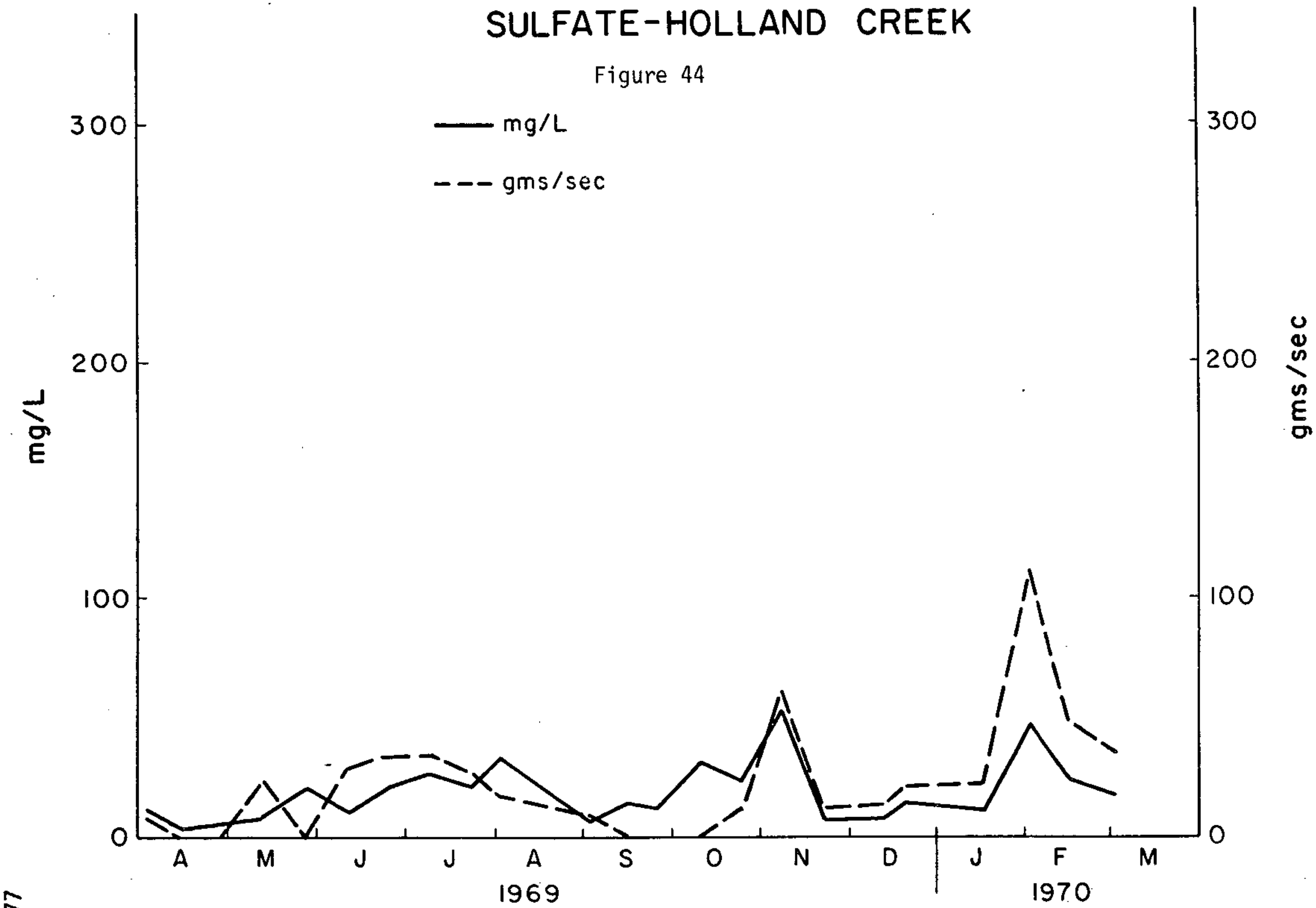
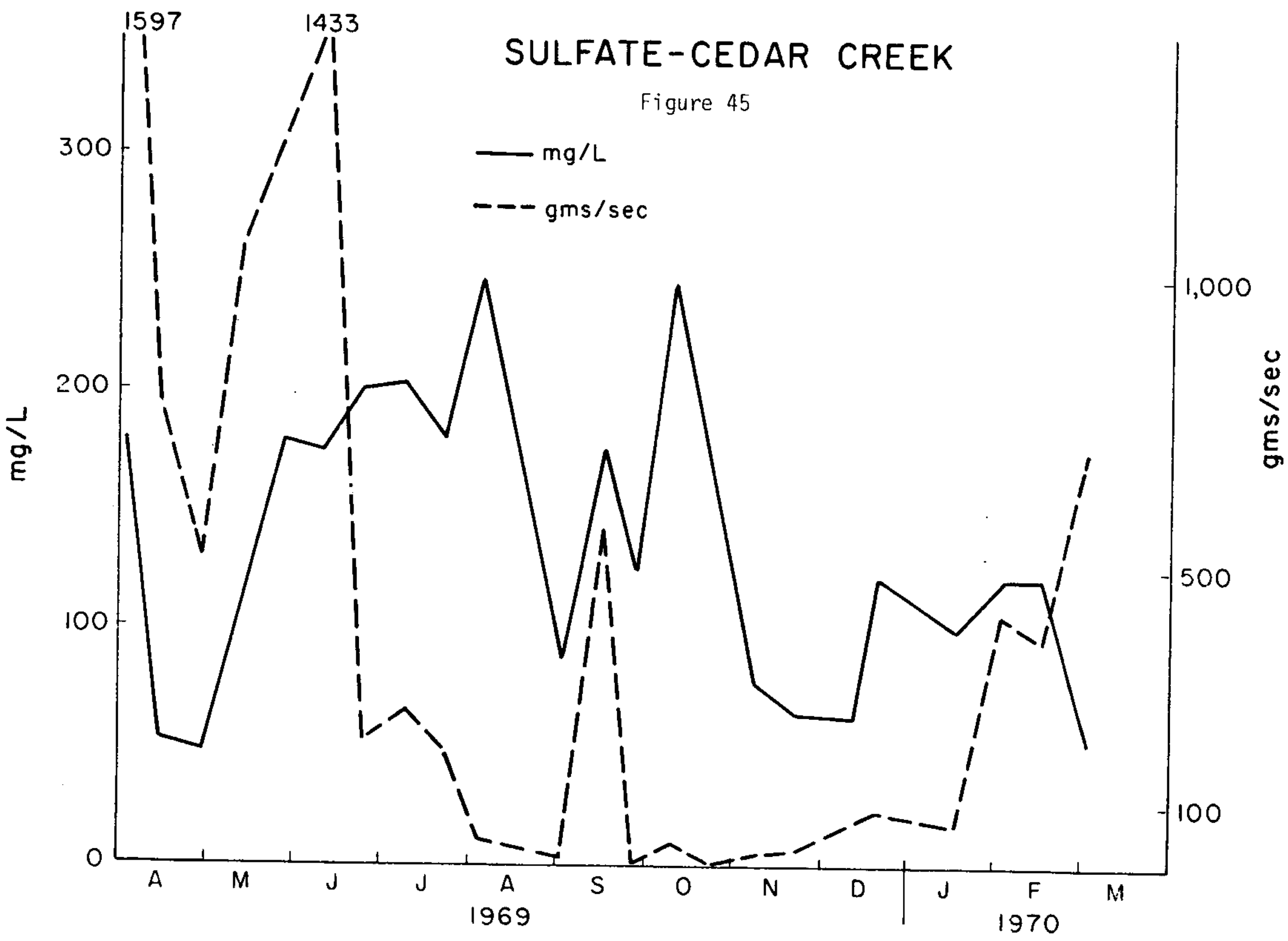

SULFATE-STATION 5
mg/L
0
200
400
600
mgs/sec
100
500
1,000
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970
2813
1707
1772
1602
1460
mg/L
gms/sec

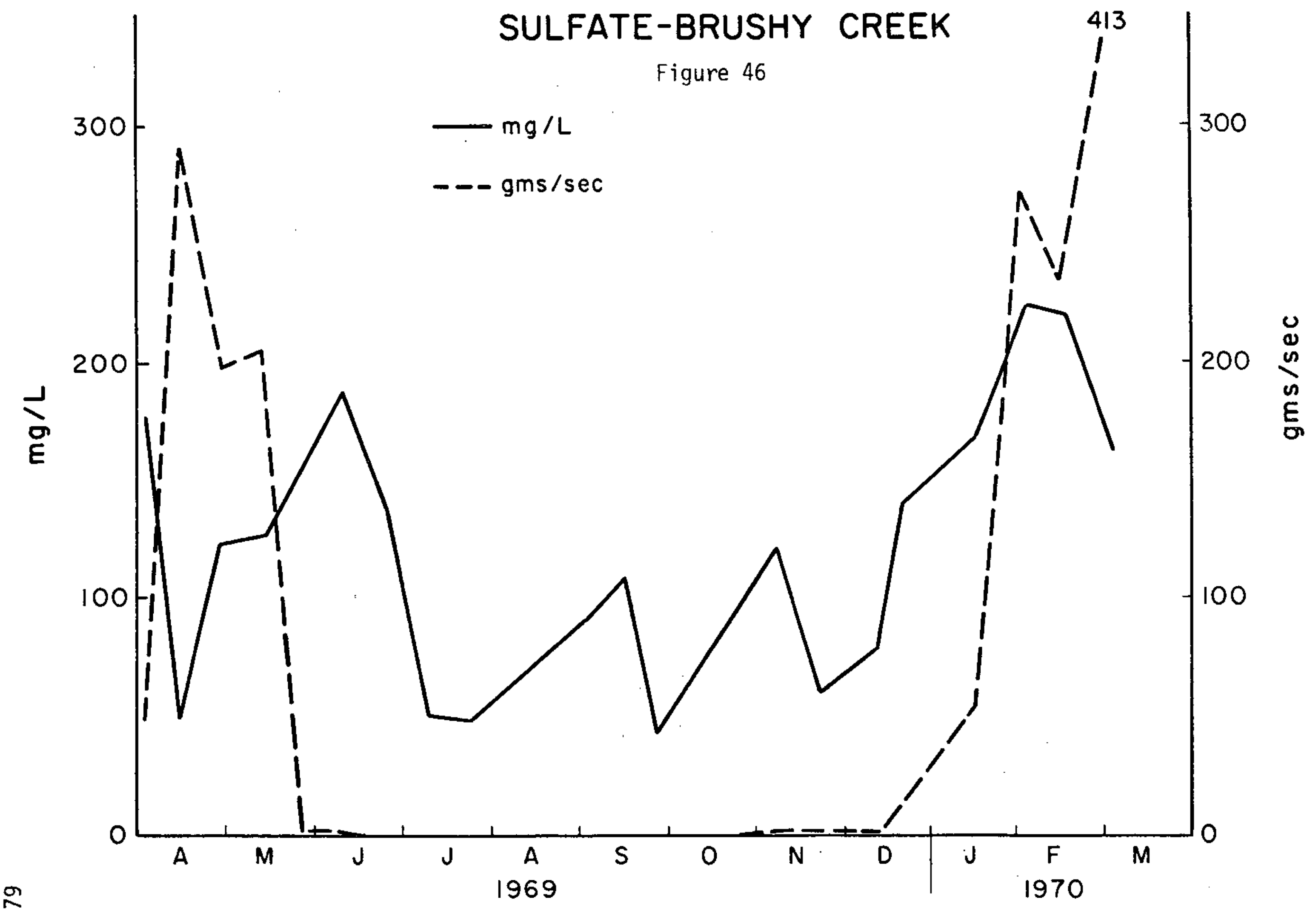
Figure 43

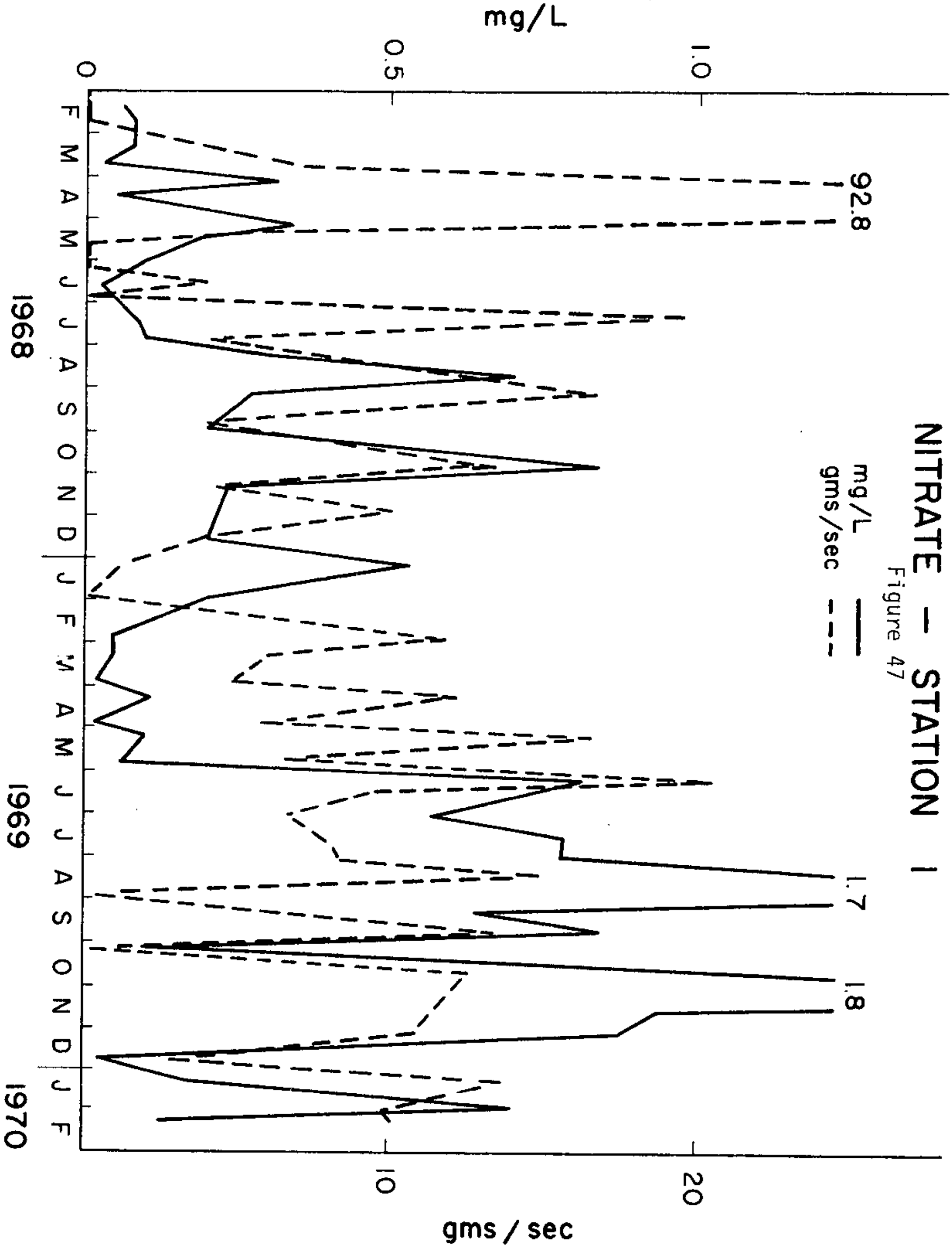
SULFATE-HOLLAND CREEK

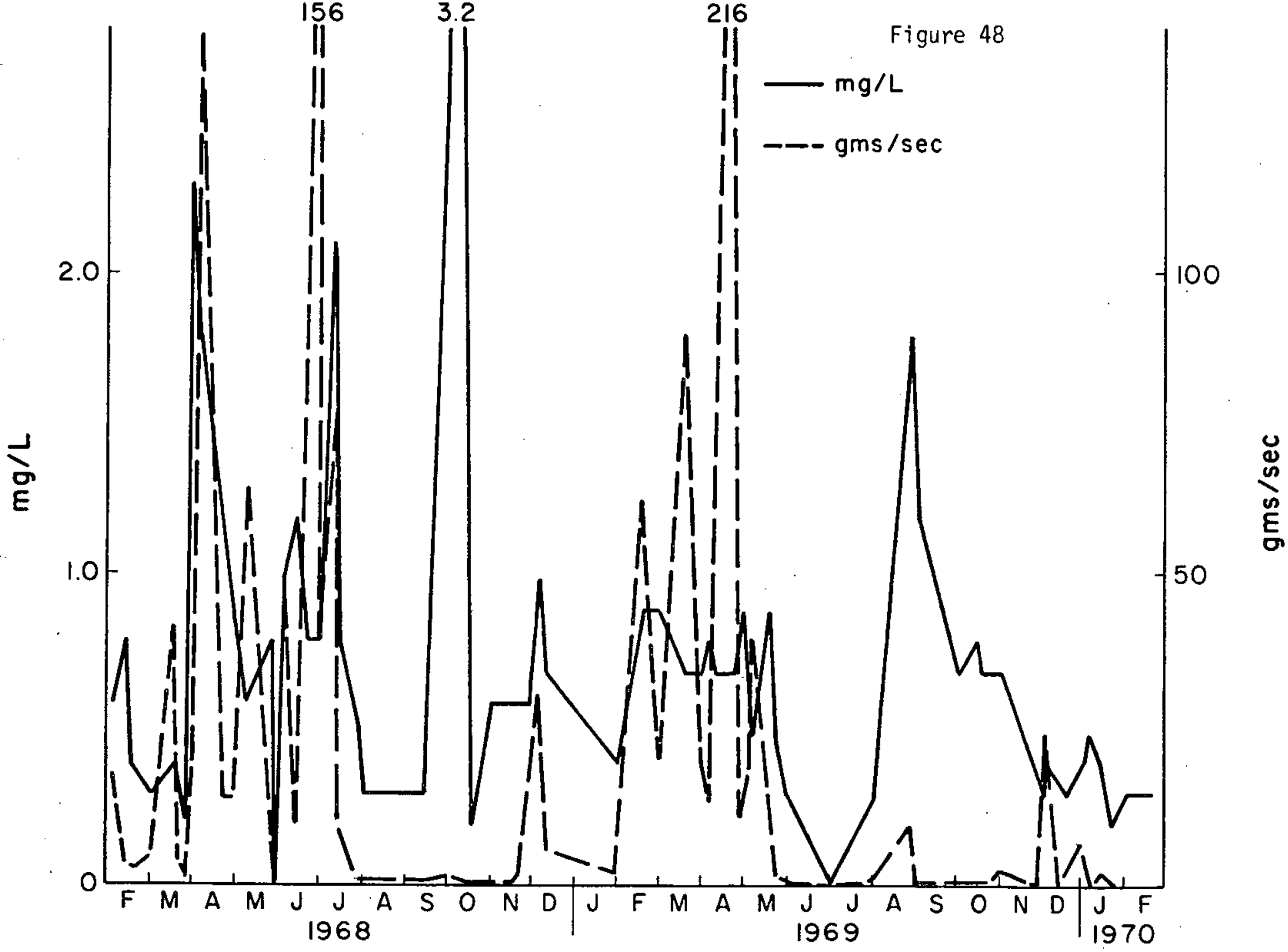
Figure 44




SULFATE-CEDAR CREEK
Figure 45
mg/L
gms/sec
1597
1433
300
200
100
0
mg/L
1,000
500
100
gms/sec
A
M
J
J
A
S
O
N
D
J
F
M
1969
1970


SULFATE-BRUSHY CREEK
Figure 46
mg/L
gms/sec
413
300
200
100
0
mg/L
gms/sec
A
M
J
J
A
S
O
N
D
J
F
M
1969
1970


NITRATE — STATION I
Figure 47
mg/L
gms/sec
mg/L
0
0.5
1.0
gms / sec
10
20
92.8
1.7
1.8
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970



NITRATE - USGS STATION 81110 BRYAN

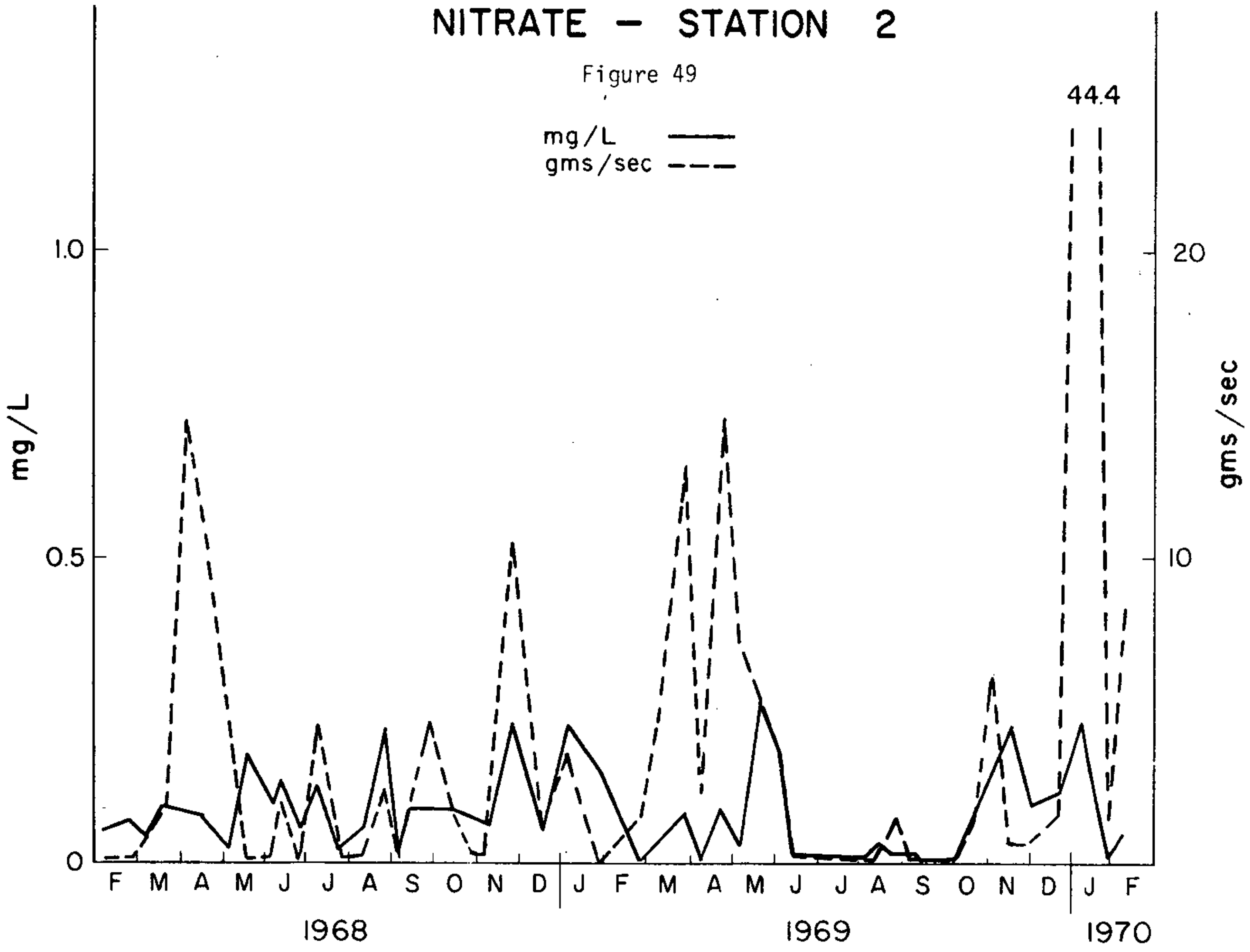
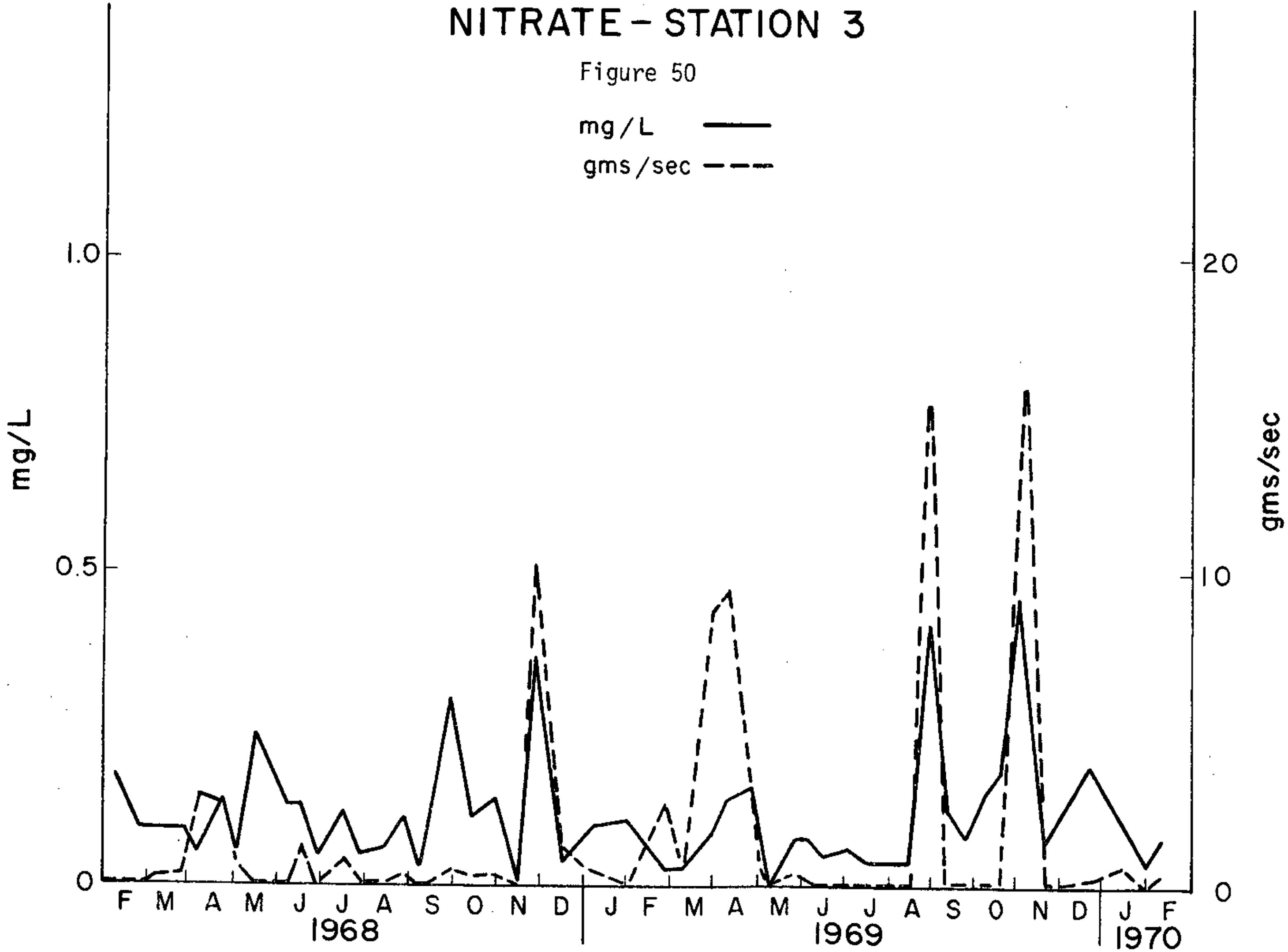
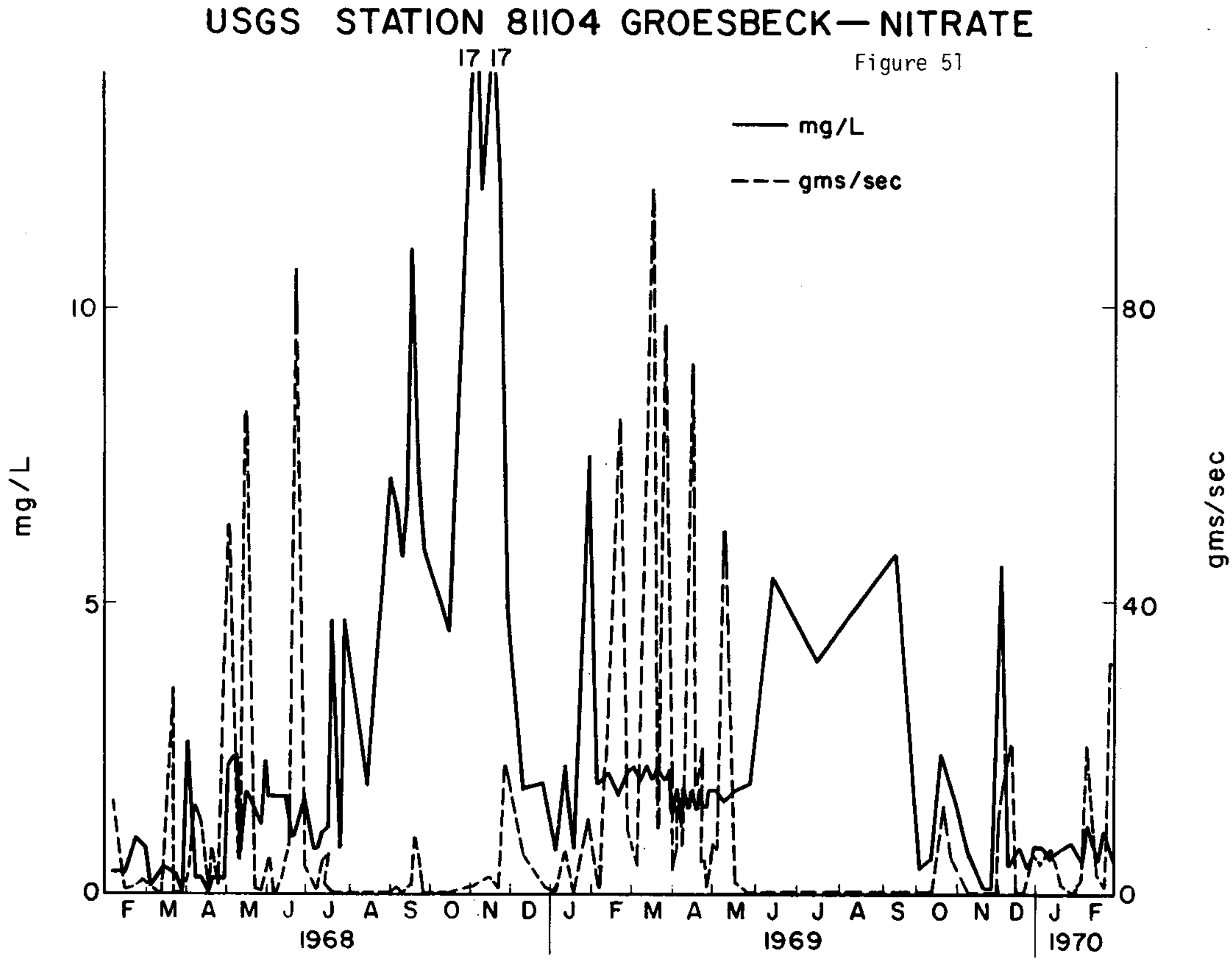

NITRATE - STATION 2
mg/L
gms/sec
44.4
1.0
0.5
0
20
10
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970
mg/L
gms/sec

Figure 49

NITRATE - STATION 3

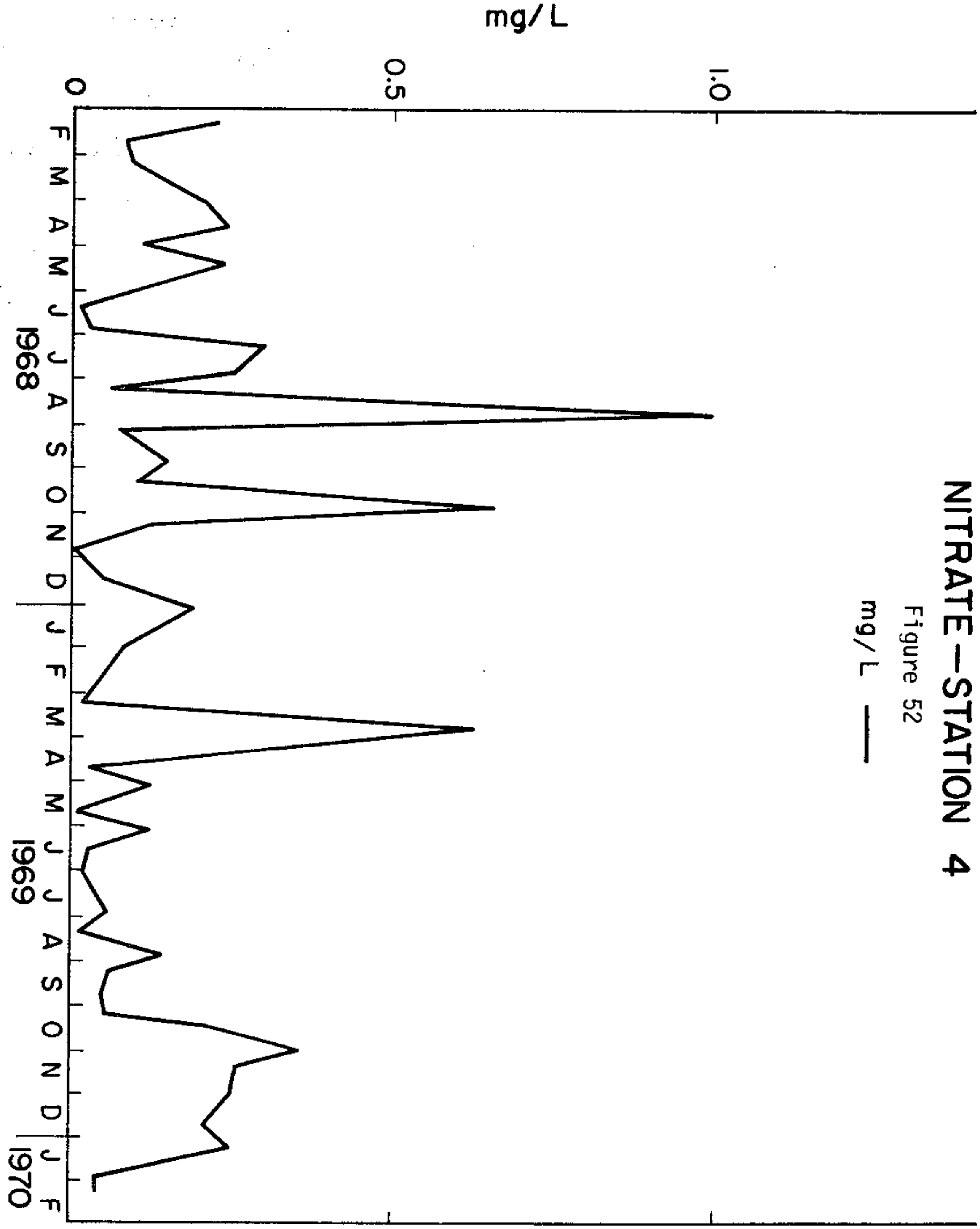
Figure 50





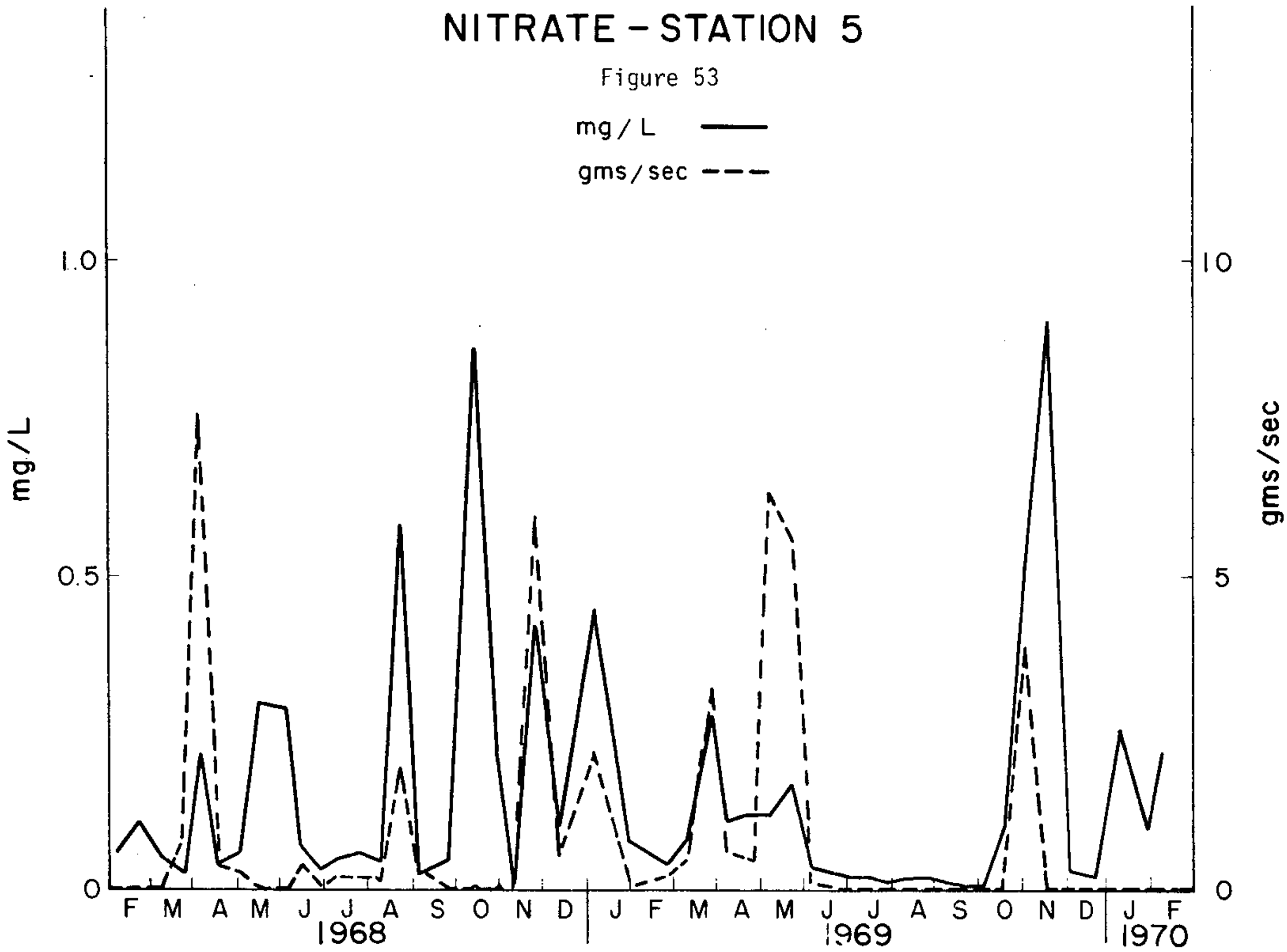
USGS STATION 81104 GROESBECK—NITRATE
17 17
mg/L
gms/sec
0
5
10
0
40
80
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970

Figure 51


NITRATE—STATION 4
Figure 52
mg/L
mg/L
0
0.5
1.0
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970

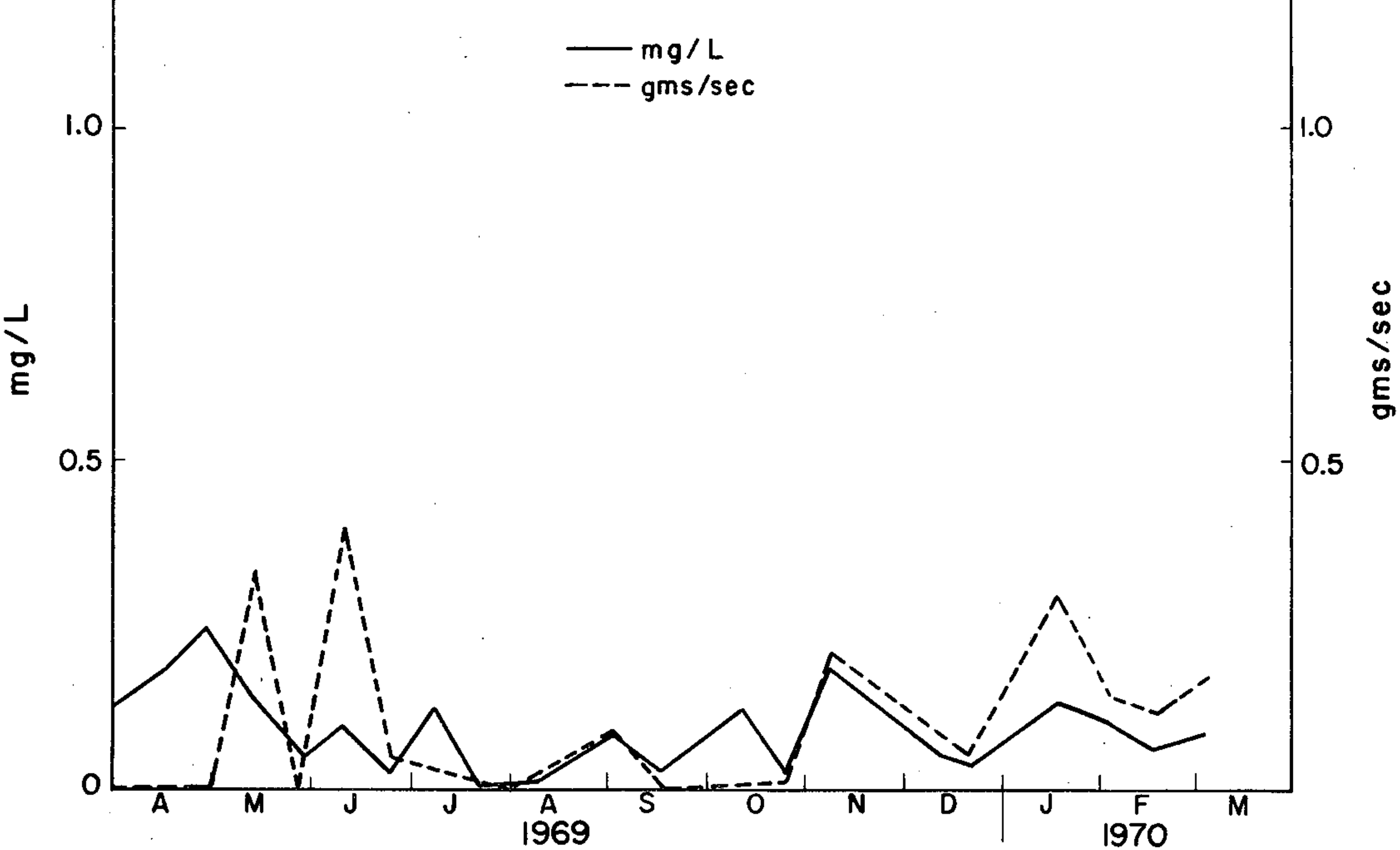
NITRATE - STATION 5

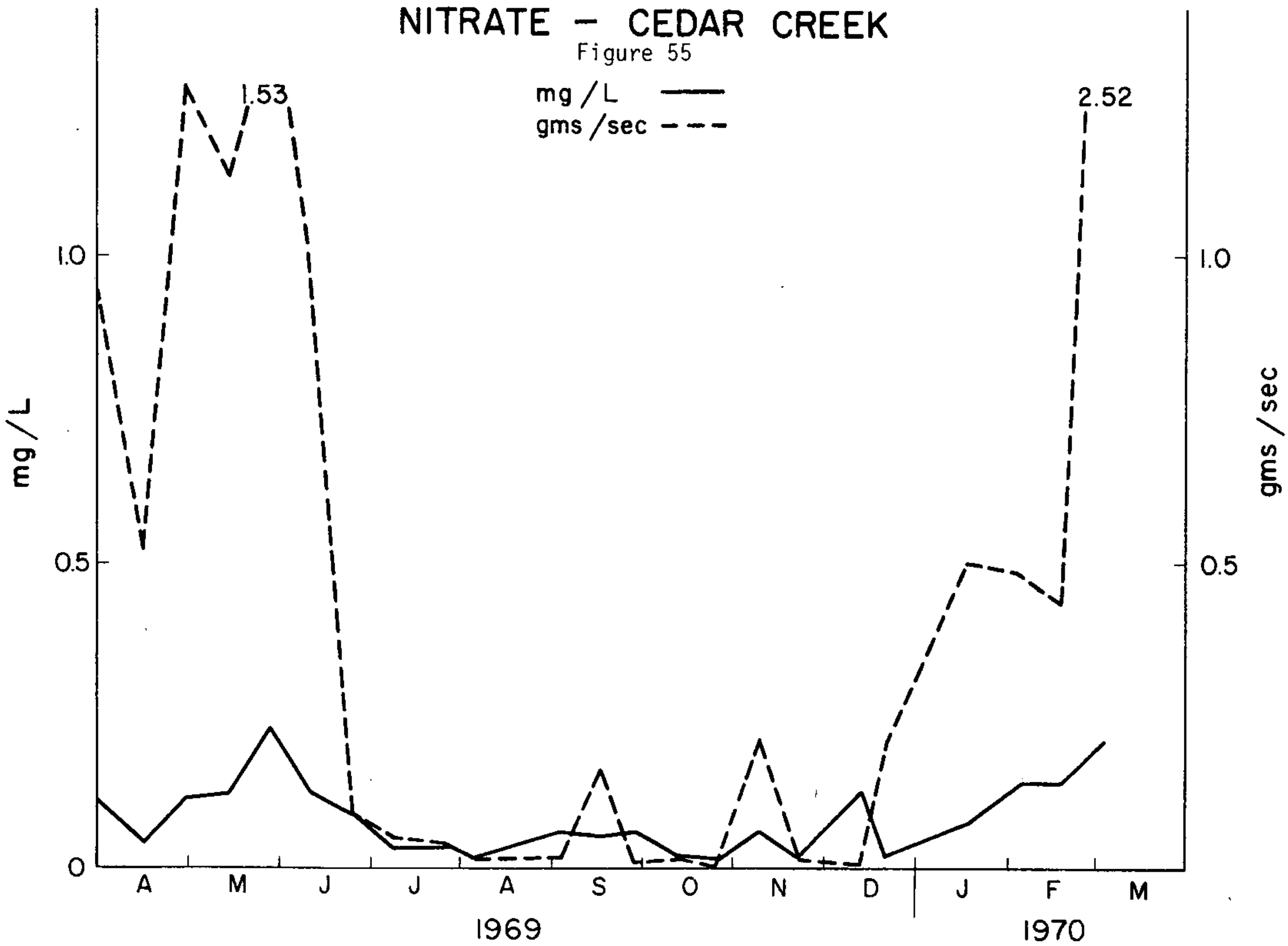
Figure 53

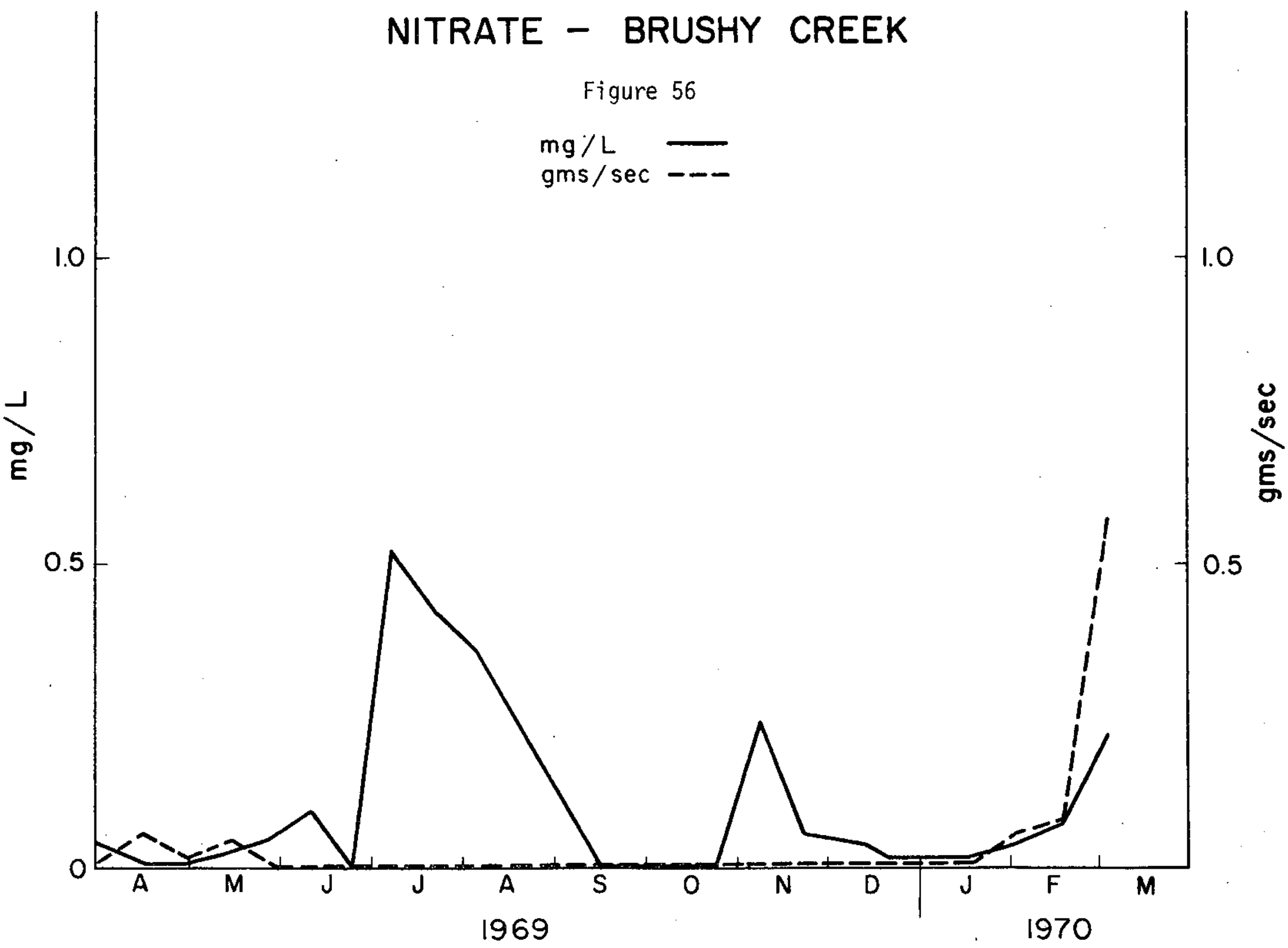


NITRATE — HOLLAND CREEK

Figure 54




NITRATE — CEDAR CREEK
Figure 55
mg / L
gms / sec
1.53
2.52
mg / L
1.0
0.5
0
gms / sec
1.0
0.5
A
M
J
J
A
S
O
N
D
J
F
M
1969
1970



NITRATE - BRUSHY CREEK
Figure 56
mg/L
gms/sec
mg/L
gms/sec
1.0
0.5
0
1.0
0.5
A
M
J
J
A
S
O
N
D
J
F
M
1969
1970

There are no known sources for the increase between stations 2 and 81110, a distance of 15 river miles.

Large amounts of treated domestic sewage are known to enter from Bryan-College Station via Carter Creek, about midway between stations 81110 and 1; yet, values at station 1 are lower than those at 81110. It is possible that there are significant differences in the methods used by the USGS and those used by project personnel, resulting in under estimations of Nitrate at project stations.

Total Hardness

The data are presented in Figures 57 through 66.

Concentration, though variable, is within the same general range for all stations - river and tributary - except 5, 81104 and 3. Station 5 values are the lowest, even lower than the tributaries. There was an increase through the lakes, with concentrations at station 4 similar to the three lower stations. Again, station 81104 showed spectacular increases; with some of the effect carried down to station 3, but not evidenced at station 2.

Total load data followed total flow quite closely and show a general downstream increase.

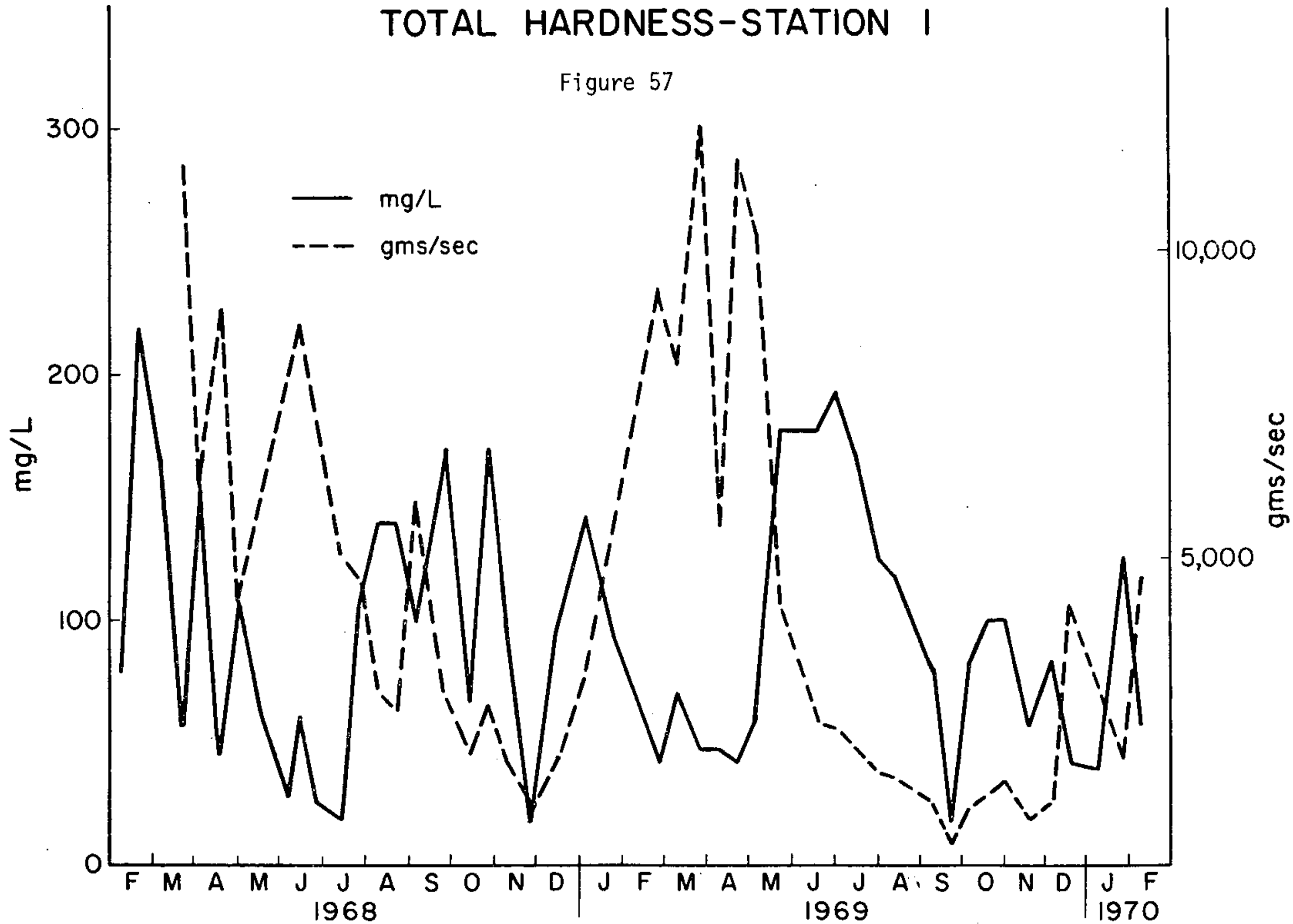
Specific Conductance

The data are reported in Figures 67 through 76.

The one generalized pattern in the conductivity data is the increase during summer and fall periods of low flow. Only Brushy and Holland Creeks failed to show this pattern. The fluctuations through-

TOTAL HARDNESS-STATION I

Figure 57



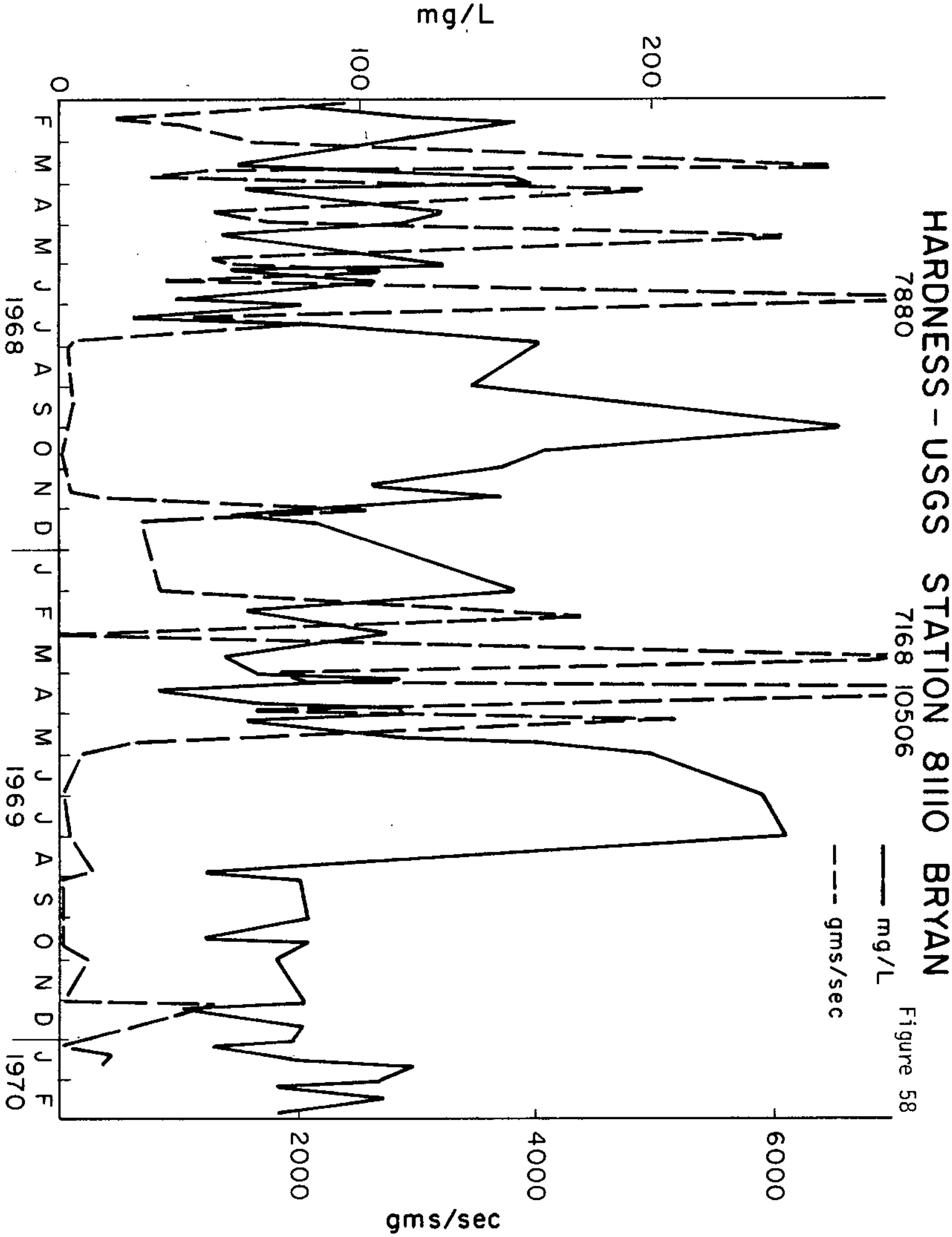

HARDNESS - USGS STATION 81110 BRYAN
mg/L
gms/sec
7880
7168
10506
mg/L
0
100
200
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970
2000
4000
6000
gms/sec

Figure 58

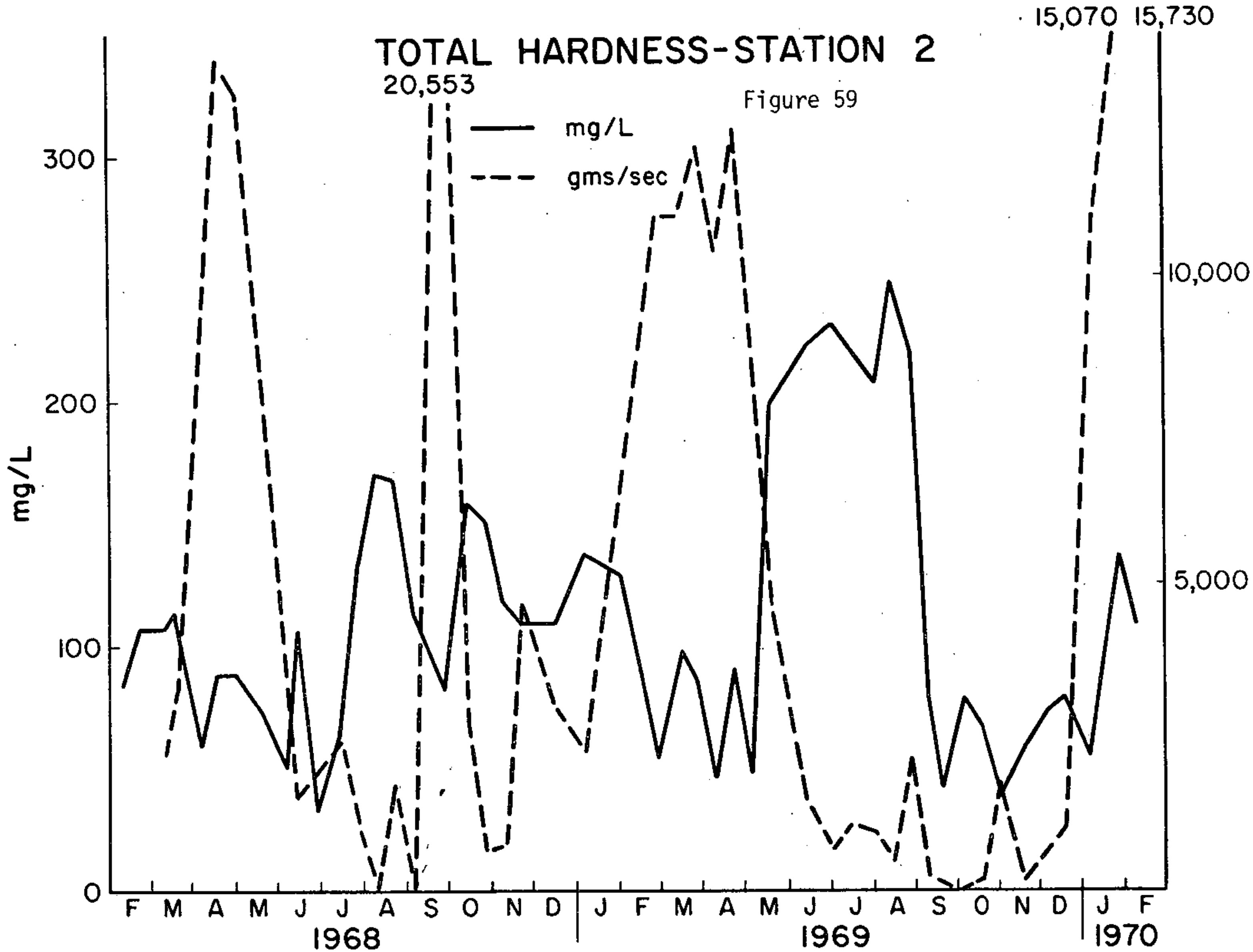
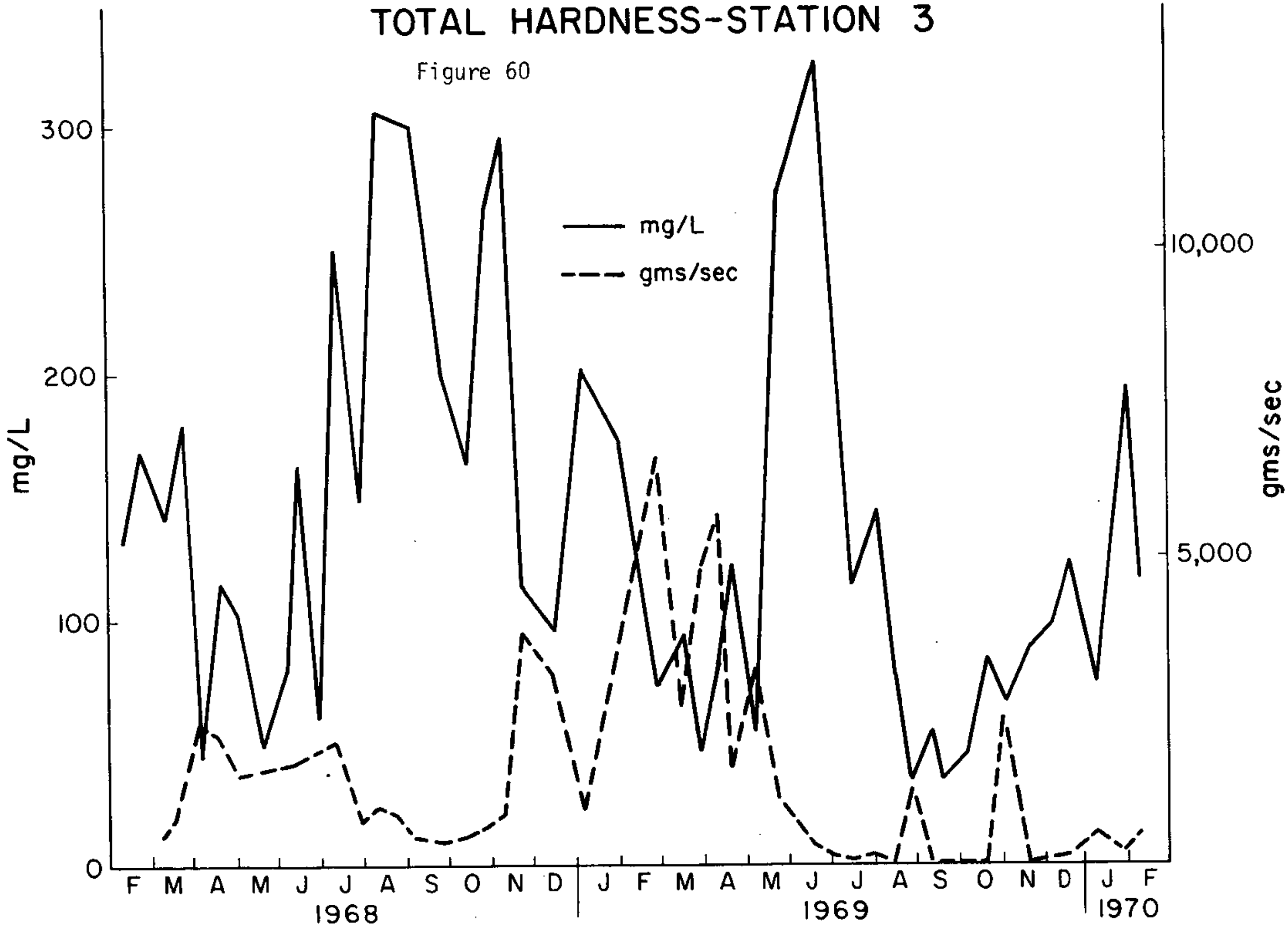

TOTAL HARDNESS-STATION 2
20,553
mg/L
gms/sec
15,070
15,730
300
200
100
0
10,000
5,000
F M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970

Figure 59

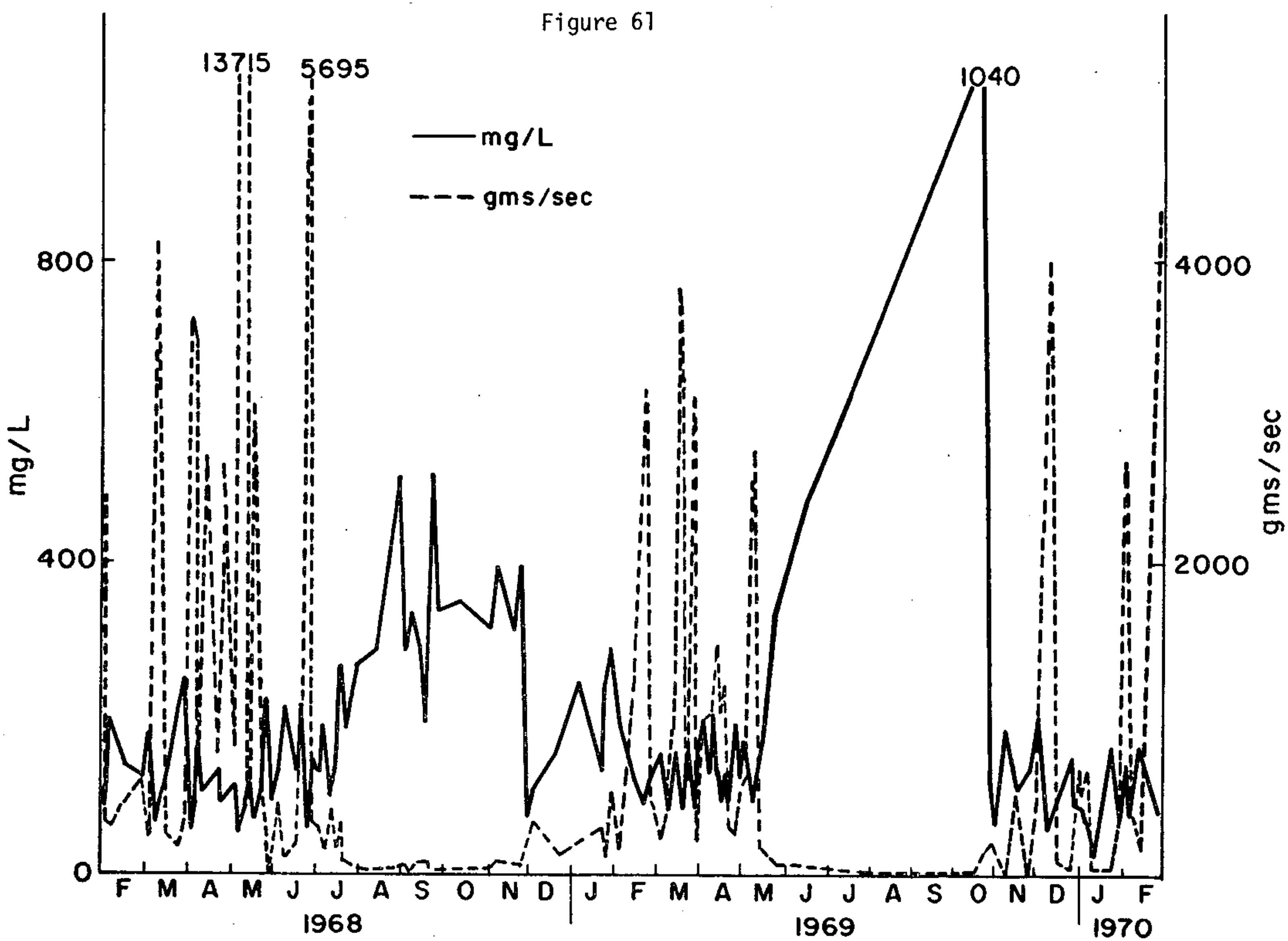
TOTAL HARDNESS-STATION 3

Figure 60



USGS STATION 81104 GROESBECK—HARDNESS (TOTAL)

Figure 61



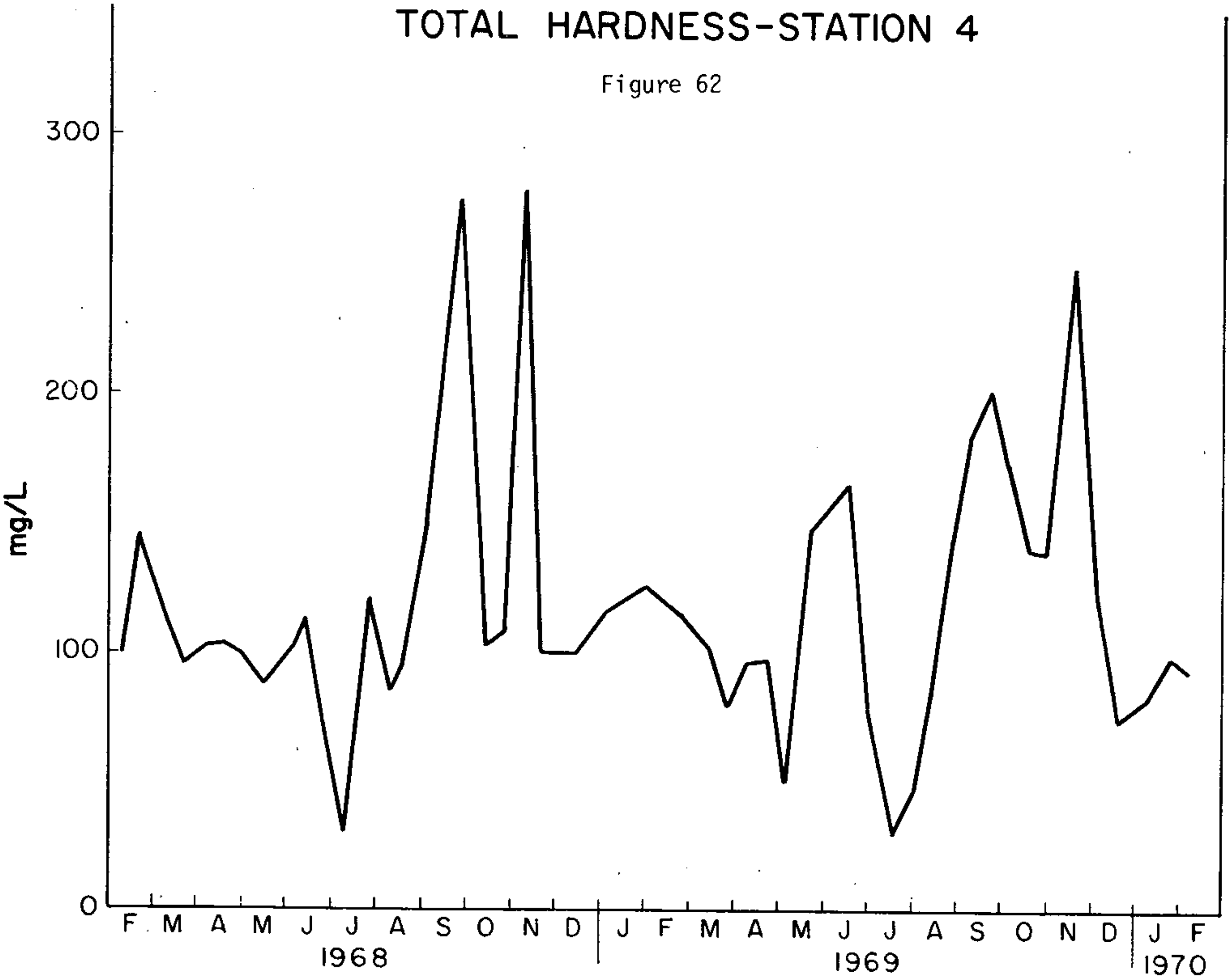
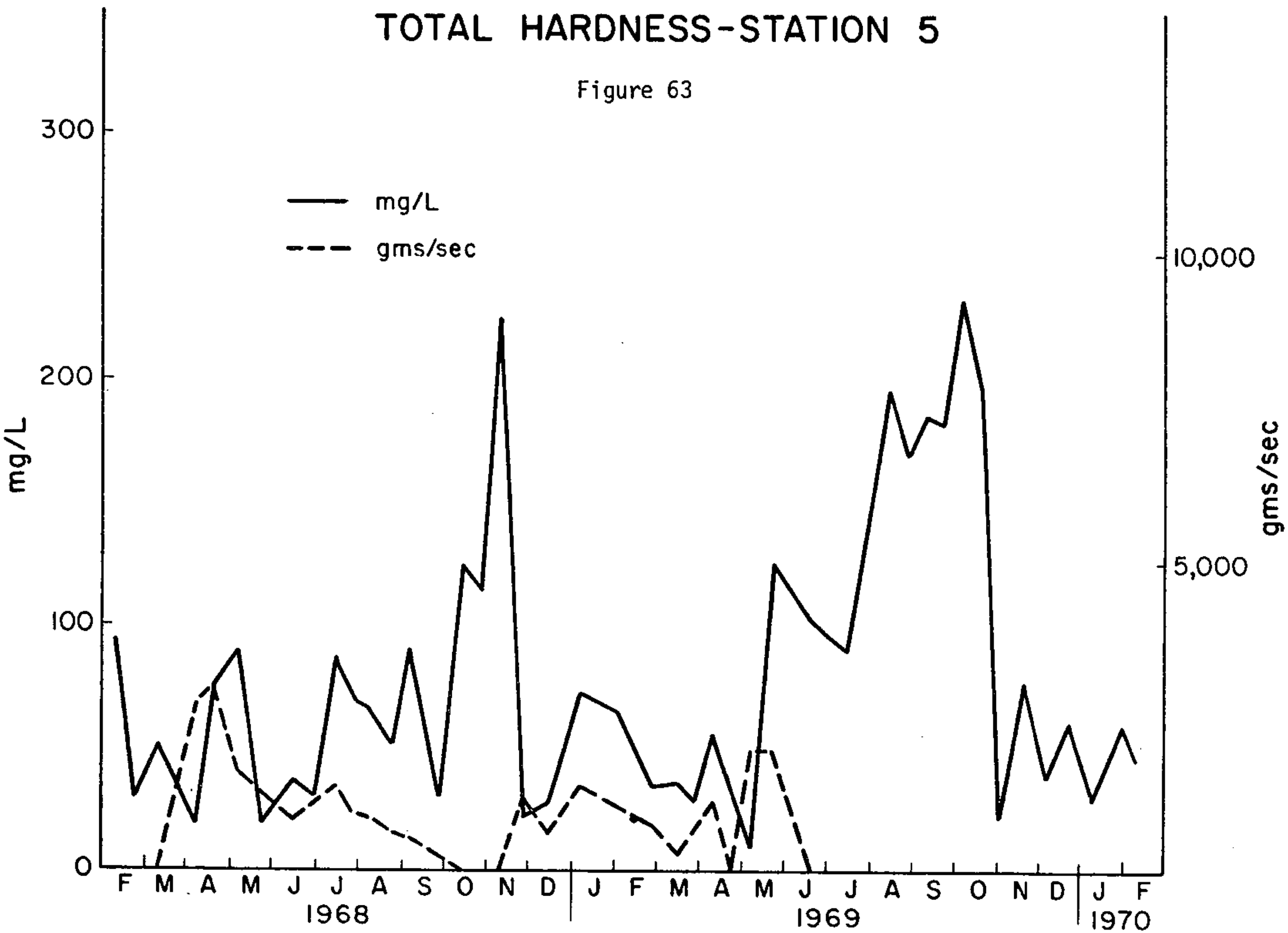
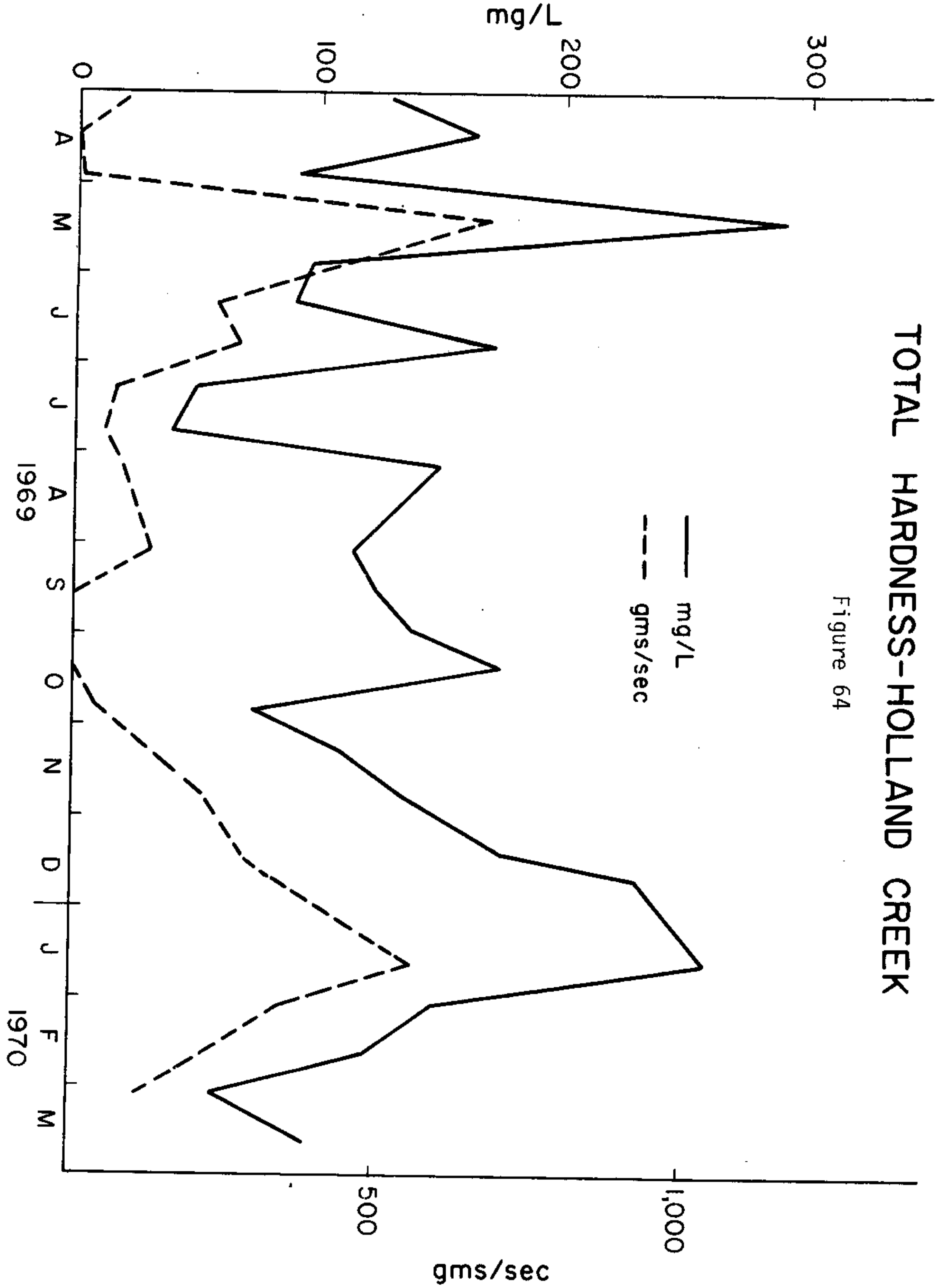

TOTAL HARDNESS-STATION 4
mg/L
0
100
200
300
F M A M J J A S O N D
1968
J F M A M J J A S O N D
1969
J F
1970

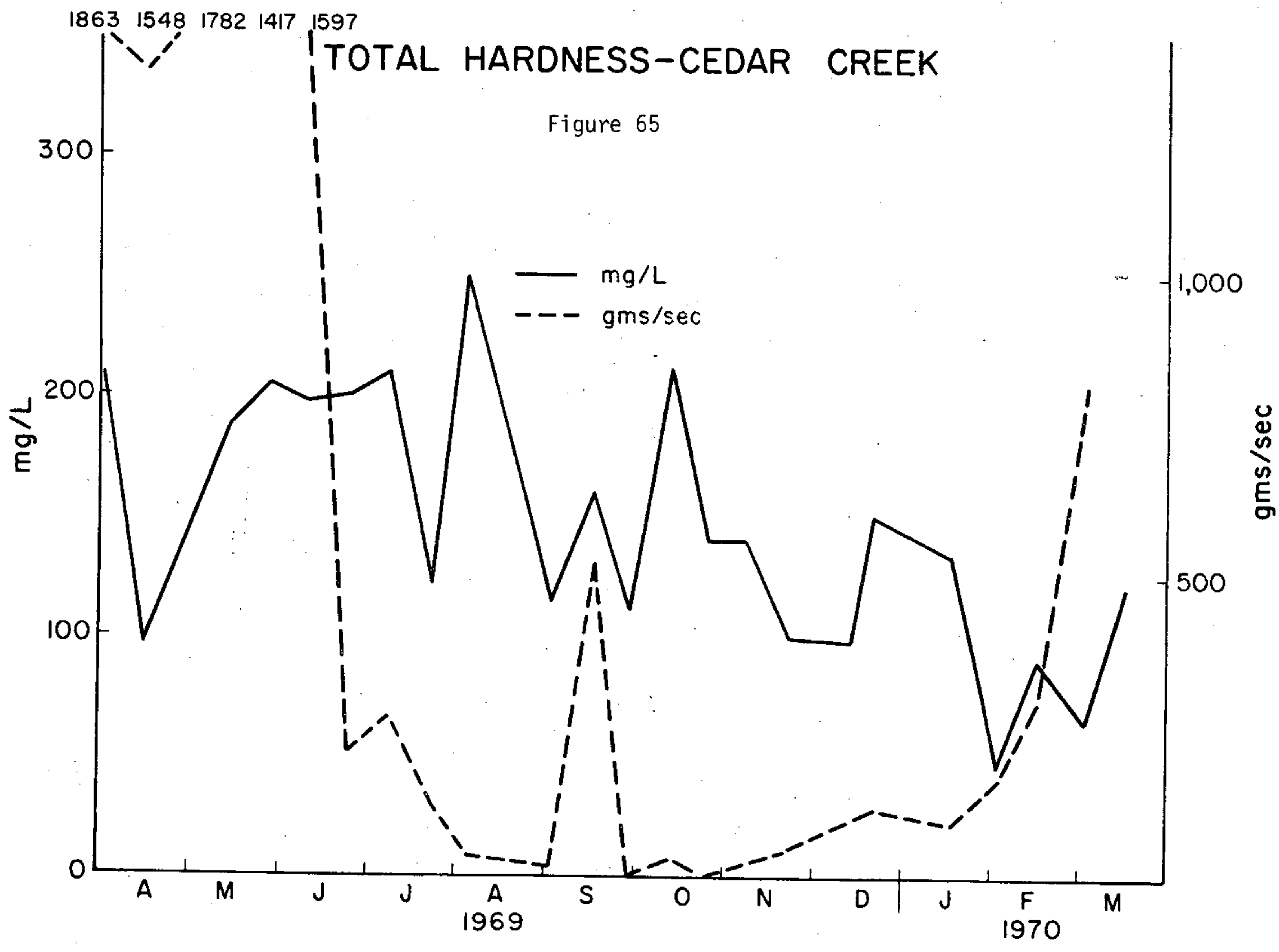
Figure 62

TOTAL HARDNESS-STATION 5

Figure 63

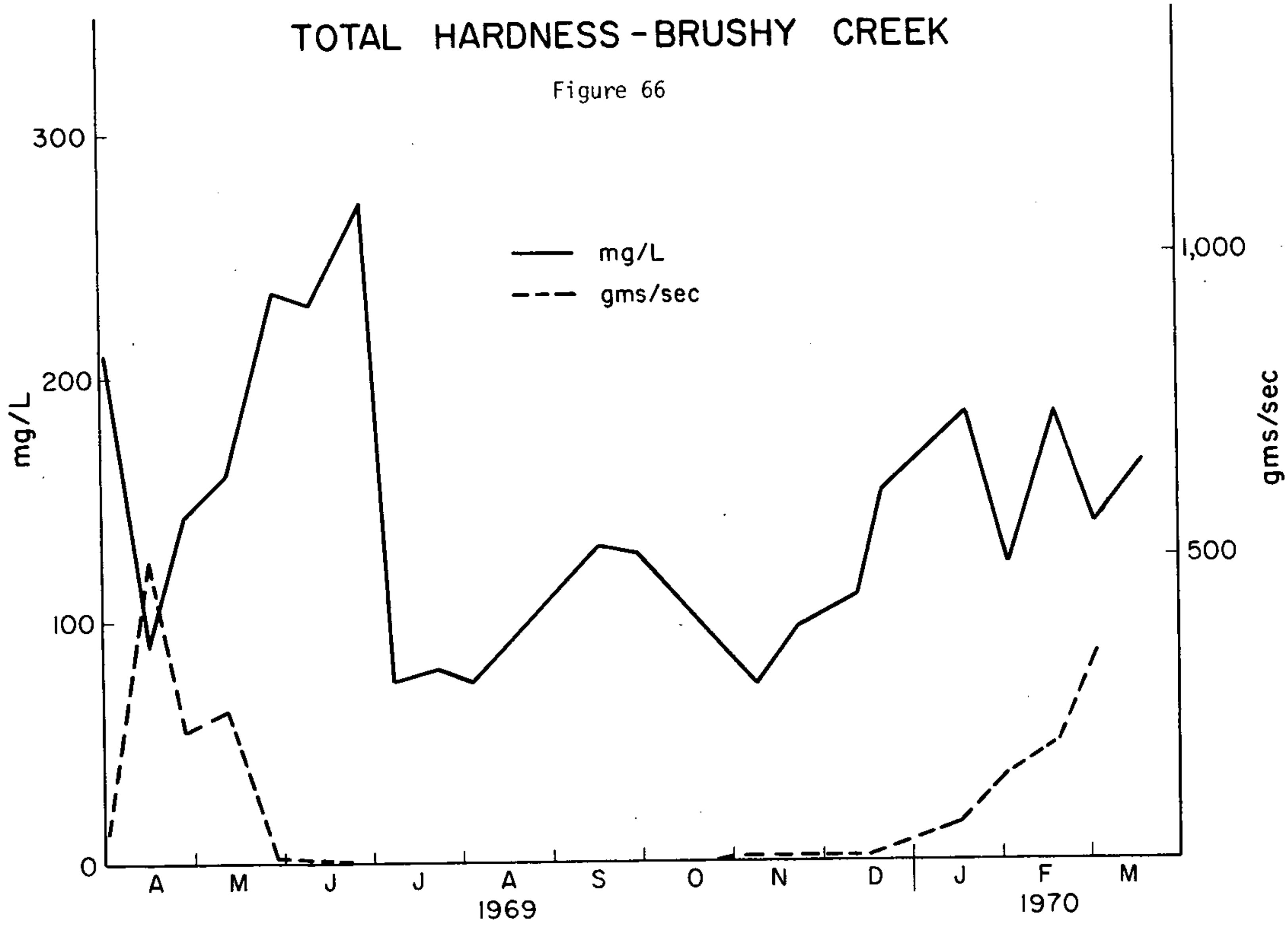



TOTAL HARDNESS-HOLLAND CREEK
Figure 64
mg/L
gms/sec
mg/L
0
100
200
300
A
M
J
J
A
S
O
N
D
J
F
M
1969
1970
500
1,000
gms/sec


1863 1548 1782 1417 1597
TOTAL HARDNESS-CEDAR CREEK
Figure 65
mg/L
gms/sec
300
200
100
0
mg/L
1,000
500
gms/sec
A M J J A S O N D J F M
1969
1970

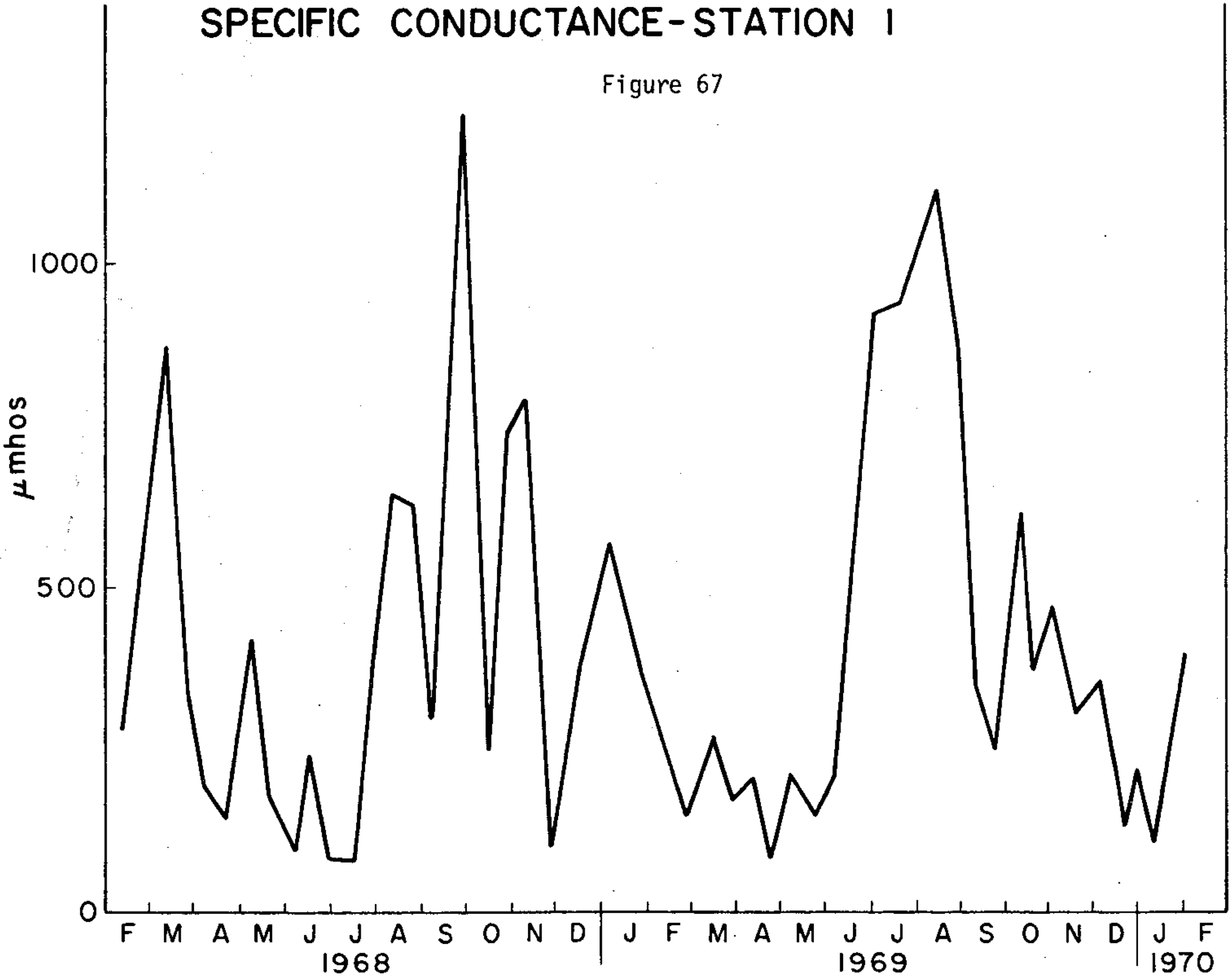
TOTAL HARDNESS-BRUSHY CREEK

Figure 66



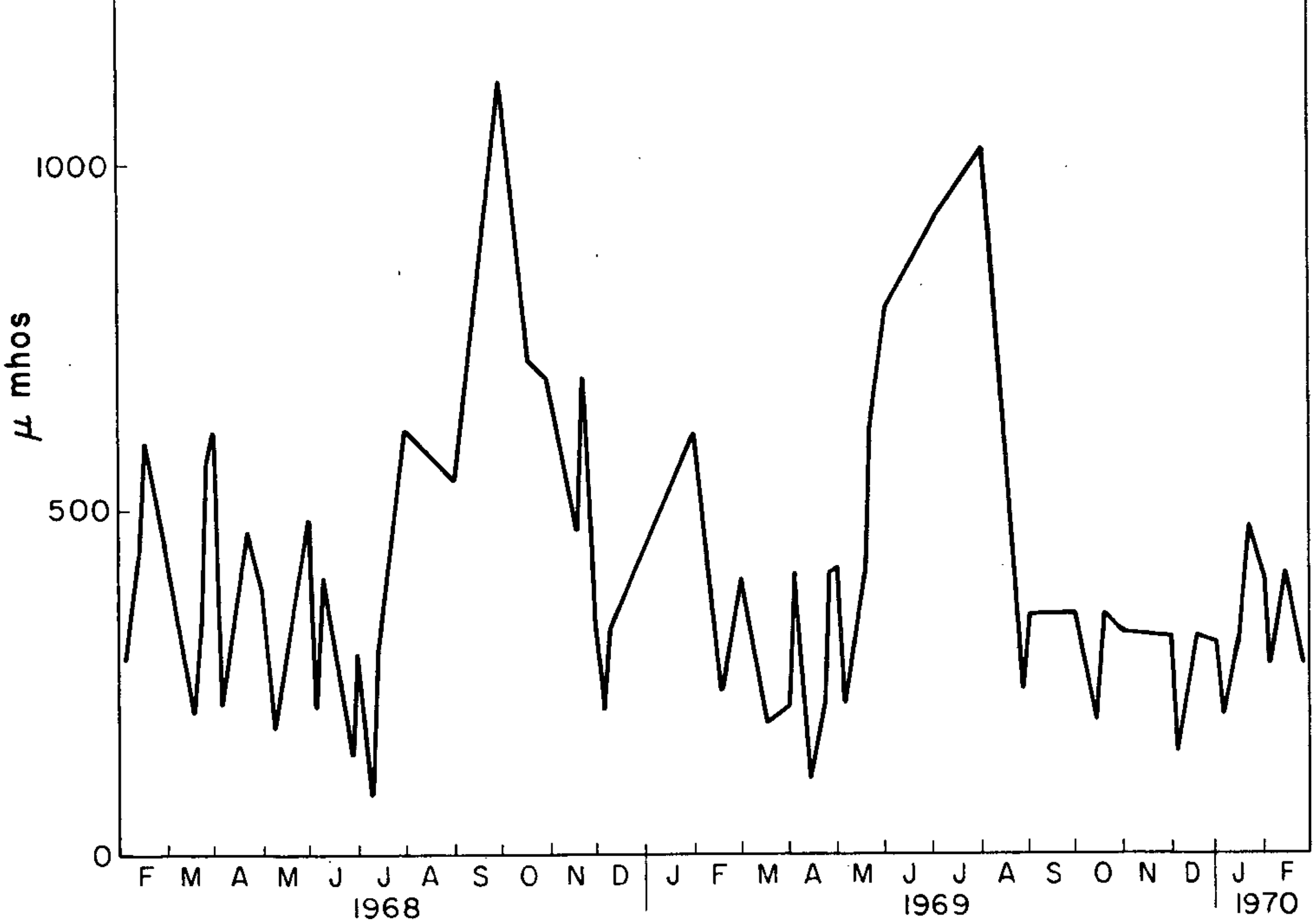
SPECIFIC CONDUCTANCE-STATION I

Figure 67



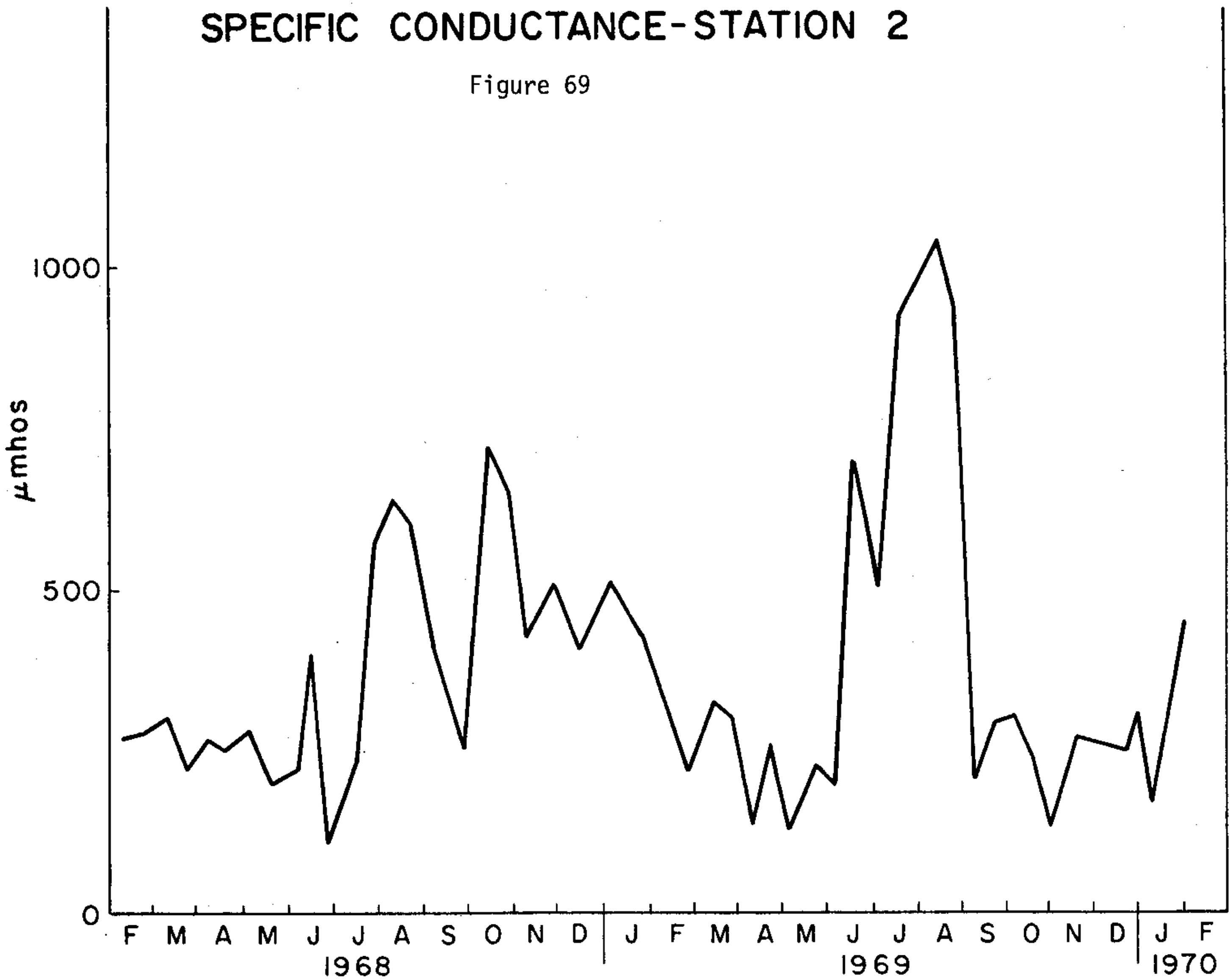
SPECIFIC CONDUCTANCE—USGS STATION 8110 BRYAN

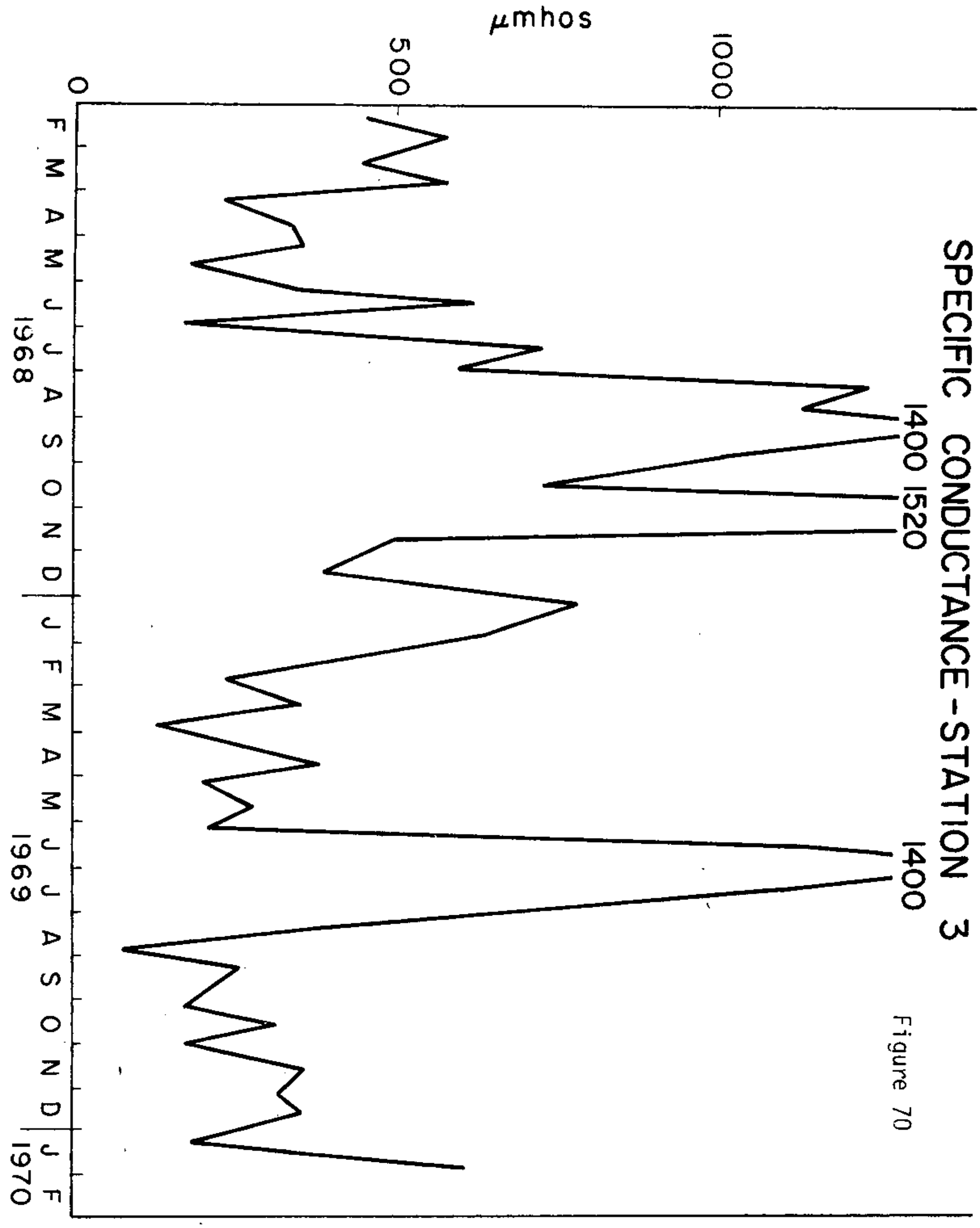
Figure 68



SPECIFIC CONDUCTANCE-STATION 2

Figure 69



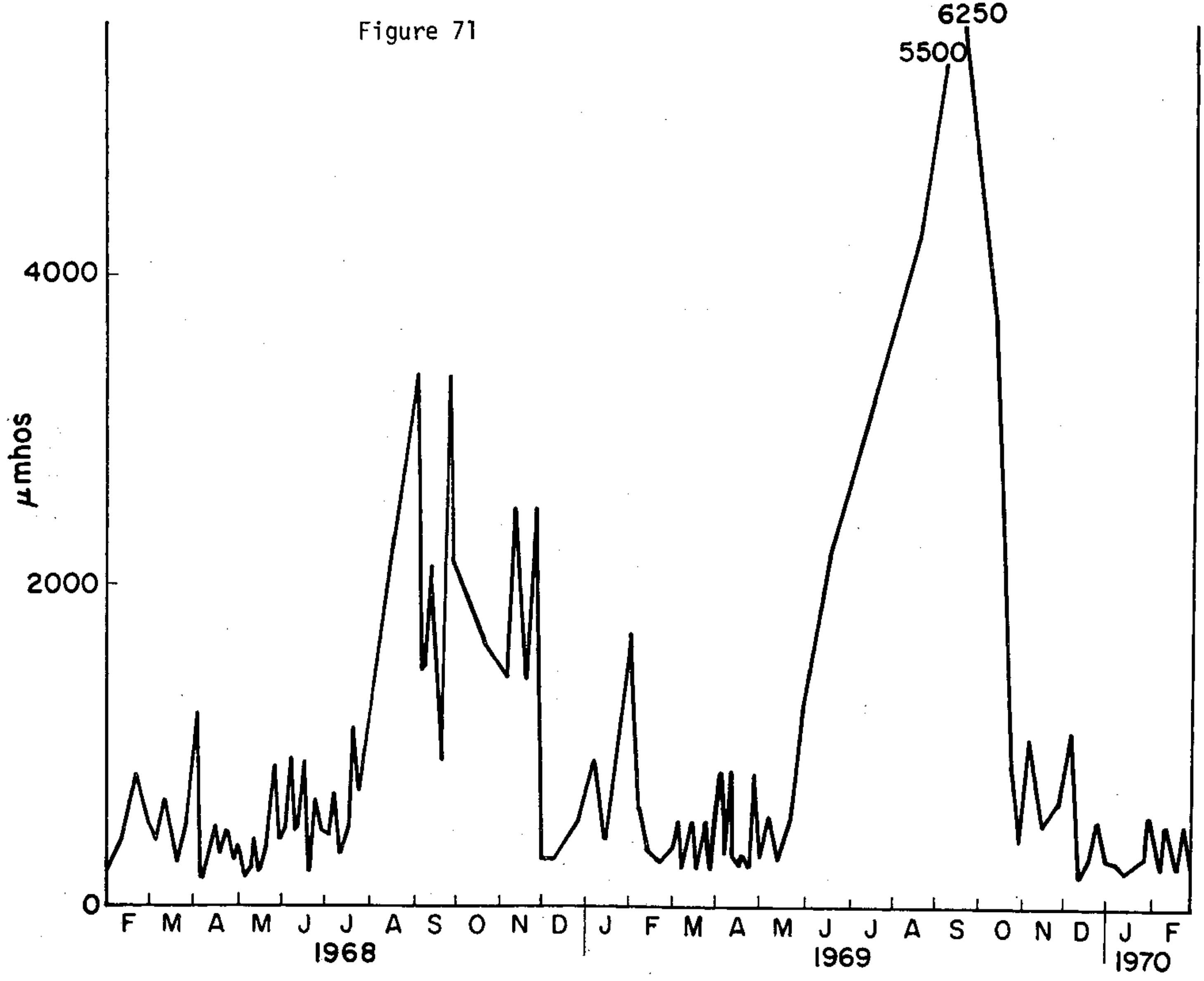


SPECIFIC CONDUCTANCE-STATION 3

Figure 70

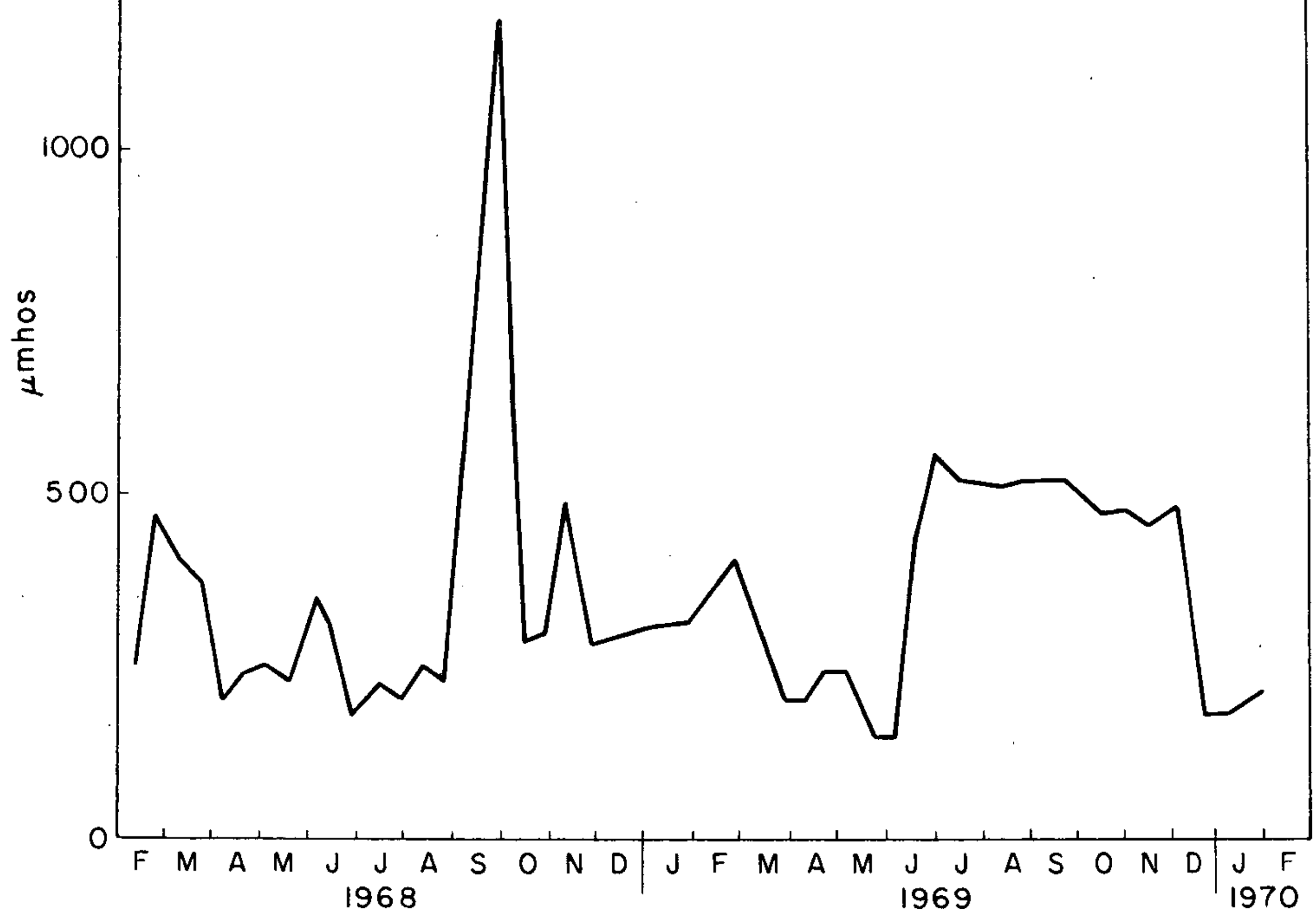
USGS STATION 81104 GROESBECK—SPECIFIC CONDUCTANCE

Figure 71



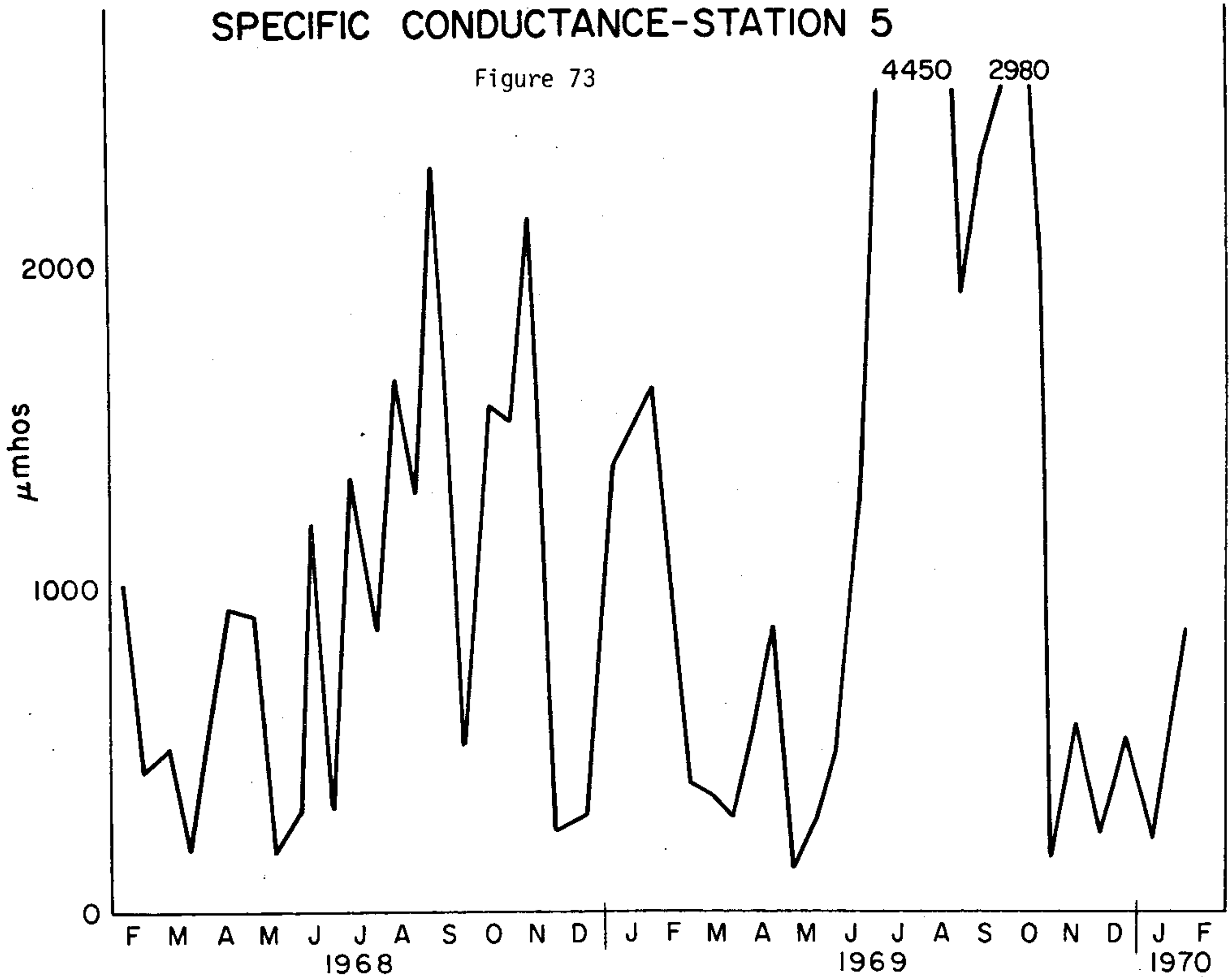
SPECIFIC CONDUCTANCE-STATION 4

Figure 72



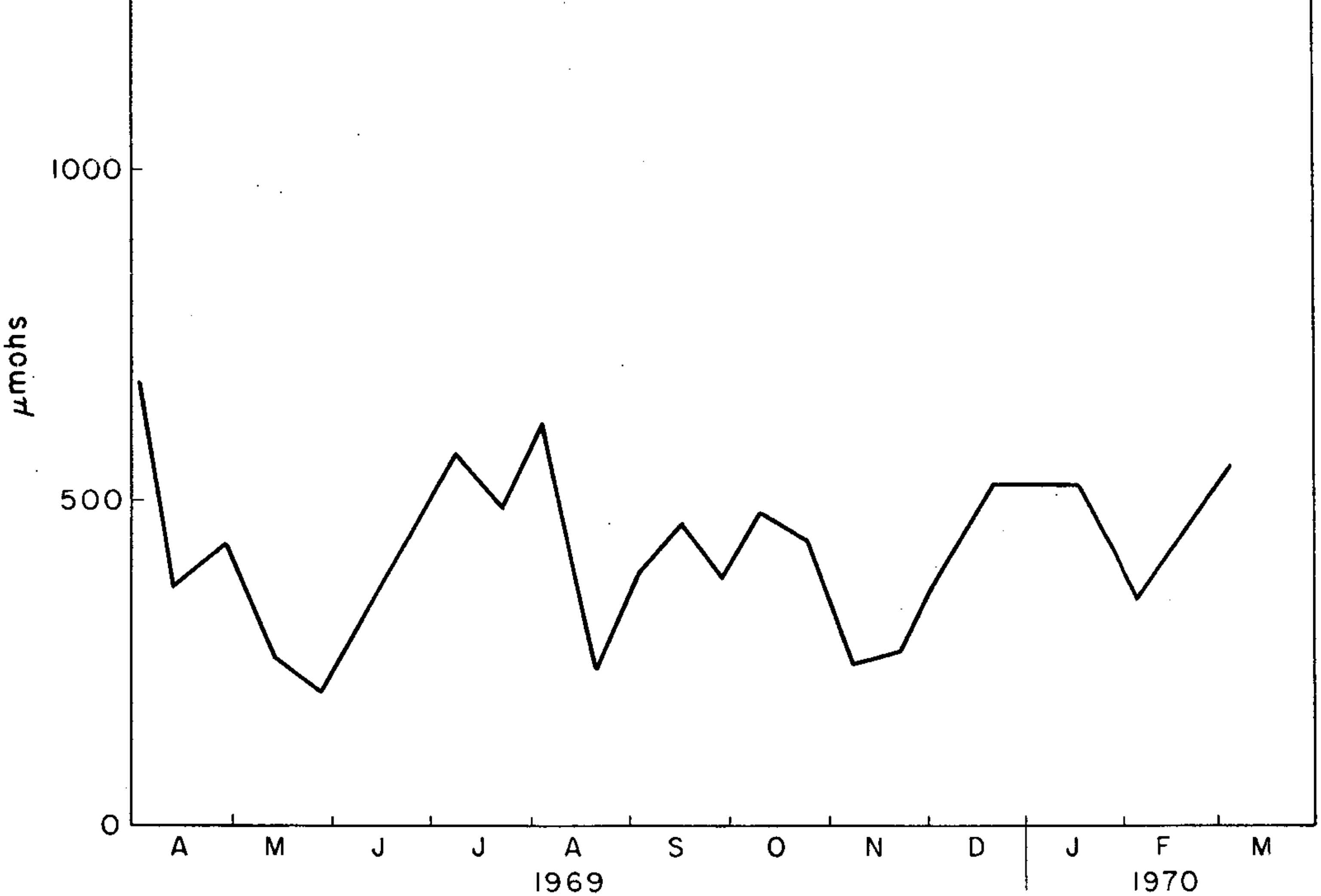
SPECIFIC CONDUCTANCE-STATION 5

Figure 73



SPECIFIC CONDUCTANCE—HOLLAND CREEK

Figure 74



out the year seem to follow a general inverse relationship with flow.

USGS Station 81104 shows low flow conductivities many times higher than any other station, reflecting the chloride concentrations.

There appears to be a general dilution effect downstream from this station.

Station 5 is an intermittent channel, with values not too different from those of the tributaries. The higher values in the summer of 1969 are coincident with use of the stream channel by considerable numbers of cattle when the water was confined to pools.

Trace Elements

Trace element analyses, along with Sodium, Potassium, Calcium and Magnesium, were done by the Analytical Services Laboratory, Texas A&M University. The data are reported in Table 9.

The trace metals are all below detection levels in unconcentrated samples, though all but mercury were present in detectable amounts in the suspended solids. Mercury was still below the detection limit of 0.3 parts per billion, even in the solids.

Organic Content

During a nine month period from June, 1967 through February, 1970, water samples from the eight project stations were analyzed by two methods designed to give estimates of organic content; the dry weight - ash weight - loss on ignition method and the Beckman Carbon Analyzer.

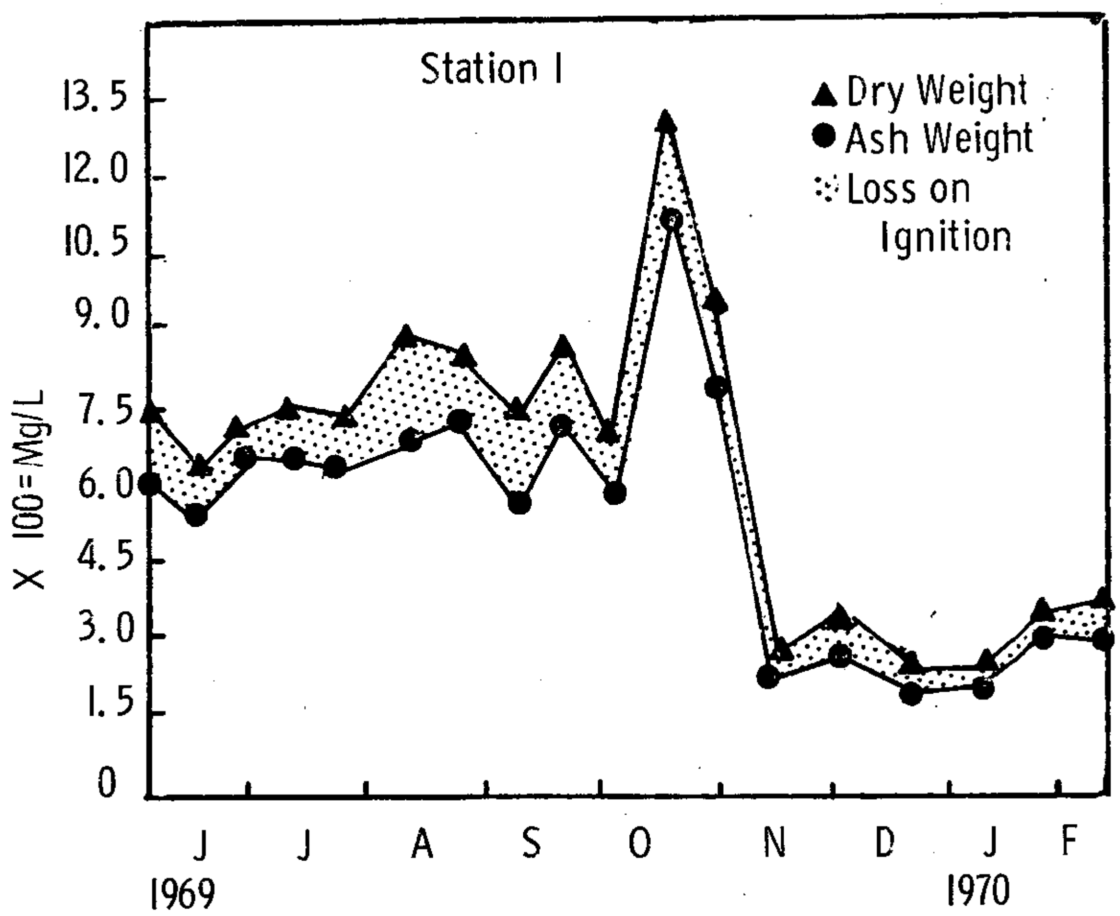
Table 9

Trace Element Analysis of Navasota River water 26 August, 1970

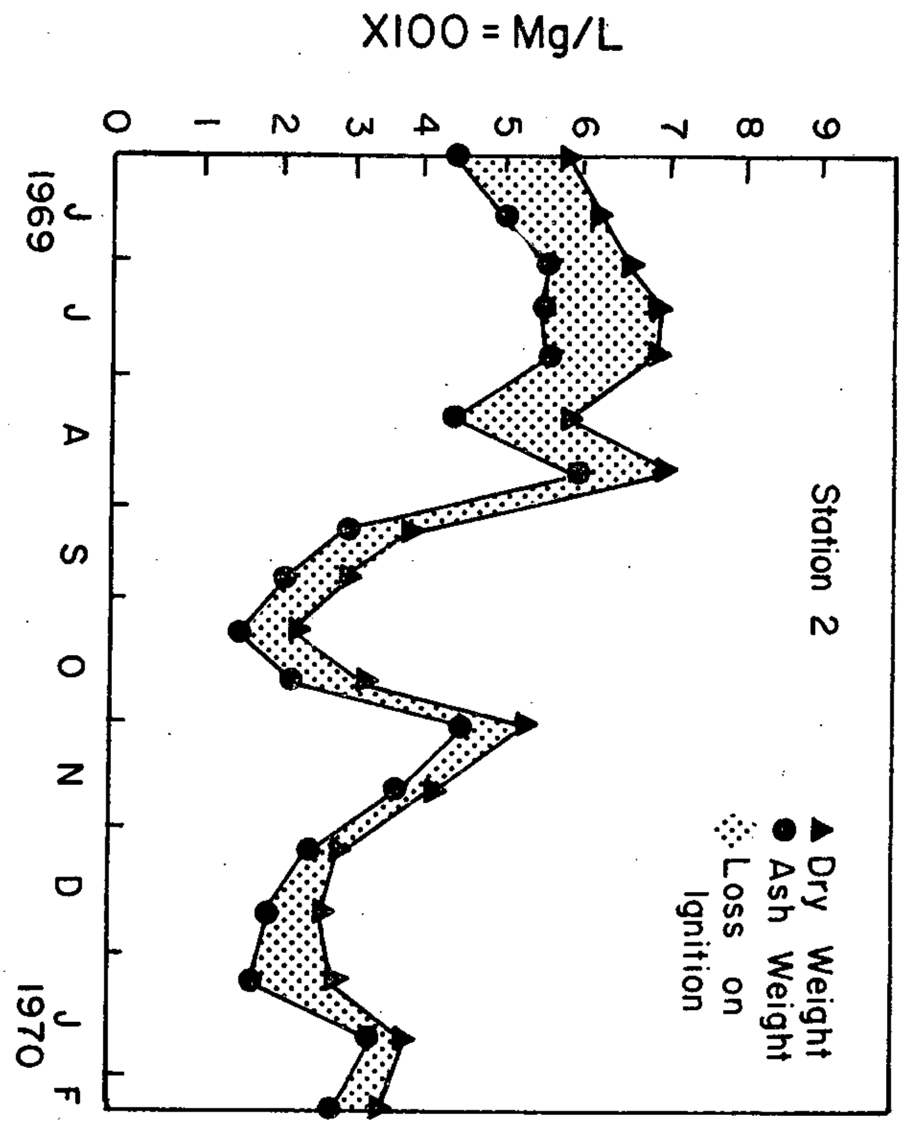
	Crossing, State Highway 30			Station 1		
	Whole Sample	Decanted Liquid	Solids*	Whole Sample	Decanted Liquid	Solids*
Mn (ppm)	0.08	0.03	1.62	0.09	0.05	0.84
Zn (ppm)	<0.03	<0.03	0.32	<0.03	<0.03	0.07
Fe (ppm)	0.2	0.06	11.20	1.3	0.5	40.0
Na (ppm)	119.0	119.0	5.6	219.0	219.0	12.3
Mg (ppm)	18.0	16.3	0.5	7.5	7.3	12.7
Ca (ppm)	62.8	62.0	2.25	33.0	32.8	21.75
K (ppm)	7.3	7.3	0.95	7.15	7.5	1.22
Cu (ppm)	<0.2	<0.2	0.19	<0.2	<0.2	0.07
Co (ppm)	<0.1	<0.1	0.34	<0.1	<0.1	0.29
Pb (ppm)	<0.4	<0.4	0.79	<0.4	<0.4	0.51
Hg (ppb)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

*Reported as Concentration in the solids, not directly comparable to concentration of the liquid samples.

Figure 77



Station I
Dry Weight
Ash Weight
Loss on Ignition
13.5
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0
X 100=Mg/L
J
J
A
S
O
N
D
J
F
1969
1970



Station 2
▲ Dry Weight
● Ash Weight
Loss on Ignition
X100 = Mg/L
0
1
2
3
4
5
6
7
8
9
J
1969
J
A
S
O
N
D
J
1970
F

Figure 78

Figure 79

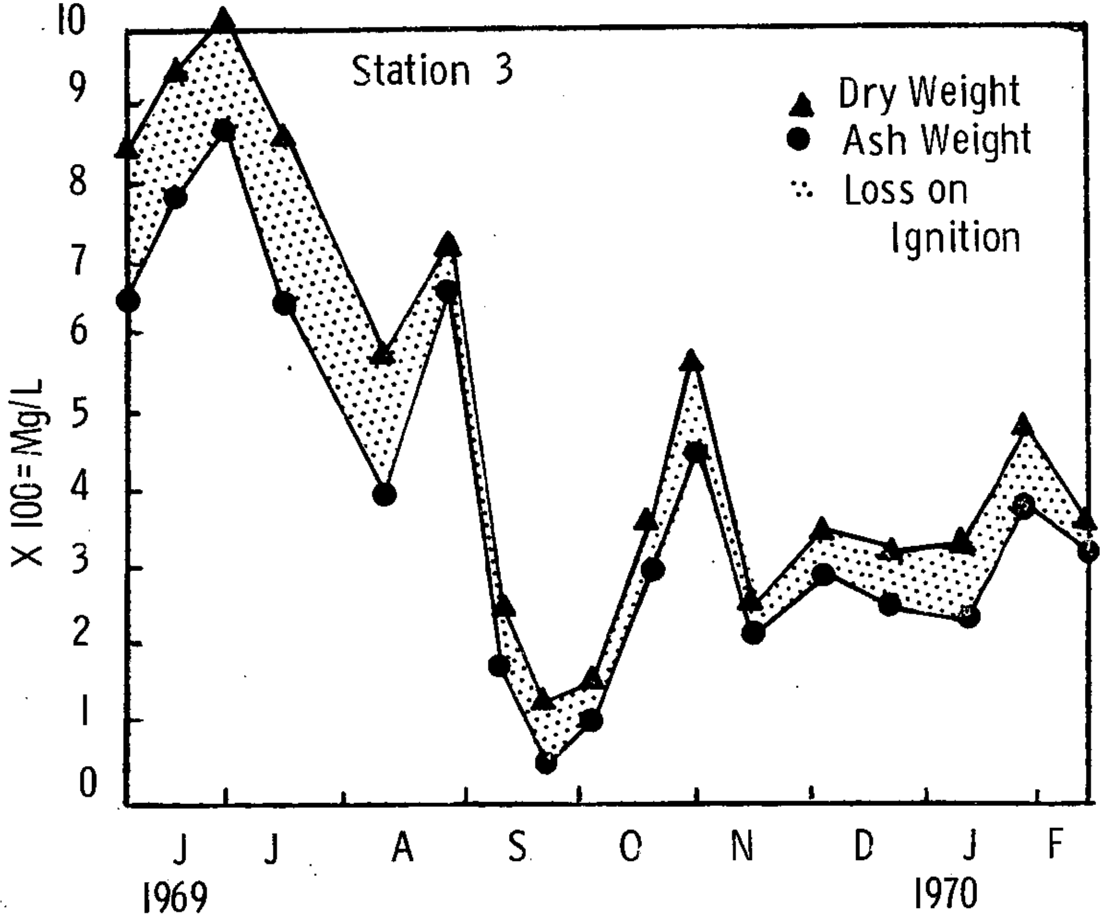

10
9
8
7
6
5
4
3
2
1
0
X 100 = Mg/L
Station 3
Dry Weight
Ash Weight
Loss on
Ignition
J
J
A
S
O
N
D
J
F
1969
1970

Figure 80

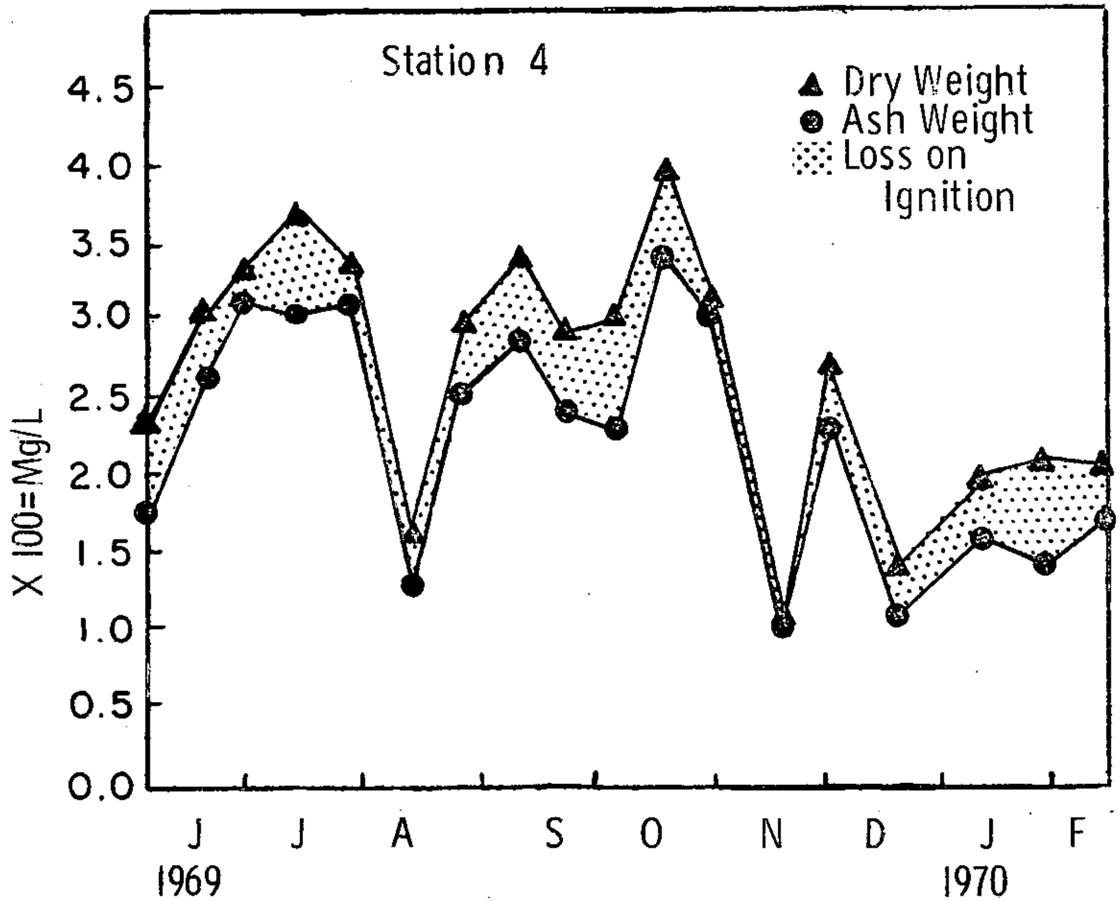

Station 4
Dry Weight
Ash Weight
Loss on Ignition
X 100=Mg/L
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
J
J
A
S
O
N
D
J
F
1969
1970

Figure 81

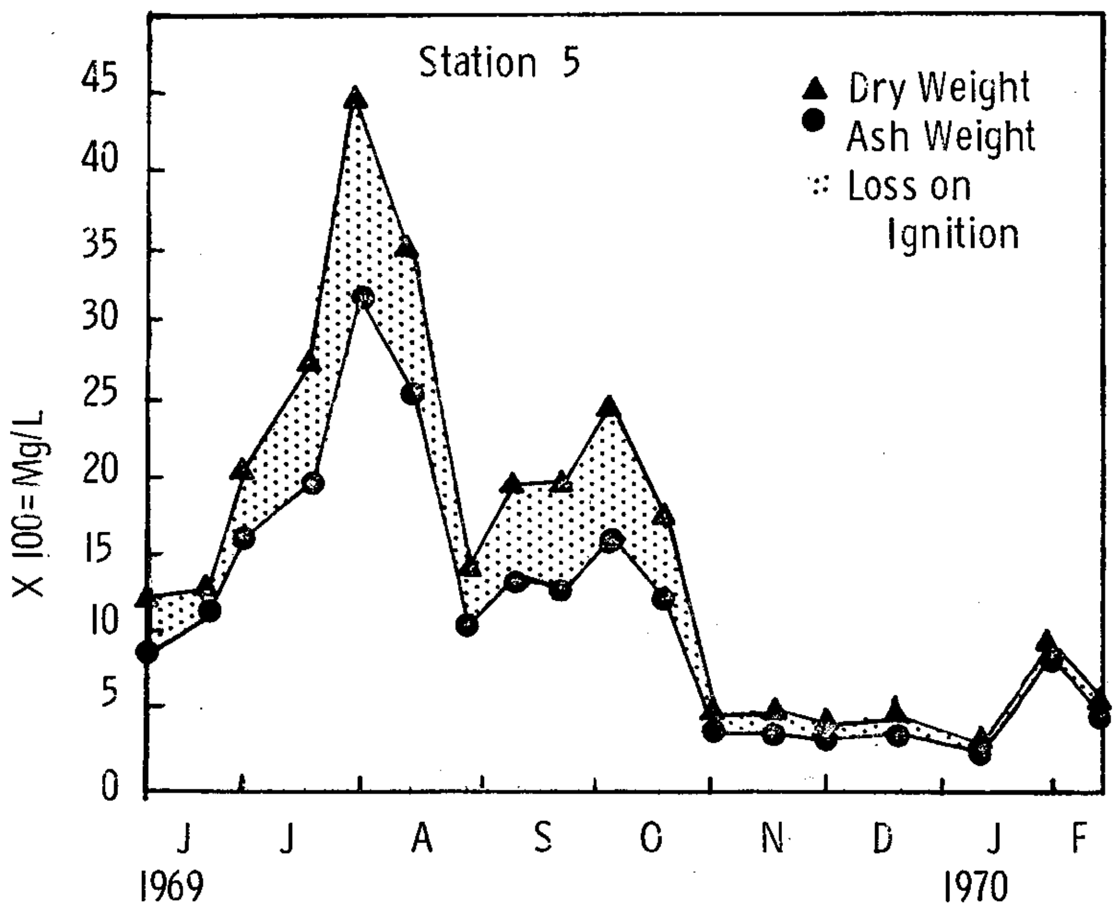

Station 5
Dry Weight
Ash Weight
Loss on Ignition
X 100= Mg/L
45
40
35
30
25
20
15
10
5
0
J
J
A
S
O
N
D
J
F
1969
1970

Figure 82

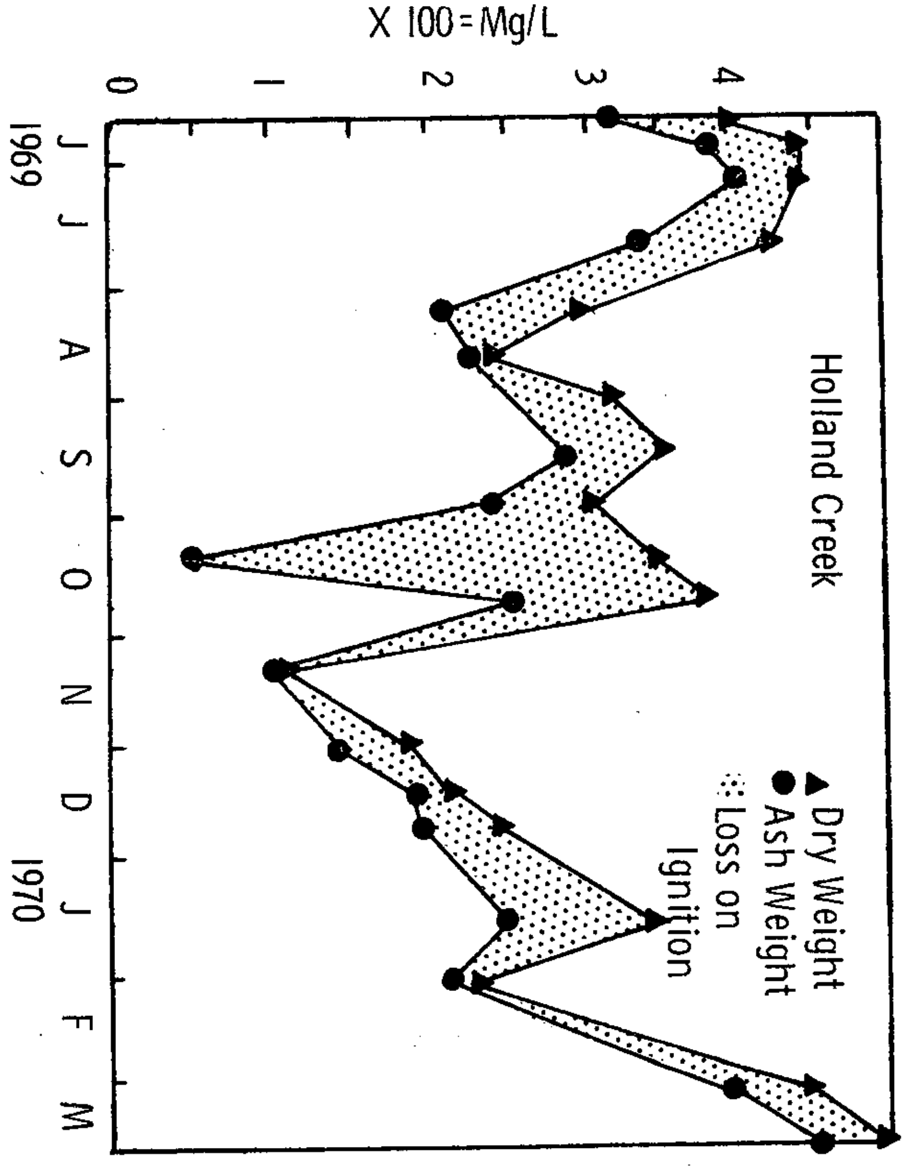

Holland Creek
▲ Dry Weight
● Ash Weight
⁘ Loss on Ignition
X 100 = Mg/L
0
1
2
3
4
J
J
A
S
O
N
D
J
F
M
1969
1970

Figure 83

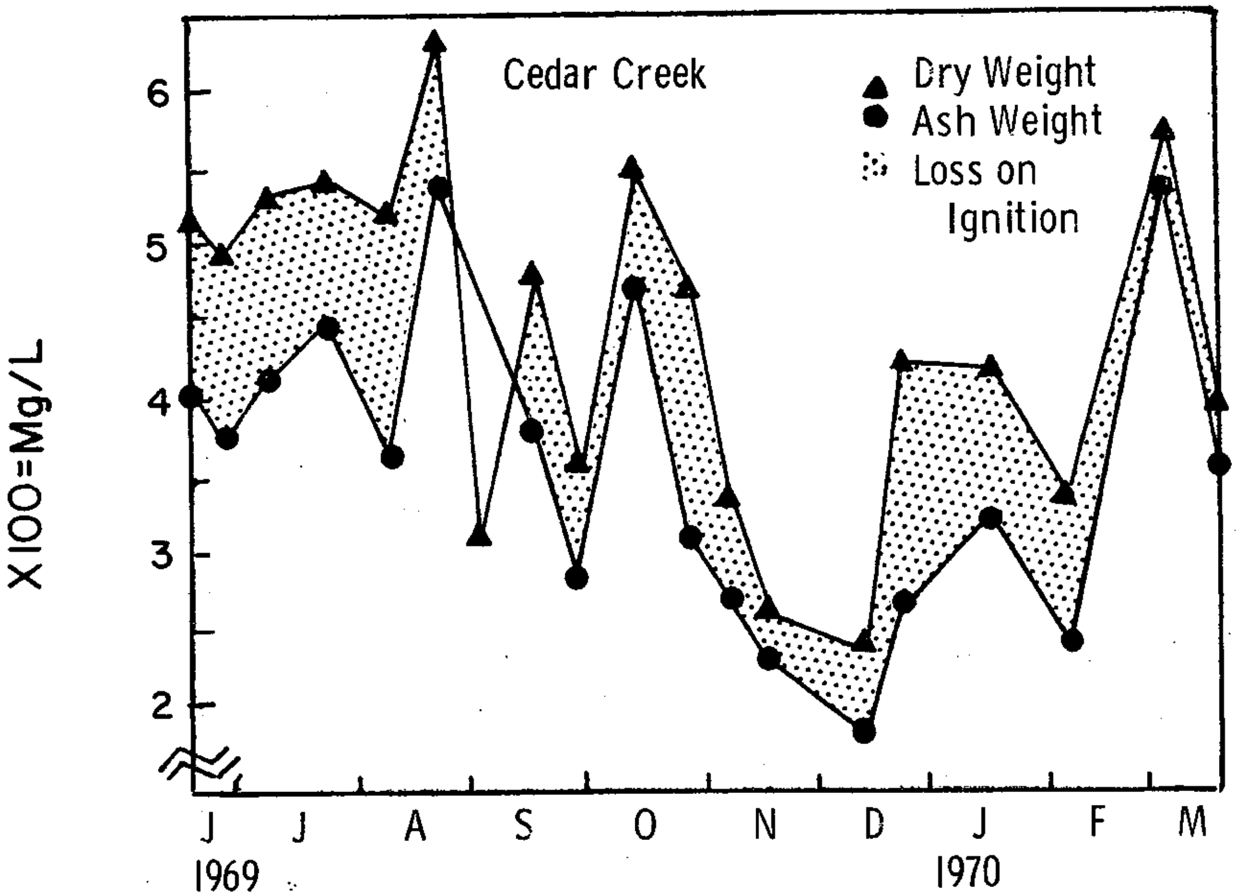
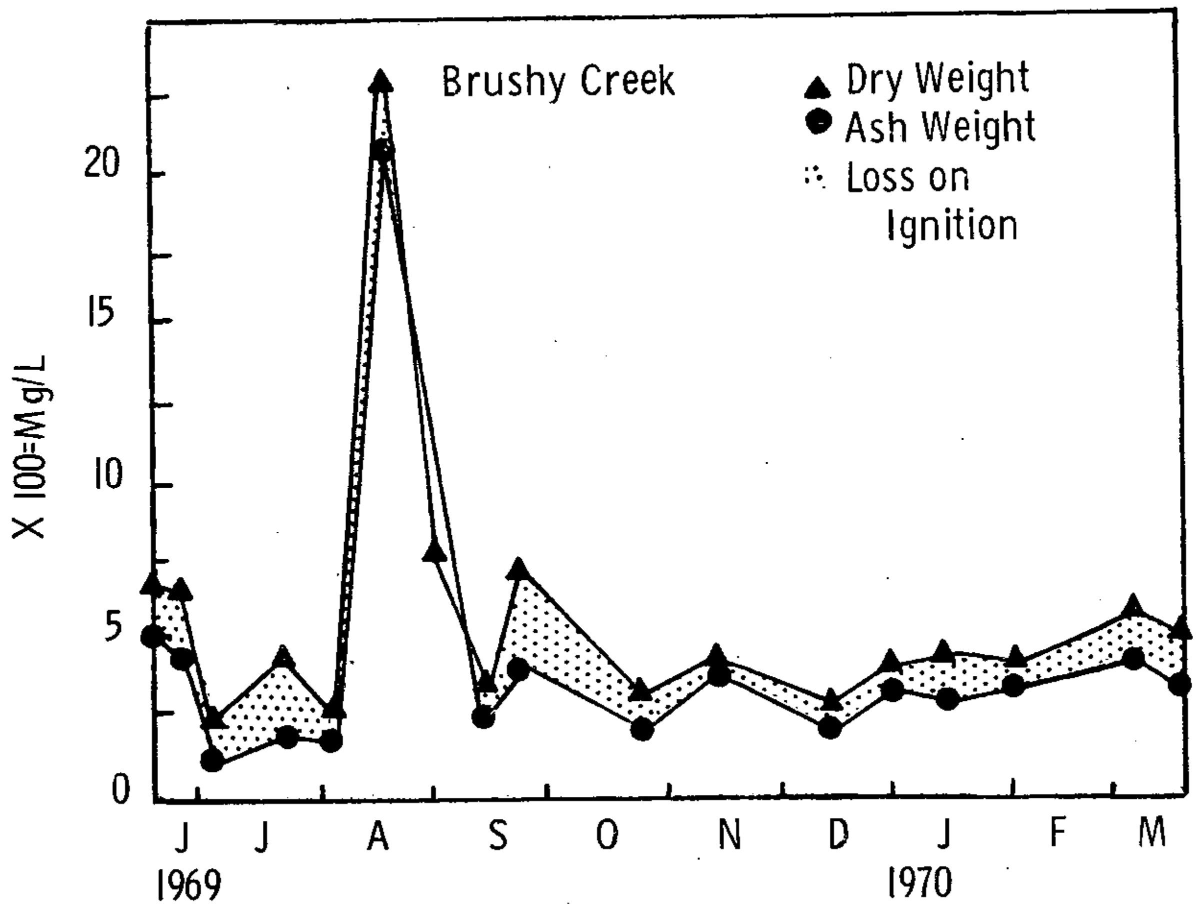

Cedar Creek
Dry Weight
Ash Weight
Loss on Ignition
X100=Mg/L
6
5
4
3
2
J
J
A
S
O
N
D
J
F
M
1969
1970

Figure 84


Brushy Creek
Dry Weight
Ash Weight
Loss on Ignition
X 100=Mg/L
0
5
10
15
20
J
J
A
S
O
N
D
J
F
M
1969
1970

Dry Weight - Ash Weight

The data (Figures 77 through 84) exhibit the individuality of the stations, though there appear to be some general trends.

The first five months covered were a period of very low discharge, with station 5 holding standing water in pools only.

Station 5 shows very high values for dry and ash weights during this period, as does one determination on Brushy Creek which also had only standing water. The values dropped sharply coincident with the increased discharge in November. Station one also shows this decrease associated with high discharge and the trend is evident but not so marked in the other river stations. The tributaries evidence no comparable reduction. In fact, both Cedar Creek and Holland Creek show increases in dry and ash weights coincident with increased discharge and Brushy Creek shows no change.

The loss in ignition values, which are at least an index of organic content, are larger in Cedar and Holland Creeks than at any of the river stations except pools at Station 5.

The systems operating in the tributaries are apparently different from those operating in the main channel, but the nature of the differences will have to await further investigation.

Carbon Analyzer

The data are given in Figures 85 through 92. It is evident from comparison of the figures for the two methods at each station that they are measuring different phenomena. In no case do the forms of the curves

Figure 85

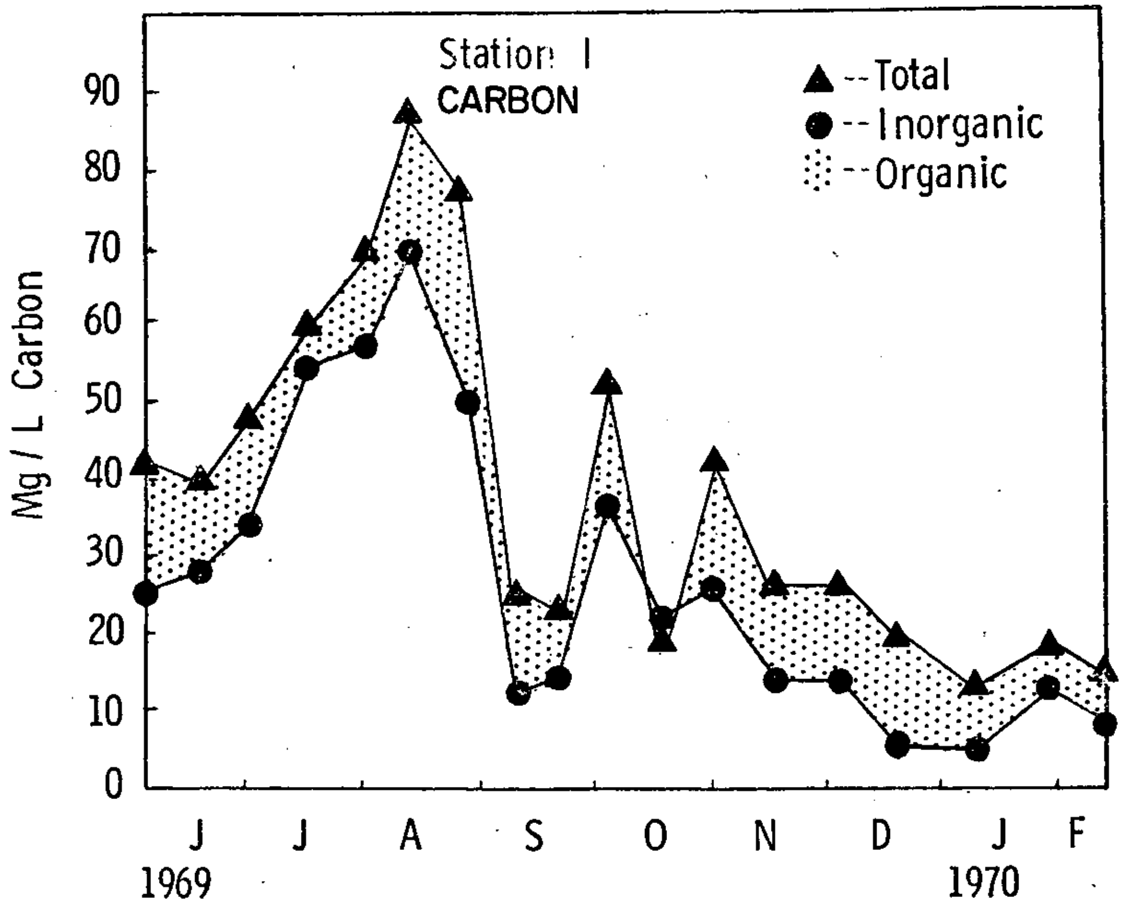

Station I
CARBON
--Total
--Inorganic
--Organic
Mg / L Carbon
0
10
20
30
40
50
60
70
80
90
J
J
A
S
O
N
D
J
F
1969
1970

Figure 86

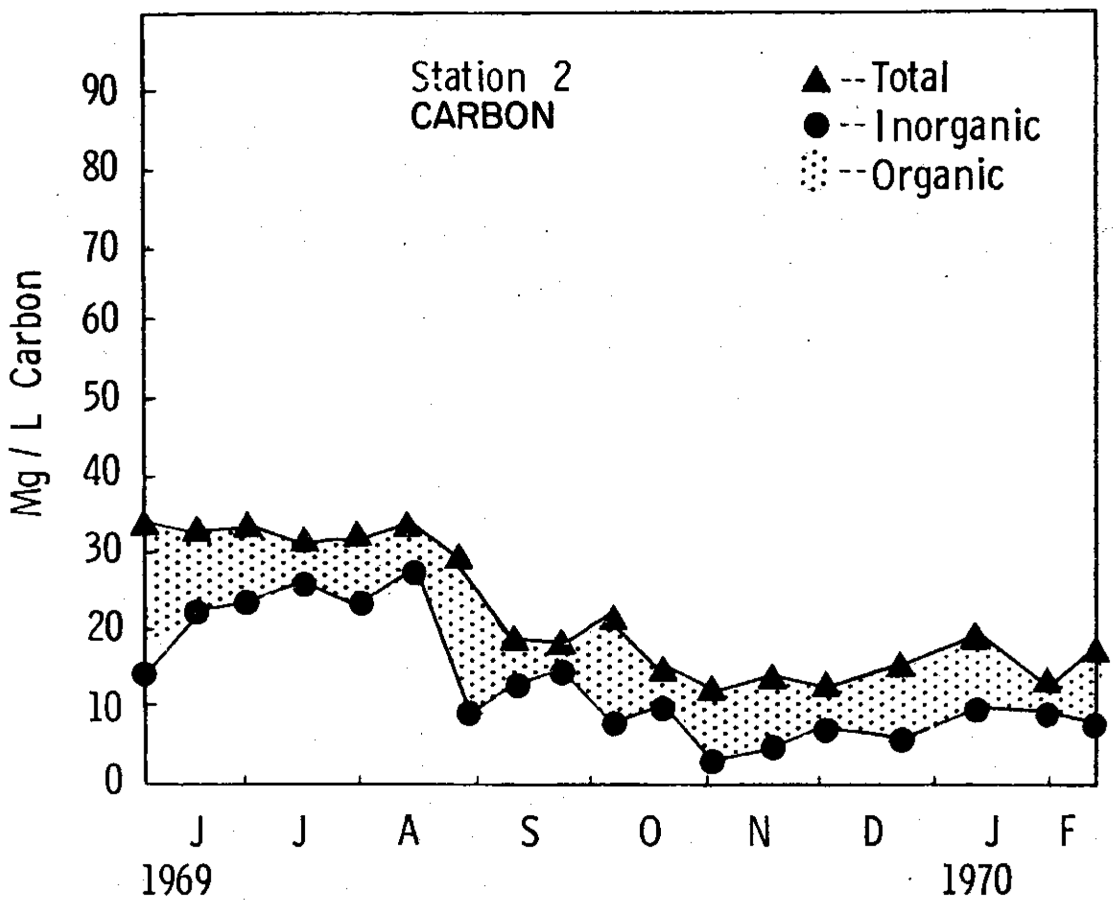
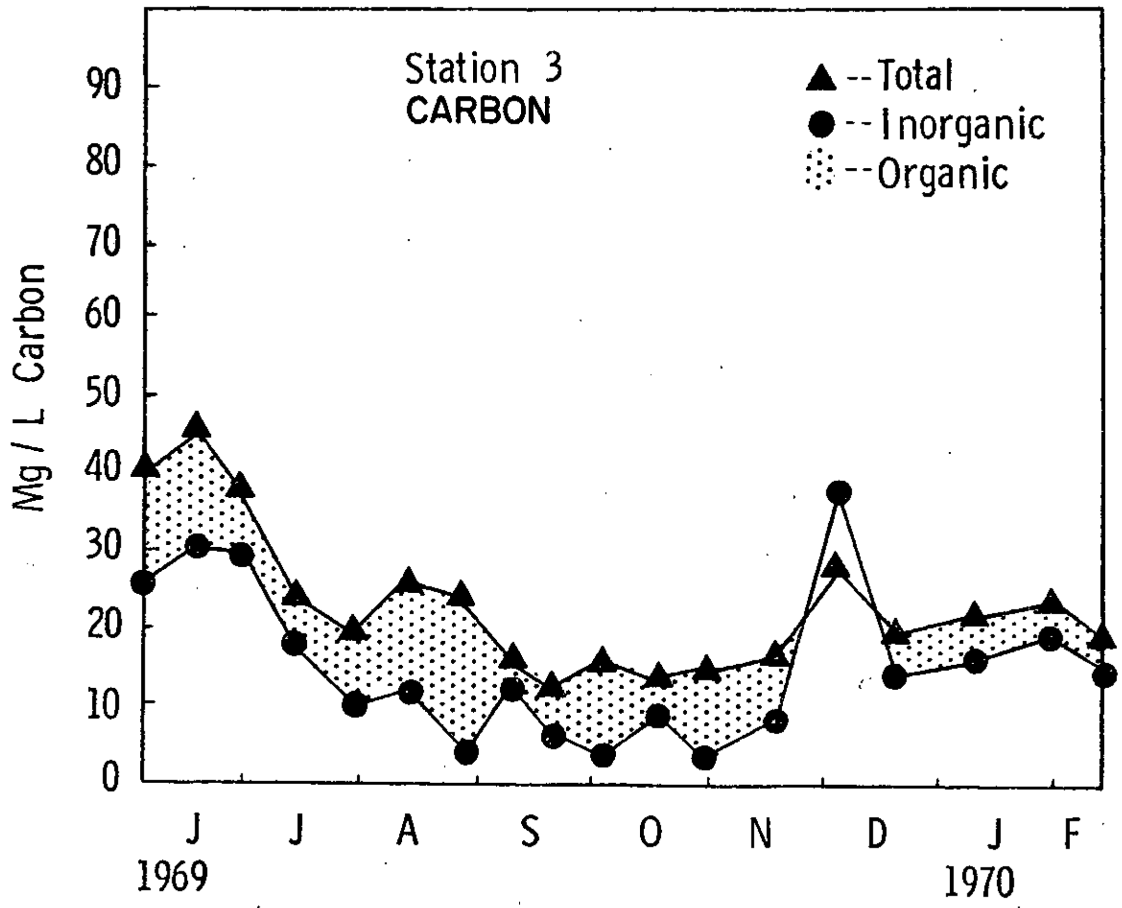

Station 2
CARBON
--Total
--Inorganic
--Organic
Mg / L Carbon
0
10
20
30
40
50
60
70
80
90
J
J
A
S
O
N
D
J
F
1969
1970

Figure 87


Station 3
CARBON
--Total
--Inorganic
--Organic
Mg / L Carbon
90
80
70
60
50
40
30
20
10
0
J
J
A
S
O
N
D
J
F
1969
1970

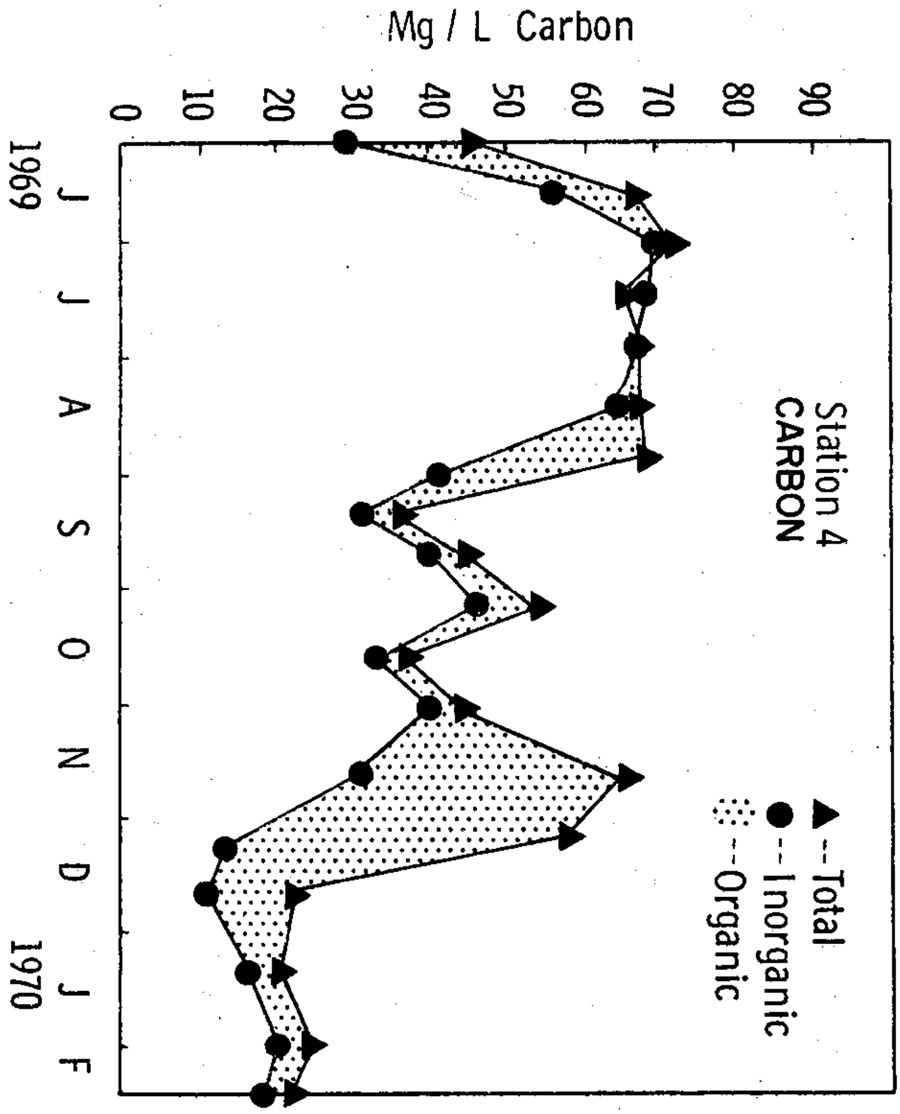
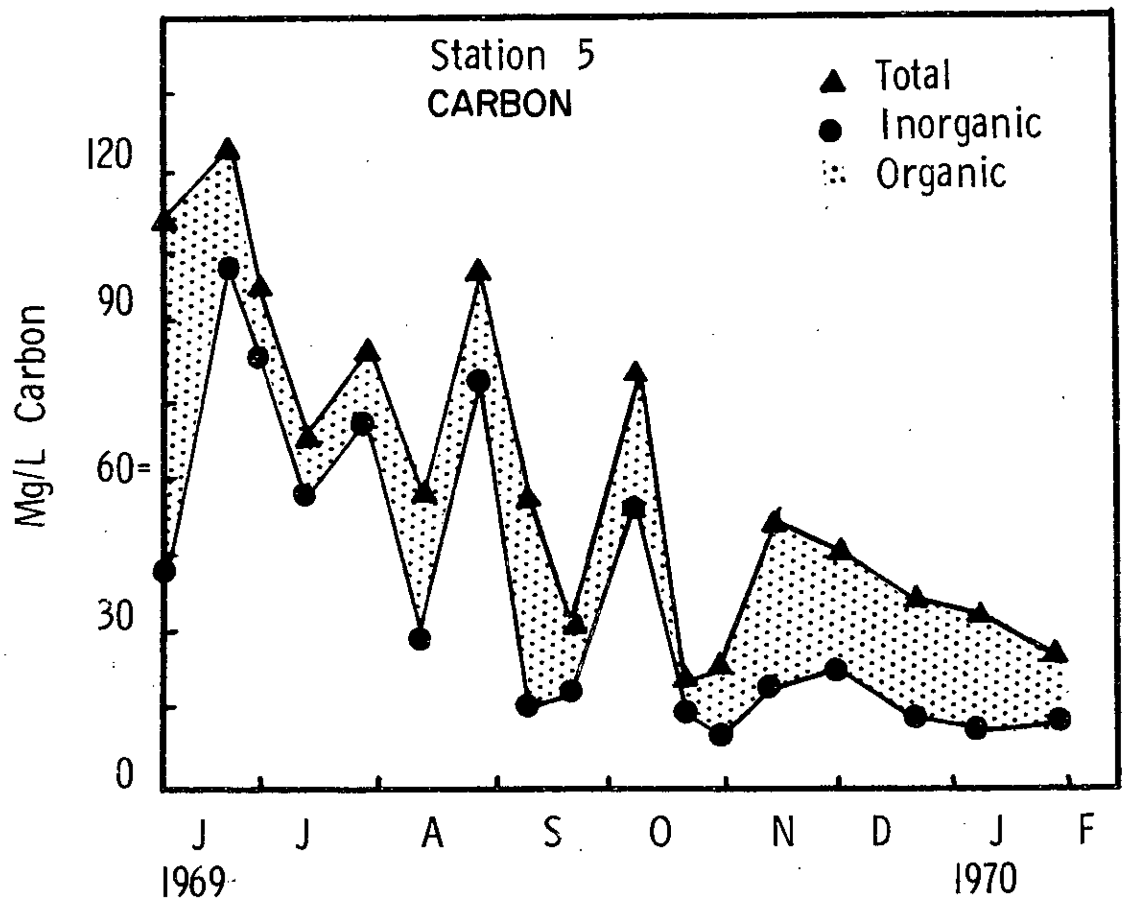

Station 4
CARBON
▲ --Total
● --Inorganic
--Organic
Mg / L Carbon
0
10
20
30
40
50
60
70
80
90
J
J
A
S
O
N
D
J
F
1969
1970

Figure 88

Figure 89



Station 5
CARBON
Total
Inorganic
Organic
Mg/L Carbon
120
90
60=
30
0
J
J
A
S
O
N
D
J
F
1969
1970

Figure 90

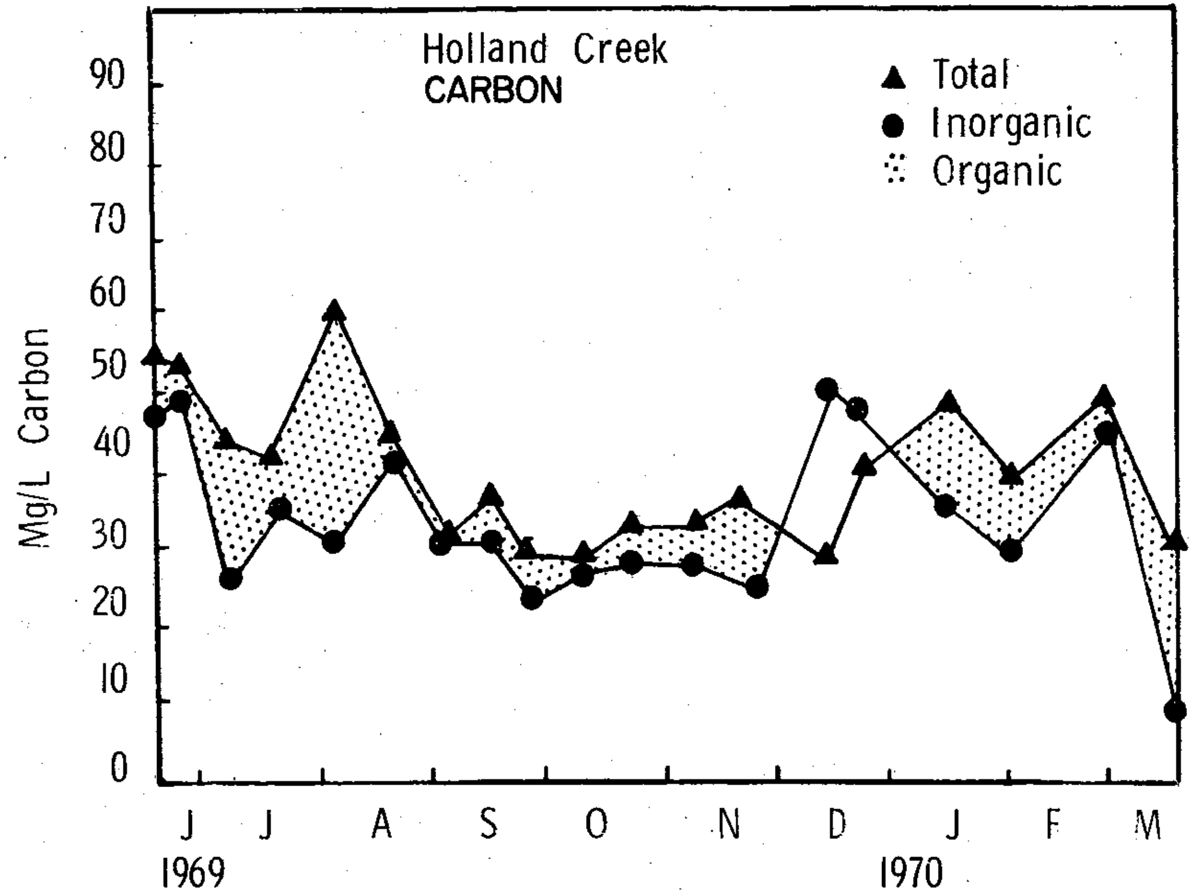

Holland Creek
CARBON
Total
Inorganic
Organic
Mg/L Carbon
0
10
20
30
40
50
60
70
80
90
J
J
A
S
O
N
D
J
F
M
1969
1970

Figure 91

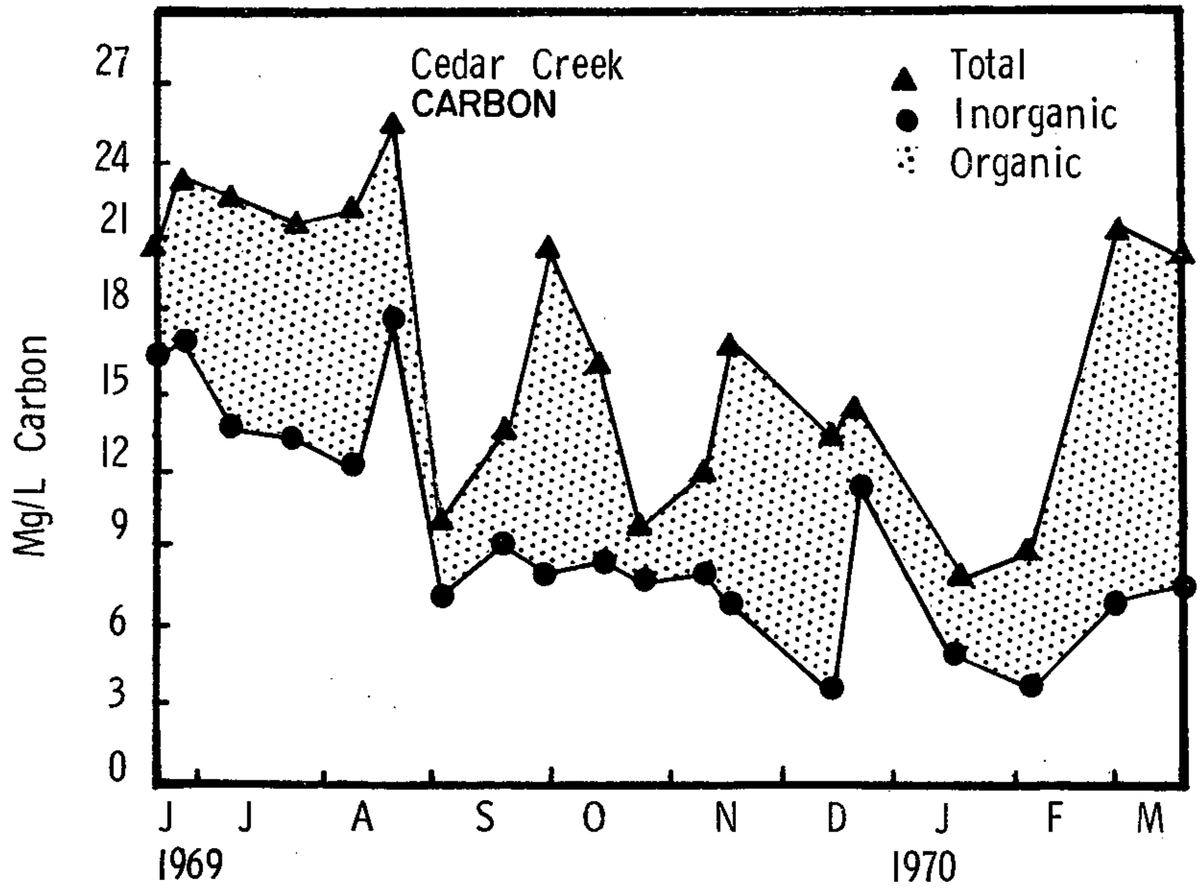
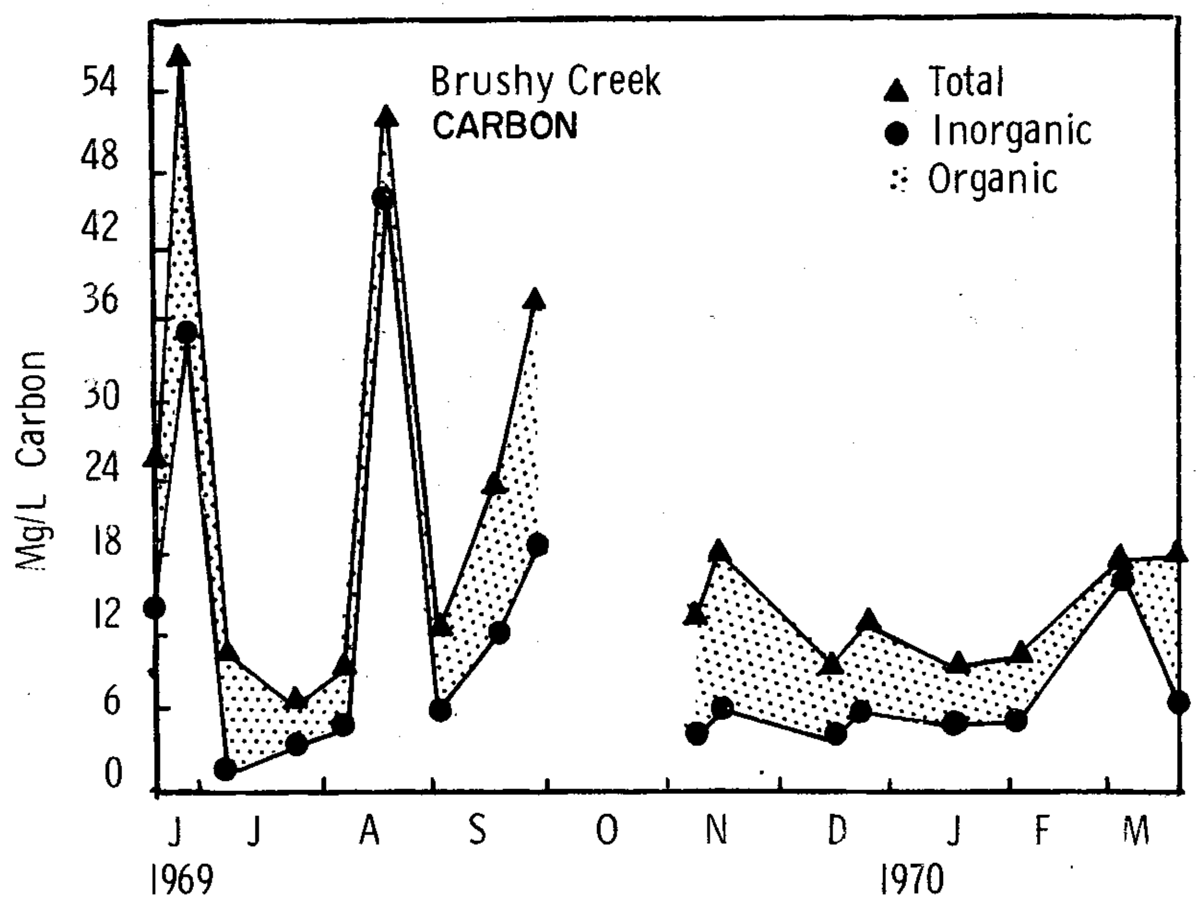

Cedar Creek
CARBON
Total
Inorganic
Organic
Mg/L Carbon
27
24
21
18
15
12
9
6
3
0
J
J
A
S
O
N
D
J
F
M
1969
1970

Figure 92



Brushy Creek
CARBON
Total
Inorganic
Organic
Mg/L Carbon
54
48
42
36
30
24
18
12
6
0
J
J
A
S
O
N
D
J
F
M
1969
1970

coincide. Maxima and minima occurr in one and not in the other. A major reason is undoubtedly the limitation on particle size imposed by the use of a micro-syringe to inject samples into the Beckman Carbon Analyzer. We are in reality dealing with the dissolved, colloidal, and very small particulate fraction. Some other carbon analyzers do not have this restriction and it will be instructive to compare data from them with loss on ignition data.

The highest organic carbon content was during November and December, 1969, at Station 4 where 30 to 40 mg/l were recorded. Maxima at the other stations were 15 mg/l or below.

Perhaps a more meaningfull picture will appear when we are able to place the data on a total load rather than concentration basis. It has not been possible to do so for this report but it will be done in a subsequent publication.

pH

The pH range was not extreme, (Table 10) with most readings at all stations between 7 and 8. For the river stations the maxima and minima are very close. There is a definite increasing trend of readings over 8 from top to bottom in the channel. There is a similar decrease in readings under 7 until station one is reached. Perhaps discharges from Bryan-College Station have an influence.

Of the tributaries, Holland and Cedar Creeks are similar; narrower in range and less basic than the main channel stations. Brushy Creek also has a narrow range, but is definitely more basic than the other tributaries.

Table 10

Ranges in pH values for project stations on the Navasota River. Main channel stations 49 readings from February, 1968 to February, 1970, tributary stations 23 readings from April, 1969 to March, 1970.

STATION

	1	2	3	4	5
pH Range	6.5 - 8.5	6.6 - 8.1	6.6 - 8.2	7.1 - 8.2	6.8 - 8.2
Readings over 8	10	6	5	0	2
Readings under 7	9	1	3	7	8

STATION

	Holland Creek	Cedar Creek	Brushy Creek
pH Range	6.6 - 7.6	6.5 - 7.4	7.6 - 8.2
Readings over 8	0	0	10
Readings under 7	7	12	0

BIOLOGICAL

Introduction

Since inventorying the total biota of the river was beyond the resources of the project, the various components of the biota have received unequal attention. Partitioning of effort has been influenced by the availability of trained personnel, the amount of effort required to obtain adequate data, and the state of the art - both taxonomic and investigative - within each group. A check list of organisms recognized in the study is given in Table 11. All indentifications should be treated as tentative until presented in formal publications.

Monera

The bluegreens have been collected with the general algae samples and identified to genus.

Limited microbial investigations were carried out during parts of two summers. The bacteria are of acknowledged pivotal importance in the aquatic ecosystem, but neither the taxonomy nor the investigative procedures have been developed to the point where large scale investigations can be a routine part of aquatic studies.

Protista

No baiting or culturing for aquatic fungi was attempted. The fungi are therefore unrepresented in our check list not because they are not there but because they were not specifically looked for.

The protozoa were also selected against by collection techniques, and those listed represent casual observations except for the plankton net sample.

A fairly good general picture of the algae flora has been obtained from examination of benthic and net plankton collections. More intensive collection would undoubtedly extend the list and would probably turn up some freshwater Rhodophyta.

Metazoa

The groups studied consisted of; the fishes, those organisms in the drift which were large enough to be retained by a No. 20 plankton net, and those benthos collected with standard dip nets or retained by a No. 30 brass sieve.

The procedures were selective at both extremes; many protozoa were excluded, as were the larger mollusca and arthropoda. The bivalve molluscs were hand collected, and the larger crustacea were qualitatively well sampled in seine hauls.

Metaphyta

The higher plants have not been considered; since there are essentially no submergent or floating metaphyta in the river, and few in the tributary channels, although there are many aquatic plants in backwaters and in the flood plain. The aquatic plants are taxonomically well covered in a masters thesis (Massey 1965).

Table 11

Check List of Organisms Collected from the Navasota River

Kingdom Monera

Phylum Schizophyta (Bacteria)
Order Pseudomonadales
Family Rhodobacteriaceae
Rhodospirillum sp.

Family Pseudomonadaceae
Pseudomonas sp.
Xanthomonas sp.

Family Spirillaceae
Vibrio sp.

Order Eubacteriales
Family Achromobacteraceae
Alcaligenes sp.
Achromobacter sp.
Flavobacterium sp.

Family Rhizobiaceae
Chromobacterium sp.

Phylum Cyanophyta (Blue-greens)
Class Myxophyceae
Order Chroococcales
Anacystis sp.
Aphanocapsa sp.
Aphanothece sp.
Chroococcus sp.
Dactylococcopsis sp.
Gloeocapsa sp.
Merismopedia sp.
Microcystis sp.
Synechococcus sp.

Order Chamaesiphonales
Chamaesiphon sp.

Order Hormogonales
Anabaena sp.
Anabaenopsis sp.
Arthrospira sp.
Aulosira sp.

Table 11. Continued

Lyngbya sp.
Nostoc sp.
Oscllatoria sp.
Phormidium sp.
Plectonema sp.
Scytonema sp.
Stigonema sp.
Spirulina sp.

Kingdom Protista

Phylum Euglenophyta (Euglenas)
Order Euglenales
Euglena sp.
Phacus sp.
Trachelomonas sp.

Phylum Chlorophyta (Green algae)
Class Chlorophyceae
Order Volvocales
Chlamydomonas sp.
Eudorina sp.
Pandorina sp.
Volvox sp.

Order Tetrasporales
Dactylothece sp.
Sphaerocystis sp.

Order Chlorococcales
Actinastrum sp.
Ankistrodesmus sp.
Characium sp.
Chlorella sp.
Chlorochytrium sp.
Crucigenia sp.
Dictyosphaerium sp.
Golenkinia sp.
Lagerheimia sp.
Oocystis sp.
Pediastrum sp.
Planktosphaeria sp.
Scenedesmus sp.
Tetraedron sp.
Treubaria sp.

Table 11. Continued

Order Zygnematales
- *Closterium* sp.
- *Cosmarium* sp.
- *Mesotaenium* sp.
- *Mougeotia* sp.
- *Penium* sp.
- *Sirogonium* sp.
- *Spirogyra* sp.
- *Zygnema* sp.

Order Ulotrichales
- *Chaetophora* sp.
- *Hormidiopsis* sp.
- *Microspora* sp.
- *Protococcus* sp.
- *Ulothrix* sp.
- *Uronema* sp.

Order Oedogoniales
- *Oedogonium* sp.

Order Cladophorales
- *Cladophora* sp.
- *Rhizoclonium* sp.

Class Charophyceae
Order Charales
- *Chara* sp.

Phylum Chrysophyta (Diatoms and others)
Class Xanthophyceae
Order Rhizochiroidales
- *Stipitococcus* sp.

Order Heterococcales
- *Arachnochloris* sp.

Order Heterotrichales
- *Tribonema* sp.

Order Heterosiphonales
- *Vaucheria* sp.

Class Chrysophyceae
Order Chrysomonadales
- *Mallomonas* sp.
- *Synura* sp.

Table 11. Continued

Order Chloromonadales
Merotrichia sp.

Class Bacillariophyceae
Order Centrales
Cyclotella sp.
Melosira sp.
Stephanodiscus sp.

Order Pennales
Achnanthes sp.
Amphora sp.
Asterionella sp.
Caloneis sp.
Campylodiscus sp.
Centronella sp.
Cocconeis sp.
Cymbella sp.
Diatoma sp.
Diatomella sp.
Diploneis sp.
Eunotia sp.
Fragillaria sp.
Gomphoneis sp.
Gyrosigma sp.
Mastogloia sp.
Navicula sp.
Neidium sp.
Nitzschia sp.
Opephora sp.
Pleurosigma sp.
Pinnularia sp.
Stauroneis sp.
Surirella sp.
Synedra sp.

Phylum Protozoa
Class Mastigophora
Order Euglenoidina
Family Astasiidae
Astasia sp.
Entosiphon sp.

Class Sarcodina
Order Testacea
Family Arcellidae
Arcella sp.

Table 11. Continued

Family Diflugiidae
Difflugia sp.

Class Ciliata
Order Holotrichia
Family Colepidae
Coleps sp.

Family Paramecidae
Paramecium sp.

Family Stentoridae
Stentor sp.

Order Spirotrichia
Family Oxytrichidae
Stylonchia sp.

Family Euplotidae
Euplotes sp.

Order Peritrichia
Family Vorticellidae
Vorticella sp.

Kingdom Metazoa

Phylum Platyhelminthes (Flatworms)
Class Turbellaria (Planarians)
Order Tricladida
Family Planariidae
Curtisia foremani

Class Trematoda
Order Digenea
Family Macroderoidae
Macroderoides spiniferus
Paramacroderoides echinus

Class Cestoda
Order Proteocephala
Family Protocephalidae
Protocephalus sp.

Phylum Nematoda
Order Spiruridea
Family Cucullanidae
Dichelyne lepisosteus

Table 11. Continued

Order Ascarididea
Family Heterocheilidae
Contracaeum spiculigerum

Phylum Rotifera (Rotifers)
Class Monogononta
Order Pliona
Family Branchionidae
Branchionus angularis
B. bidentata
B. calyciflorous
B. havaenesis
B. quadridenta
Euchlanis sp.
Kellicottia longispina
K. bostoniensis
Keratella cochlearis
K. valga
K. spp.
Lepadella sp.
Notholca sp.
Platyias patulus
P. polyacanthus
P. quadricornis

Many species of aloricate rotifers found which could not be identified from preserved material.

Family Lecanidae
Lecane sp.
Monostyla sp.

Family Gastropidae
Ascomorpha sp.

Family Trichocercidae
Trichocera sp.

Family Asplanchinidae
Asplanchna sp.

Family Synchaetidae
Polyartha sp.
Synchaeta sp.

Order Flosulariaceae
Family Testudinellidae
Filinia sp.
Trochosphera sp.

Table 11. Continued

Family Hexarthridae
Hexartha sp.

Phylum Ectoprocta
Class Phylactolaemata (Bryozoans, moss animals)
Order Plumatellina
Family Plumatellidae
Plumatella sp.

Phylum Annelida
Class Oligochaeta (Earthworms)
Order Opisthopora
Family Lumbricidae
Lumbriculus sp.

Order Plesiopora
Family Enchytraeidae
Enchytraeus sp.

Class Hirudinea (Leeches)
Order Rhychobdellida
Family Glossiphoniidae
Glossiphonia sp.
Placobdella sp.
P. rugosa
P. parasitica

Family Erpobdellidae
Erpobdella punctata

Phylum Arthropoda
Class Arachnoidea
Order Hydracarina (Water mites)
Unidentified spp.

Class Crustacea
Sub-Class Branchiopoda
Order Anostraca (Fairy shrimp)
Family Streptocephalidae
Streptocephalus seali

Order Conchostraca (Clam shrimp)
Family Leptestheriidae
Leptestheria compleximanus

Order Cladocera (Water fleas)
Family Sididae
Diaphanosoma brachyurum

Table 11. Continued

Family Daphinidae
- *Ceriodaphnia lacustris*
- *C. pulchella*
- *C. quadriangula*
- *C. rigaudi*

Family Moinidae
- *Moina micrura*

Family Bosminidae
- *Bosmina coregoni*
- *B. longirostris*
- *B. longirostris var. cornuta*

Family Macrothrieidae
- *Ilyocryptus sordidus*
- *I. spinnifer*
- *Macrothrix laticornis*

Family Chyoridae
- *Alona affinis*
- *A. karva*
- *A. rectangula*
- *Camptocercus oklahomensis*
- *C. rectirostris*

Sub-Class Ostracoda
Order Podocopa (Seed shrimp)
- Unidentified spp.

Sub-Class Copepoda (Copepods)
Order Eucopepoda
Family Diaptomidae
- *Diaptomus dorsalis*
- *D. pallidus*
- *D. siciloides*

Family Cyclopidae
- *Cyclops exilis*
- *C. vernalis*
- *Ectocyclops phaleratus*
- *Eucyclops agilis*
- *E. speratus*
- *Paracyclops fimbriatus poppei*
- *Tropocyclops parsinus*

Family Ergasilidae
- *Ergasilus chautauguensis*

Table 11. Continued

Family Lernaeidae
Lernaea sp.

Order Isopoda (Aquatic sow bugs)
Family Asellidae
Asellus sp.
Lirceus sp.

Order Amphipoda (Scuds, Sideswimmers)
Family Talitridae
Hyalella azteca

Order Decapoda (Freshwater shrimps, Crayfish)
Family Astacidae
Subfamily Cambarinae
Cambarus diogenes ludovicianus
Fallicambarus hedgpethi
Orconectes palmeri longimanus
Procambarus acutus
P. clarki
P. curdi
P. incilis
P. simulans

Subfamily Cambarellinae
Cambarellus puer

Family Palaemonidae
Palaeomonetes kadiakensis

Class Insecta
Order Collembola (Springtails)
Family Smynthruidae
Smynthruides sp.

Order Ephemeroptera (Mayflies)
Family Baetidae
Baetis sp.
Callibaetis sp.
Centrophilum sp.
Cloeon sp.
Pseudocloen sp.
Neocloeon
Tricorythodes sp.

Family Ephemeridae
Hexagenia limbata venusta
Pentagenia vittigera

Table 11. Continued

Family Heptageniidae
- *Stenonema* spp.
- *S. interpunctatum canadense*

Family Caenidae
- *Brachycercus* sp.
- *Caenis* sp.

Family Polymitarcidae
- *Campsurus* sp.
- *Tortopus* sp.

Family Siphlonuridae
- *Ameletus* sp.
- *Isonychia rufa*

Order Odonata (collected and identified as adults)

Suborder Anisoptera (Dragonflies)

Family Gomphidae
- *Ariogaomphus lentulus*
- *Dromogomphus armatus*
- *D. spinosus*
- *D. spoliatus*
- *Erpetogomphus compositus*
- *E. designatus*
- *Gomphoides stigmatus*
- *Gomphurus externus*
- *G. militaris*
- *G. vastus*
- *Hagenius brevistylyus*
- *Ophiogomphus* sp.
- *Progomphus borealis*
- *P. obscurus*
- *Stylurus plagiatus*

Family Libellulidae
- *Celithemis elisa*
- *C. epoinina*
- *Dythemis fugax*
- *D. velox*
- *Epicordulia* sp.
- *Erythemis simplicollis*
- *Erythrodiplax berenice*
- *E. minuscula*
- *E. umbrata*
- *Libellula auripennis*
- *L. commanche*

Table 11. Continued

L. flavida
L. incesta
L. luctosa
L. pulchella
L. subornata
L. vibrans
Neurocordulia sp.
Orthemis ferruginea
Pachydiplax longipennis
Palothemis sp.
Pantala flavescens
P. hymenea
Perithemis tenera
Plathemis lydia
Tarnetrum corruptum
Sympetrum ambiguum
S. linearis
Trama carolina
T. lacertae
T. onusta

Family Macromidae
Didymops transversa
Macromia georgina
M. taeniolata

Family Aeshnidae
Anax junius
Boyeria vinosa
Nasiaeshna pentacantha

Family Cordulegasteriidae
Cordulegaster sayi

Suborder Zygoptera (Damselflies)
Family Agrionidae - Calopteryidae
Calopteryx maculata
Hetaerina americana
H. titia

Family Lestidae
Lestes disjuntus australis

Family Coenagrionidae
Amphiagrion sp.
Anomalagrion hastatum
Argia apicalis
A. fumipennis violacea

Table 11. Continued

A. immunda
A. moesta
A. nahuana
A. sedula
A. tibialis
A. translata
Chromagrion sp.
Enallagma basidens
E. civile
E. divagans
E. exsulans
E. signatus
Ischnura posita
I. ramburi
Nehalennia sp.
Telebasis salva

Order Plecoptera (Stoneflies)
Family Perlidae
Perlesta placida

Family Perlodidae
Isoperla sp.

Family Nemouridae
Taeniopteryx titia

Order Hemiptera (True bugs)
Family Naucoridae
Pelocoris sp.

Family Notonectidae
Buenoa sp.
Notonecta sp.

Family Hydrometridae
Hydrometra sp.

Family Belostomatidae
Abedus sp.
Belostoma sp.
Benacus griseus

Family Pleidae
Plea striola

Family Nepidae
Ranatra sp.

Table 11. Continued

Family Corixidae
- *Corbella edullus*
- *Graptocorixa* sp.
- *Palmacorixa buenoi*
- *Trichocorixa calva*
- *T. kanza*
- *T. louisianae*

Family Hebridae
- *Hebrus consolidus*
- *Merragata* sp.
- *M. hebroides*

Family Gerridae
- *Gerris* sp.
- *Limnogonus* sp.
- *Rheumatobaetes* sp.
- *R. hungerfordi*
- *R. rileyi*
- *R. tenuipes*
- *Trepobates subnitidus*

Family Gelastocoridae
- *Gelastocoris oculatus oculatus*

Family Mesoveliidae
- *Mesovelia amoena*
- *M. mulsanti*

Order Neuroptera (Spongillaflies)

Family Sialidae
- *Sialis* sp.

Order Megaloptera (Dobsonflies)

Family Corydalidae
- *Chauliodes* sp.
- *Corydalus cornutus*

Order Coleoptera (Beetles)

Family Dytiscidae
- *Ababus*
- *Agabates* sp.
- *Bidessus* sp.
- *Comptotomus* sp.
- *C. interogotus*
- *Copelatus* sp.
- *C. chevrolati*
- *Derovatellus* sp.
- *Hydrocanthus* sp.

Table 11. Continued

Hydroporus dimidicatus
Laccodytes sp.
Laccophilus proximus
Laccornus sp.
Oreodytes sp.
Thermonectus ornaticolis

Family Hydrophilidae
Anacaena sp.
Berosus infuscatus
B. pereginus
Cymbiodyta sp.
Enochrus spp.
E. pygaes
Helochares sp.
H. maculiocollis
Helophorus sp.
Hydrobius sp.
Hydrochara sp.
Hydrochus sp.
Hydrophilus sp.
Laccobius sp.
Peracymus sp.
Tropisternus sp.
T. lateralus nimbatus
T. mexicanus

Family Gyrinidae
Dineutes sp.
Gyretes sp.
Gyrinus sp.

Family Elmidae
Dubiraphia sp.
Stenelmis sp.

Family Haliplidae
Haliplus spp.
H. triopsis
Peltodytes spp.

Family Dryopidae
Helichus sp.

Family Noteridae
Hydrocanthus sp.

Table 11. Continued

Family Chrysomelidae
- *Donacia* sp.

Family Helodidae
- *Scirtus* sp.
- *Cyphon* sp.

Family Omophoronidae
- *Omophoron nitidum*

Order Trichoptera (Caddisflies)

Family Hydropsychidae
- *Cheumatopsyche* spp.
- *Hydropsyche* sp.

Family Psychomyiidae
- *Neureclipsis* sp.
- *Polycentropus* sp.

Family Leptoceridae
- *Leptocella* sp.
- *Mystacides* sp.
- *Triaenodes* sp.

Family Hydroptilidae
- *Agraylea* sp.
- *Tascobia* sp.

Order Diptera (Flies & Midges)

Family Tendipedidae - Chironomidae
- *Anatopynia* sp.
- *Calospectra* sp.
- *Cardiocladius* sp.
- *Coelotanypus* sp.
- *Hydrobaenus* sp.
- *Lauterborniella* sp.
- *Pentaneura* spp.
- *Polypedilum* spp.
- *Precladius skuse*
- *Prodiamesa* sp.
- *Sphaeromias* sp.
- *Tanytarsus* spp.
- *Tendipes* spp.

Family Ceratopogonidae
- *Alluaudomyia* sp.
- *Culicoides* 2 spp.
- *Dasyhelea* sp.
- *Palpomyia* sp.

Table 11. Continued

Family Simuliidae
- Unidentified sp.

Family Culicidae
- *Anopheles* sp.
- *Chaoborus* sp.
- *Culex* sp.

Family Stratiomyiidae
- *Nemotelus* sp.
- *Stratiomys* sp.

Family Tabanidae
- *Chrysops* sp.
- *Tabanus* sp.

Family Tipulidae
- *Erioptera* sp.

Phylum Mollusca
- Class Gastropoda (Snails)
  - Subclass Pulmonata
    - Order Basommatophora
      - Family Physidae
        - *Physa virgata*--*Physa anatina*
      - Family Lymnaeidae
        - *Lymnaea* sp.
      - Family Planorbidae
        - *Gyraulus* sp.
        - *Helisoma* sp.
        - *H. trivolvis lentum*
      - Family Ancylidae
        - *Ferrissia* sp.
        - *Helicina arbiculata*--*Oligyra orbiculata*
        - *Mesodon* sp.
- Class Pelecypoda (Clams and Mussles)
  - Subclass Eulamellibranchia
    - Family Unionidae
      - *Amblema costata*--*A. perplicata*
      - *Anodonta imbecilis*
      - *Carnunculina parva*
      - *C. texasensis*
      - *Elliptio* sp.
      - *Fusconaia* sp.

Table 11. Continued

Lasmigonia complanata
Tritogonia verrucosa
Uniomerus tetralasmus

Subclass Heterodonta
Family Sphaeriidae
Sphaerium striatinum

Phylum Chordata
Class Osteichthyes (Bony fishes)
Order Amiiformes
Family Amiidae
Amia calva, Bowfin

Order Lepisosteiformes
Family Lepisosteidae
Lepisosteus oculatus--*L. pruductus*, Spotted gar
L. osseus, Longnose gar
L. spatula, Alligator gar

Order Clupeiformes
Family Clupeidae
Dorosoma cepedianum, Gizzard shad
D. petenense, Threadfin shad

Order Salmoniformes
Family Esocidae
Esox americanus, Redfin pickerel

Order Cypriniformes
Family Cyprinidae
Campostoma anomalum, Stoneroller
Cyprinus carpio, Carp
Hybognathus nuchalis, Silvery minnow
Notemigonus crysoleucas, Golden shiner
Notropis atrocaudalis, Blackspot shiner
N. buchanani, Ghost shiner
N. fumeus, Ribbon shiner
N. lutrensis, Red shiner
N. oxyrhynchus, Sharpnose shiner
N. shumardi, Silverband shiner
N. venustus, Blacktail shiner
Opsopoedus emiliae--*Notropis emiliae*, Pugnose minnow
Pimephales promelas, Bluntnose minnow
P. vigilax, Bullhead minnow

Table 11. Continued

Family Catostomidae
- *Carpiodes carpio*, River carpsucker
- *Erimyzon sucetta*, Lake chubsucker
- *Ictiobus bubalus*, Smallmouth buffalo fish
- *I. niger*, Black buffalo fish
- *Minytrema melanops*, Spotted sucker

Order Siluriformes

Family Ictaluridae
- *Ictalurus furcatus*, Blue catfish
- *I. melas*, Black bullhead
- *I. natalis*, Yellow bullhead
- *I. punctatus*, Channel catfish
- *Noturus gyrinus*, Tadpole madtom
- *Pylodictis olivaris*, Flathead catfish

Order Percopsiformes

Family Aphredoderidae
- *Aphredoderus sayanus*, Pirateperch

Order Atheriniformes

Family Cyprinodontidae
- *Fundulus notatus*, Blackstripe topminnow
- *F. notti*, Starhead topminnow
- *F. olivaceus*, Blackspotted topminnow

Family Poeciliidae
- *Gambusia affinis*, Mosquitofish

Family Percichthyidae
- *Roccus chrysops*--*Morone chrysops*, White bass

Order Perciformes

Family Centrarchidae
- *Chaenobryttus gulosus*--*Lepomis gulosus*, Warmouth sunfish
- *L. cyanellus*, Green sunfish
- *L. humilis*, Orangespotted sunfish
- *L. macrochirus*, Bluegill sunfish
- *L. marginatus*, Dollar sunfish
- *L. megalotis*, Longear sunfish
- *L. microlophus*, Redear sunfish
- *L. punctatus*, Spotted sunfish
- *L. symmetricus*, Bantam sunfish
- *Micropterus punctulatus*, Spotted bass
- *M. salmoides*, Largemouth bass
- *Pomoxis nigromaculatus*, Black crappie
- *P. annularis*, White crappie

Table 11. Continued

Family Elassomatidae
- Elassoma zonatum, Banded pigmy sunfish

Family Percidae
- Etheostoma chlorosomum, Bluntnose darter
- E. gracile, Slough darter
- E. parvipinne, Goldstripe darter
- Percina macrolepida, Logperch
- P. sciera, Dusky darter

Family Sciaenidae
- Aplodinotus grunniens, Freshwater drum

The following species are in the Texas A&M University Cooperative Wildlife Collection with collection locations in the Navasota River drainage, but were not collected during this project.

- Astyanax fasciatus, Banded tetra
- Hybopsis destivalis, Speckled chub
- Labidesthes sicculus, Brook silversides
- Lepomis auritus, Redbreast sunfish
- Notropis amablish, Texas shiner
- N. aminis, Pallid shiner
- N. texanus, Weed shiner

Benthos

Rivers generally are an intractible habitat for quantitative sampling of benthos.

The main channel of the Navasota often consists of steep clay banks, hard, current swept clay bottom, and in sheltered spots deep accumulations of only partially decomposed twigs and leaves. Dredges will not operate well in any of these habitats, and the water is too deep for the use of Surber type samplers. Much of the invertebrate biota also was associated with the abundant submerged tangles of brush and trees. The best mayfly collecting was sometimes from under the loosened bark of submerged branches.

Quantitative methods could have been devised for each of these habitats but the effort would have absorbed much of the resources of the project.

In addition, the biota is so taxonomically unknown that the organisms must be lumped into Genus, Family, or higher groups in many cases, thus confounding the most valuable ecological relationships, which are at the species level.

Work on the collections resulting from this study will advance our taxonomic knowledge, but such results come slowly, and most cannot be included in this report. We are now paying a high price for the long standing neglect of taxonomy by institutions and granting agencies. Unfortunately we cannot catch up quickly in this area; it is not possible to substitute money for time in taxonomic work.

Monera

The bluegreens were collected with the general algae samples, and as with the algae, the data provide only a general picture of the make-up of the flora (Table 12). The Bacteria are discussed with the Drift Organisms since no benthic samples of Bacteria were taken.

Protista

Benthic algae were collected at the regular stations at least once a month during the first year (Table 12). All forms are included, both the truly benthic and those which had settled out or become trapped. The stations show some individuality, with the most obvious difference being the very sparse list at Station 3. Observation leads me to suspect that the differences are more the result of the nature of the substrate than position on the river. Most of the "other locations" were on tributaries, with quieter water and different substrate from the main channel, and this is reflected in the number of forms reported only from these collections.

The benthic algae were obvious only during the low flow periods in summer. Most of the time collections were very sparse. Also, because of the constant high turbidity the benthic algae were confined to a narrow band at the water surface.

Metazoa

Collections were made at over 150 locations on the water courses of the watershed, using a variety of dip nets and hand nets.

Table 12

Occurrence of algae and bluegreens at stations on the Navasota River

	Regular Stations 1	2	3	4	5	Other Locations
KINGDOM MONERA						
Phylum Cyanophyta						
Order Chroococcales						
Anacystis sp.	x	x			x	
Aphanocapsa sp.	x			x	x	x
Aphanothece sp.						x
Chroococcus sp.	x	x	x			x
Dactylococcopsis sp.						x
Gloeocapsa sp.	x				x	x
Merismopedia sp.	x	x		x		
Microcystis sp.		x		x	x	x
Synechococcus sp.		x				
Order Chamaesiphonales						
Chamaesiphon sp.						x
Order Hormogonales						
Anabaena sp.	x	x	x	x	x	x
Anabaenopsis sp.		x			x	
Arthrospira sp.	x	x		x	x	
Aulosira sp.					x	
Lyngbya sp.		x		x		x
Nostoc sp.	x	x				x
Oscillatoria sp.	x	x	x	x	x	x
Phormidium sp.		x		x		
Plectonema sp.					x	
Stigonema sp.						x
Spirulina sp.		x		x	x	x
KINGDOM PROTISTA						
Phylum Euglenophyta						
Order Euglenales						
Euglena sp.	x	x	x	x	x	x
Phacus sp.	x	x		x	x	x
Trachelomonas sp.	x	x	x	x	x	x
Phylum Chlorophyta						
Class Chlorophyceae						
Order Volvocales						
Chlamydomonas sp.	x	x		x		x

Table 12. Continued

	Regular Stations 1	2	3	4	5	Other Locations
Eudorina sp.						x
Pandorina sp.						x
Volvox sp.						x
Order Tetrasporales						
Dactylothece sp.		x				
Sphaerocystis sp.						x
Order Chlorococcales						
Actinastrum sp.		x		x		
Ankistrodesmus sp.	x	x	x	x	x	x
Characium sp.				x		
Chlorella sp.	x	x	x	x	x	x
Chlorochytrium sp.						x
Crucigenia sp.	x	x	x	x		
Dictyosphaerium sp.	x	x				
Golenkinia sp.		x		x		
Lagerheimia sp.		x	x			
Oocystis sp.		x			x	
Pediastrum sp.		x				
Planktosphaeria sp.	x					
Scenedesmus sp.	x	x	x	x	x	
Tetraedron sp.	x					
Treubaria sp.		x				
Order Zygnematales						
Closterium sp.	x	x		x	x	x
Cosmarium sp.	x	x		x		x
Mesotaenium sp.		x				
Mougeotia sp.			x		x	
Penium sp.				x		
Sirogonium sp.						x
Spirogyra sp.				x		x
Staurastrum sp.	x					
Zygnema sp.						x
Order Ulotrichales						
Chaetophora sp.						x
Hormidiopsis sp.	x					
Microspora sp.		x				
Protococcus sp.	x	x				
Ulothrix sp.						x
Uronema sp.				x		
Order Oedogoniales						
Oedogonium sp.	x			x	x	x

Table 12. Continued

	Regular Stations 1	2	3	4	5	Other Locations
Order Cladophorales						
Cladophora sp.	x				x	x
Rhizoclonium sp.					x	
Class Charophyceae						
Order Charales						
Chara sp.						x
Phylum Chrysophyta						
Class Xanthophyceae						
Order Rizochiroidales						
Stipitococcus sp.						x
Order Heterococcales						
Arachnochloris sp.		x				
Order Heterotrichales						
Tribonema sp.				x		
Order Heterosiphonales						
Vaucheria sp.					x	x
Class Chrysophyceae						
Order Chrysomonadales						
Mallomonas sp.						x
Synura sp.	x					
Order Chloromonadales						
Merotrichia sp.				x		
Class Bacillariophyceae						
Order Centrales						
Cyclotella sp.	x	x		x	x	
Melosira sp.	x	x		x		
Stephanodiscus sp.				x		
Order Penalles						
Achnanthes sp.						x
Amphora sp.	x					
Asterionella sp.	x					x
Caloneis sp.					x	
Campylodiscus sp.		x				
Centronella sp.					x	
Cocconeis sp.	x	x	x			x
Cymbella sp.	x	x	x	x	x	x
Diatoma sp.	x					
Diatomella sp.		x	x			
Diploneis sp.						x
Eunotia sp.						x
Fragillaria sp.	x	x	x	x	x	x

Table 12. Continued

	Regular Stations 1	2	3	4	5	Other Locations
Gomphoneis sp.					x	
Gomphonema sp.	x			x	x	x
Gyrosigma sp.	x	x	x	x	x	x
Mastogloia sp.	x	x		x	x	x
Navicula sp.	x	x	x	x	x	x
Neidium sp.						x
Nitzchia sp.				x		
Opephora sp.			x	x		
Pleurosigma sp.						x
Pinnularia sp.				x		x
Stauroneis sp.		x			x	
Surirella sp.						x
Synedra sp.	x	x	x	x	x	x

Table 13

Occurrence of macroinvertebrates from benthic collections on the Navasota River and tributaries. The letters "U, M, L" stand for upper, middle and lower sections.

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
Platyhelminthes													
Turbellaria													
<u>Curtisia</u> <u>foremani</u>										x			
Annelida													
Oligochaeta													
<u>Lumbriculus</u>	x			x						x			
<u>Enchytraeus</u>								x					
Hirudinea													
<u>Plaxobdella</u> sp.	x	x		x	x	x		x					
<u>P</u>. <u>rugosa</u>				x									
<u>P</u>. <u>parasitica</u>									x				
<u>Glossiphonia</u> spp.													x
<u>Erpobdella</u> <u>punctata</u>								x	x				x
Arthropoda													
Crustacea													
Conchostraca													
<u>Leptestheria</u> <u>compleximanus</u>			x										
Amphipoda													
<u>Hyalella</u> <u>azteca</u>	x			x			x	x					x
Decapoda													
<u>Cambarus</u> <u>diogenes</u> <u>ludovicianus</u>	x												x
<u>Fallicambarus</u> <u>hedgepethi</u>									x				
<u>Orconectes</u> <u>palmeri</u> <u>longimanus</u>					x								
<u>Procambarus</u> <u>curdi</u>		x											
<u>P</u>. <u>acutus</u>	x												x
<u>P</u>. <u>clarki</u>	x		x		x								x
<u>P</u>. <u>simulans</u>	x		x										x
<u>P</u>. <u>incilis</u>									x				x
<u>Palaemonetes</u> <u>kadiakensis</u>	x	x	x	x		x	x	x	x			x	

Table 13. Continued

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other
	U	M	L	U	M	L	U	M	L	U	M	L	Tributaries
Insecta													
Collembola													
Smynthurides sp.				X		X							
Ephemeroptera													
Baetis sp.	X			X							X		X
Callibaetis sp.	X			X	X				X				X
Centrophilum sp.	X								X		X		X
Cloeon sp.	X		X					X					
Pseudocloeon sp.									X				
Neocloeon sp.			X			X							
Tricorythodes sp.			X			X							
Hexagenis limbata venusta	X	X	X	X	X	X	X	X	X	X	X		X
Stenonema sp.	X	X	X		X	X		X				X	X
S. interpunctatum canadense			X					X					
Caenis sp.	X	X	X	X	X	X	X	X	X	X	X	X	X
Isonychia rufa	X	X	X		X	X							
Ameletus sp.						X							
Odonata (adults)													
Anisoptera													
Progomphus obscurus	X	X		X		X					X		X
Erpetogomphus designatus			X	X		X					X		
Dromogomphus spinosus				X	X	X							X
D. spoliatus	X	X	X					X					
Gomphurus vastus						X						X	
Gomphoides stigmatus	X			X									X
Erythemis simplicicollis	X	X	X	X	X	X	X	X	X	X	X	X	X
Pachydiplax longipennis	X	X	X	X	X	X	X	X	X	X	X	X	X
Pantala flavescens			X	X				X		X			X
Celithemis epoinina													X
C. elisa				X			X				X		
Perithemis tenera	X			X			X	X					X
Libellula commanche		X		X				X		X			X
L. luctosa	X	X	X	X			X	X	X	X	X	X	X

Table 13. Continued

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other
	U	M	L	U	M	L	U	M	L	U	M	L	Tributaries
L. flavida				X						X			X
L. incesta		X	X	X			X	X	X				X
L. vibrans	X		X	X			X		X				
L. pulchella			X	X	X								
Plathemis lydia	X	X		X	X		X	X	X	X		X	X
Dythemis fugax	X									X			X
D. velox	X		X	X							X		X
Tarnetrum corruptum		X											
Tramea onusta													X
T. lacertae								X	X	X			
Pantala hymenea				X				X					
Orthemis ferruginea	X			X									X
Sympetrum ambiguum			X	X	X					X	X		X
S. linearis							X		X				
Erythrodiplax minuscula		X	X	X				X					
Didymops transversa					X								X
Nasiaeshna pentacantha					X	X			X				
Anax junius			X	X				X					X
Boyeria vinosa				X	X			X					
Zygoptera (adults)													
Calopteryx maculata			X		X		X	X	X		X		X
Hetaerina titia		X	X	X	X						X		X
H. americana		X	X								X	X	X
Lestes disjuntus australis			X	X			X						X
Argia sedula	X	X	X	X							X	X	X
A. tibialis	X		X	X	X	X		X	X		X		X
A. translata	X									X			X
A. apicalis	X	X	X						X		X	X	X
A. immunda				X							X		X
A. nahuana				X									
A. moesta	X	X	X		X	X						X	X
A. fumipennis violacea		X		X							X	X	X
Ischnura posita		X		X		X							X
I. ramburi		X	X	X		X						X	
Telebasis salva		X		X	X			X			X		X
Enallagma exsulans			X	X							X		

Table 13. Continued

Organisms	River U	River M	River L	Cedar U	Cedar M	Cedar L	Brushy U	Brushy M	Brushy L	Holland U	Holland M	Holland L	Other Tributaries
E. basidens			x	x							x		
E. divagans													x
E. signatus													x
E. civile		x	x	x			x				x		
Anomalagrion hastatum	x	x	x	x			x	x					x
Plecoptera													
Perlesta placida					x								x
Isoperla sp.									x				x
Taencopteryx titia			x										
Hemiptera													
Notonectidae													
Notonecta sp.													x
Buenoa sp.													x
Hydrometridae													
Hydrometra sp.	x												
Belostomatidae													
Benacus griseus			x										
Belostoma													x
Abedus		x	x										
Pleidae													
Plea striola	x												
Nepidae													
Ranatra sp.	x												x
Corixidae													
Trichocorixa calva			x			x							
T. kanza						x							
T. louisianae						x							
Palmacorixa buenoi						x							
Corbella edullus						x							
Graptocorixa sp.													x
Hebridae													
Merragata sp.						x							
M. hebroides						x							
Hebrus consolidus						x							
Gerridae													
Gerris		x	x										x
Rheumatobaetes sp.	x												x
R. tenuipes						x							
R. rileyi						x							
R. hungerfordi						x							

Table 13. Continued

Organisms	River U	River M	River L	Cedar U	Cedar M	Cedar L	Brushy U	Brushy M	Brushy L	Holland U	Holland M	Holland L	Other Tributaries
Trepobates subnitidus	x		x										x
Limnogonus sp.	x												
Gelastocoridae													
Gelastocoris oculatus oculatus						x							
Mesoveliidae													
Mesovelia amoena						x							
M. mulsanti						x							
Neuroptera													
Sialis sp.				x	x	x		x		x	x		
Megaloptera													
Corydalus cornutus		x	x		x	x							x
Chauliodes sp.		x											x
Coleoptera													
Dytiscidae													
Agabates sp.			x										
Laccophilus proximus	x			x			x	x	x		x		x
Laccodytes sp.			x		x		x	x	x		x	x	
Bidessus sp.								x					
Hydroporus dimidicatus		x	x	x									
Derovatellus sp.			x										
Copelatus sp.			x										
C. chevrolati				x			x						
Comptotomus sp.		x	x			x							x
Ababus													x
Oreodytes sp.								x					
Laccornus sp.			x										
Thermonectus ornaticolis													x
Hydrocanthus sp.				x									
Hydrophilidae													
Tropisternus sp.				x					x				
T. mexicanus						x							x
T. lateralus nimbatus	x						x	x					x
Berosus pereginus	x			x			x	x	x				
B. infuscatus	x	x					x					x	x
Helophorus sp.					x						x		
Hydrochus sp.	x		x	x			x	x	x			x	
Paracymus sp.	x			x								x	

Table 13. Continued

Organisms	Occurrence														
	River			Cedar			Brushy			Holland				Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L		
Anacaena										x				
Helochares sp.					x				x					
H. maculicollis								x		x				
Cymbiodyta sp.										x				
Hydrochara sp.														x
Hydrophilus sp.								x	x					
Enochrus spp.				x				x						
E. pygaeus						x								
Laccobius sp.				x										
Hydrobius sp.				x										
Gyrinidae														
Dineutes sp.	x	x	x		x	x								x
Gyrinus sp.					x			x						
Gyretes sp.	x				x			x						
Elmidae														
Stenelmis sp.			x	x		x								x
Dubiraphia sp.						x								
Halipilidae														
Peltodytes spp.			x	x		x	x	x		x				x
Haliplus spp.		x	x				x			x				
H. triopsis				x										x
Dryopidae														
Helichus sp.				x	x									
Noteridae														
Hydroconthus sp.				x										
Chrysomelidae														
Donacio sp.														x
Helodidae														
Scirtus														x
Cyphon sp.														x
Omphoronidae														
Omophoron nitidum														x
Trichoptera														
Hydropsyche sp.				x		x					x			
Cheumatopsyche spp.				x	x	x				x	x			
Polycentropus sp.				x	x									
Neureclipsis sp.					x									
Mystacides sp.			x											
Leptocella sp.							x							
Triaenodes sp.						x								
Agraylea sp.										x				
Tascobia sp.						x								

Table 13. Continued

Organisms	Occurrence River U	River M	River L	Cedar U	Cedar M	Cedar L	Brushy U	Brushy M	Brushy L	Holland U	Holland M	Holland L	Other Tributaries
Diptera													
Tendipedidae (Chironomidae)													
Pentaneura sp.	x	x	x	x	x	x	x	x	x	x	x		
Tendipes spp.			x	x	x	x		x	x		x		
Procladius skuse				x									
Coelotanypus sp.						x							
Polypedilum spp.						x							
Prodiamesa sp.						x							
Cardiocladius sp.						x							
Anatopynia sp.						x							
Sphaeromias sp.						x							
Hydrobaenus sp.						x							
Lauterborniella sp.						x							
Tanytarsus spp.						x							
Calospectra sp.						x							
Ceratopogonidae													
Dasyhelca						x							
Culicoides spp.						x							
Alluaudomyia sp.						x							
Palpomyia sp.						x							
Simuliidae						x							
Culicidae													
Culex sp.		x						x			x		
Chaoborus sp.		x						x					
Anopheles sp.						x							
Stratiomyiidae													
Stratiomys sp.								x	x		x		
Nemotelus sp.											x		
Tabanidae													
Tabanus sp.				x							x		x
Chrysops sp.				x									
Tipulidae													
Erioptera sp.		x						x					
Mollusca													
Gastropoda													
Physa virgata = *Physa anatina*	x	x	x	x	x		x	x	x	x	x	x	x
Lymnaea sp.			x							x	x	x	
Gyraulus sp.			x				x						
Helisoma sp.													x

Table 13. Continued

Organisms	Occurrence: River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
H. trivolvis lentum	x												x
Ferrissia sp.				x									
Helicina arbiculata			x										
Polygyra sp.	x												
Pelecypoda													
Carnunculina texasensis	x		x	x	x		x	x	x			x	
C. parva						x							x
Tritogonia verrucosa			x										
Fusconaia sp.			x										
Amblema costata = *A. perplicata*			x			x							
Elliptio sp.			x										
Anodonta imbecilis													x
Sphaerium striatinum	x	x	x	x	x		x	x	x				x

The watershed was divided, as previously described, into three sections. There were sufficient benthos collections on the main channel and the three tributaries to make these divisions reasonable for comparative purposes. (Table 13).

There are some general differences between the three sections. The lower section has a much better developed flood plain, numerous overflow channels and some oxbow lakes. The central section has stretches of slightly higher gradient and a smaller flood plain, with brush and trees along the water course where it is not cleared for pasture. The upper section is in savannah, and some open prairie.

The three tributaries were also divided into three sections, based on what appeared to be a valid generalization about the tributaries of the central and lower sections of the watershed. The upper tributary sections are cleared land or savannah grassland and the streams are intermittent with a few isolated pools. The central sections are steeper in gradient, with more brush and trees, with channels often shaded. Flowing water is present much of the year and pools are long lasting even during fairly dry periods.

The lower sections are on the flood plain and have many of the characteristics of the main channel; slow flowing, often meandering, with steep clay banks.

The selectivity of the collection system has been discussed. Subject to those limitations some observations are in order.

Annelida

In the Annelida the Hirudinea seem to be better represented in the tributaries than in the main channel. Turbellaria are rare, in contrast to the Little Brazos, the next major upstream tributary of the Brazos, where literally dozens may be collected on a single rock.

Mollusca

In the Mollusca, the Pelecypoda show the generally recognized trend of better representation in the lower section, where water is deeper and flow more consistent. Observation also indicates a concurrent downstream increase in biomass and in average and maximum size. The biomass is considerable in many areas and the place of the Pelecypoda in the stream ecosystem is one of the important outstanding problems in the ecology of the river. In two years of plankton net collections glochidia were collected only once.

Arthropoda

A. Crustacea

A paper on the Decapod Crustacea of the watershed is in press (Rymer and Clark 1974). Although important in the floodplain and backwaters, most of the decapoda are not numerous in the channels. It is interesting to note that whenever the river floods the catfish are quick to go into the flooded area and when caught they are often gorged with crayfish.

The freshwater shrimp Palaemonetes is very abundant in the main river channel and in the lower tributaries. It is a rare dip net sweep at the waters edge which does not capture several.

Observation supports the premis that the river ecosystem is fueled to a considerable degree by allochthonous organic material, and it appears that Palaemonetes fill an important niche in this system.

B. Insecta

1-Ephemeroptera

There were 6 families, 20 genera, 5 species and two subspecies identified in the watershed.

A reference collection of mayflies was checked by Dr. Richard W. Koss currently of John Hopkins University. He verified 18 genera with a possible 4 new species that were reared out in the laboratory by Claron Bjork. Two genera, (Ameletus and Neocloen) were not in the collection sent to Dr. Koss.

At some locations mayfly nymphs were the most common aquatic form (ex. Brushy Creek). The mayflies in general reached peak abundance in May, and declined through the summer. There was a general succession in the spring involving peaks of stoneflies first, then mayflies, then caddisflies. Two families are more common than the others. These families are: Caenidae, containing the widespread genus Caenis; and the Family Ephemeridae, containing two genera and two species Hexagenia limbata venusta and Pentagenia vittigera. Hexagenia limbata venusta is the commonly known burrowing mayfly, and was the most abundant mayfly in the river. In Brushy Creek at FM 977 for example, it was possible to obtain 40-50 specimens on a handscreen in a short time.

2-Odonata

Identification is based on the adults only, and although all the forms reported were collected in the vicinity of the stream channels it is apparent that most of the nymphal stages were in ponds and back waters, few nymphs were collected from the streams themselves in spite of considerable collecting effort.

The data represent a good beginning of a check list for the watershed.

Considerable collecting and rearing must be done to identify those species in the stream channels and to work out the nymphal ecology.

In the Suborder Anisoptera there have been found in the watershed 5 families and 46 probable species. In the Suborder Zygoptera in the watershed there are three families and 21 species. Adding the species of the Zygoptera and Anisoptera there are approximately 67 species of Odonata in the watershed. When the immatures or nymphs are fully identified there might be another 5-10 species to add to this list. Some of the Dragonflies have not been positively identified, particularly in the Family Macromidae.

In the Family Gomphidae the two species of Progomphus are sand burrowers usually found in riffle areas. In the pools or soft mud are usually found Arigomphus lentulus, Stylurus plagiatus, Gomphurus externus, Dromogomphus spinosus, D. spoliatus, and perhaps Gomphus militaris. In riffle areas where there usually is some silt, rocks and perhaps sand, the following species are usually found under rocks paritally buried: Ophiogomphus sp., Erpetogomphus designatus, E. compositus and Dromogomphus armatus. Hagenius brevistylus is the large black or dark brown flat nymph that is found in leaf litter or debris in streams.

In the Family Libellulidae the following 5 species are the most common: Erythemis simplicicollis, Pachydiplax longipennis, Libellula luctosa, Plathemis lydia, Perithemis tenera. Of these five species named *Erythemis simplicicollis* and *Pachydiplax longipennis* are the most widespread and abundant. The species in this family are much more active than those in the Family Gomphidae who are really "awaiters" waiting for their food to come to them, whereas the Libellulids are very active and apparently hunt their food more actively. Most of these are pond forms, and although the adults are seen patrolling the streams their larvae or numphs are not found in the streams. An example of this is Brushy Creek FM 977 where many Libellulids patrol the stream but nymphs are never found in the stream. These species often bury themselves partially in the mud and often have hairy bodies to which the mud sticks as a protective coating. They are often found in or on leaf litter or aquatic plants.

In the Family Macromidae there are at least 3 species but the identification is unsure at this time. *Didymops transversa* is apparently a spring emerging species while the genus *Macromia* is a late spring and summer emerging form. These are long legged forms that move easily over soft bottoms or bottoms covered by organic matter. They are widespread in the streams but not abundant, with very few being picked up in the main river.

In the Family Aeshnidae there have been 3 genera and 3 species found in the watershed. These forms are very active, good eyesight, and voracious. They are climbers, usually found on sticks or stocks of aquatic plants, but often are found in leaf litter.

The Family Cordulegasteriidae has been only picked up in the watershed once as a nymph; in Devil's Jump Creek FM 1940. This stream is clear, relatively fast with some mud bottom but gravel and sand in most places.

In the Suborder Zygoptera, Calopteryx maculata is the most abundant. It is possible to collect hundreds of specimens at one location if desired at certain times of the year, for example at Cedar Creek OSR. The Family Agrionidae-Calopteryidae is often collected rather than other specimens because they are large and colorful. In the Family Coenagrionidae the genus Argia is the most abundant. They are usually found along the edges of streams in the aquatic vegetation hanging in the water, in leaf litter, log jams, under bark, and more often in quieter water than fast running water. The species Anomalagrion hastatum was picked up only once, at Cedar Creek FM 46.

3-Plecoptera

In the Navasota River Watershed there are three families, 3 genera and probably only 3 species of Plecoptera. The identifications were checked by Dr. Richard Baumann at the University of Utah.

Two of the genera, Perlesta and Isoperla, are late spring emerging forms. They emerge usually in the last two weeks in May and sometimes the first week in June. This depends to a great extent on how warm the weather has been early in the season and during the time of emergence. In 1968 and 1969, the adults plus larvae were gone from streams by the first part of June. Whereas in 1970, larvae were picked up in Lick Creek on the Sulfur Springs Road and Cedar Creek on Highway 190 as late as the middle of June. Apparently the nymphs have a two-to-three month life cycle, over summer as eggs, and emerge in winter and spring.

Taeniopteryx titia in the Family Nemouridae is not a common form in the watershed. In February, 1970, one adult plus 13 nymphs were picked up at the Navasota River highway 6 (Station 1). One adult was picked up near Country Club Lake and one adult near Wellborn (by the Entomology Department) within a few days of the above date. Adults of this family plus larvae were only found in February and had not previously been collected in this area. Although many attempts were made to pick up other larvae at the Navasota River Highway 6 in 1970, collecting was impossible because of floods for a number of months; and when the water went down, no larvae were found. Often stoneflies are attracted by lights, and a lantern was used one night to no effect at the above location. One possible reason why the Nemourids were found at at the Navasota River at Highway 6 is that this larvae is usually found under rocks; and there is considerable rocky debris under the bridge. One other possible reason why there are stoneflies at Station 1 in the winter and not in the early spring, besides the temperature, is that later in the spring the helgrammites are nearly full grown and would be a big predator of stoneflies.

Between December-January, and March-May, stoneflies were one of the major insects orders found in Duck Creek, Steele Creek, Mineral Creek, and Cedar Creek from OSR down. Stoneflies were picked up sometimes between December and March in the gravel below the bridge at Brushy Creek FM 977.

The opportunistic nature of the distribution is demonstrated by the collection of numerous stoneflies during the spring of 1970 at Old Sulpher Springs on the main channel, in an area where numerous previous samples had never included stoneflies. The water was unusually low over a stretch of bottom with some gravel. Normally the water is deeper and the gravel fairly well silted in.

Water chemistries in general appear to be not too important in controlling distribution; other than extremes, high or low pH's and pollution. Stoneflies are naturally or usually found in colder, cleaner streams with fast, steady flow, with very little pollution, and where there is a gravel, sand, or rock bottom.

Stonefly adults are often picked up on campus on the lighted doors of buildings, and near lighted signs. This could indicate that stoneflies might be more prevalent in the area than once thought, since the nymphs have not thus far been picked up within many miles of where the adults were found. The specimens found at the lighted site are usually from the genera Isoperla and Perlesta.

4-Hemiptera

Hemiptera appear more common in the larger ponds and temporary and overflow pools of the river, than in the tributary streams or the main river channel. Most of the Hemiptera were found along the edges of the streams in the quiet water, and on the shore, and in or near the vegetation along the bank. Few were found in areas where the water was swifter, and where there was less vegetation along the banks. The high diversity of lower Cedar Creek is an artifact of more intense taxonomic effort, as well as more quiet water habitat.

5-Coleoptera

The beetles were the most widely represented and distributed insect group collected from the river or tributaries. Numbers were usually small however, except for the very large populations of whirlygig beetles in the main channel.

6-Trichoptera

The concentration of occurrences in Cedar Creek appears to reflect the actual distribution. So little is known about the Texas Trichopera that identifications beyond genus are not practical at present.

Drift Organisms

Monera

Bacteria

Despite the long recognized fundamental role of the bacteria in all ecosystems, the study of non-pathogenic forms has proceeded very slowly. The procedures are time consuming and the taxonomy is primitive. We were able to fund only a limited reconnisance during two summers. The results are sumarized in Table 14.

The determinative scheme of Shewan, Hobbs and Hodgkiss (1960) was adopted, since our preliminary work agreed with their conclusion that the majority of isolates were gram negative asporogenous rods. An outline of the determinative scheme is given in the Data Appendix.

We also did limited MPN (most probable number) determinations and some Coliform tests.

Coliforms tests were run July 23, 1968, on Steele, Frost and Rocky Creeks and on the Navasota River at Highway 164. All were negative. Tests were run July 29, 1968, at the five regular river stations. Stations 2 and 5 were negative, 4 a solid positive, and 1 and 3 borderline positive. The river was very low at this time. The MPN data are given in Table 15.

On February 13, 1969, Coliform counts on Holland, Duck and Brushy Creeks were negative.

Table 14

Bacteria Isolated from the Navasota River

Date	Location	Isolates
7/9/68	Station #1	Flavobacterium
		Alcaligenes
		Pseudomonas
		Flavobacterium (yellow)
7/9/68	Station #2	Flavobacterium
7/9/68	Station #3	Pseudomonas spp. (yellow)
		Achromobacter
7/9/68	Station #4	Achromobacter
7/9/68	Station #5	Achromobacter
7/9/68	Plummers Creek	Flavobacterium (orange)
		Flavobacterium (yellow)
		Pseudomonas
		Alcaligenes
7/9/68	Springfield Lake	Flavobacterium (pink)
		Flavobacterium (orange)
8/3/68	Navasota River e. Delia	Pseudomonas Group I - 2 varieties
		Pseudomonas Group II - 2 varieties
		Pseudomonas Group IV

Table 14. Continued

Date	Location	Isolates
8/3/68	Navasota River	_Achromobacter_
8/3/68	Station #4	_Pseudomonas_ Group II
8/3/68	Navasota River at Mt. Calm	_Pseudomonas_ Group I _Pseudomonas_ Group II
8/3/68	Indian Lake	_Pseudomonas_ Group II - 2 varieties _Pseudomonas_ Group I - 2 varieties
8/8/68	Navasota River at State Highway 90	_Pseudomonas_ Group I - 2 varieties _Pseudomonas_ Group IV - 2 varieties
8/8/68	Navasota River Station # 1	_Achromobacter_ _Alcaligenes_
8/16/68	Navasota River at State Highway 90	_Pseudomonas_ Group I
8/25/68	Navasota River at State Highway 90	_Xanthomonas_ _Alcaligenes_ - 2 varieties _Pseudomonas_ Group IV - 3 varieties _Pseudomonas_ Group I - 3 varieties _Flavobacterium_

Table 14. Continued

Date	Location	Isolates
8/25/68	Station #4	*Flavobacterium* - 2 varieties
		Xanthomonas
		Pseudomonas Group IV
		Pseudomonas Group II
		Alcaligenes
		Vibrio
		Achromobacter
2/13/69	Holland Creek	*Pseudomonas* Group III
		Chromobacterium
2/13/69	Duck Creek	*Pseudomonas* Group II
		Pseudomonas Group III
		Rhodospirillum
		Aeromonas
2/13/69	Brushy Creek	*Pseudomonas* Group III
		Rhodospirillum

Table 15

Most Probable Number Determinations of Bacteria in Water Samples From the Navasota River and Tributaries

Date and River Stage	Location	MPN (org/ml)
6/17/68 river high	Station 1	<3,000
	Station 2	<3,000
	Station 3	3,300
	Station 4	<3,000
	Station 5	3,000
8/25/68 river very low	Station 1	>100,000
	Station 2	>100,000
	Station 3	>100,000
	Station 4	100,000
	Station 5	35,000
2/13/69 no flow data	Holland Creek	63,000
	Duck Creek	58,000
	Brushy Creek	90,000
5/15/69 high flow all stations	Holland Creek	9,300
	Brushy Creek	870,000
	Cedar Creek	3,200
	Station 1	9,800

Table 16

Coliform Data, Navasota River, From Texas State Department of Health.
Taken at Project Station 1 (Highway 6)

Date	MPN-Total Coliforms/100 ml	MPN-Fecal Coliforms/100 ml	Stream Condition
3-14-67	1,300	-	Normal
4-23-68	3,450	130	High, Muddy
8-20-68	1,300	46	Low, Muddy
2-17-70	130,000	79,000	Normal
4-22-70	1,720	700	High, Muddy
6-9-70	1,720	330	Low
10-6-70	2,210	14	High, Muddy
2-17-71	190	80	Low
6-8-71	2,100	130	Normal

On May 15, 1969, Coliform tests were positive for Holland, Brushy and Cedar Creeks and negative for Station 1 on the river.

The Texas State Department of Health kindly furnished data on Coliform tests made at Station 1 during 1967 through 1971. (Table 16) Only February 17, 1970, shows significant numbers.

Protista

The organisms collected as net plankton are listed in Table 17. The net occasionally collected the Protozoans *Difflugia* and *Arcella* and the algae *Euglena*, *Pediastrum*, *Closterium*, *Eudorina*, *Volvox* and *Surirella*. The occurrences were random, not repeating from one year to the next, and not showing a definitive pattern over the stations. Numerical data are given in the Data Supplement.

The plankton net is not a phytoplankton sampling device, but the resources of the project did not permit implementation of a phytoplankton sampling system. The constant high turbidity would make any such system difficult to operate, but the problem must be tackled, eventually.

Metazoa

Macro-drift

Floating nets of plastic window screen on metal frames were set at the surface and at times 1-2 feet below the surface for 1/2 hour periods during the winter and spring. Few organisms were ever caught, though considerable amounts of organic debris accumulated. The largest catch in any one set was 10 blackfly larvae.

The magnitude of the macro-drift was very much lower than expected,

Table 17

Check List of Net Plankton, Navasota River

Only those algae large enough to be relatively adequately sampled with the plankton net are listed.

ZOOPLANKTON

Phylum - Protozoa
Class Rhizopodea
Arcella sp.
Difflugia spp.

Phylum - Rotifera
Class Monogononta
Order Plioma
Brachionus calyciflorous
B. angularis
B. havaenensis
B. bidentata
B. quadridenta
Platyias patulus
P. quadricornis
P. polyacanthus
Keratella cochlearis
K. valga
K. spp.
Kellicottia longispina
K. bostoniensis
Euchlanis sp.
Notholca sp.
Lepadella sp.
Trichotria sp.
Lecane sp.
Monostyla sp.
Ascomorpha sp.
Trichocera sp.
Asplanchna sp.
Polyartha sp.
Synchaeta sp.

Order Flosulariaceae
Filinia sp.
Trochosphera sp.
Hexartha sp.

*Also found were many species of aloricate rotifers which could not be identified from preserved material.

Table 17. Continued

Phylum - Arthropoda
Class Crustacea
Order Cladocera
Diaphanosoma brachyurum
Daphnia parvula
Simocephalus serrulatus
Scapholeberis kingi
Ceriodaphnia quadrangula
C. pulchella
C. lacustris
C. rigaudi
Moina micrura
Bosmina longirostris
B. longirostris var. *cornuta*
B. coregoni

Family Macrothricidae
Macrothrix laticornis
Ilyocryptus spinnifer
I. sordidus

Family Chydoridae
Pleuroxus denticulatus
P. hamulatus
Chydorus sphericus
Alona rectangula
A. affinis
A. karua
Camptocercus rectirostris
C. oklahomensis

Order Calanoida
Diaptomus pallidus
D. siciloides
D. dorsalis

Order Cyclopoida
Ectocyclops phaleratus
Paracyclops fimbriatus poppei
Eucyclops agilis
E. speratus
Cyclops exilis
C. vernalis
Tropocyclops prasinus
Ergasilus chautauquensis

Order Harpacticoida

Table 17. Continued

PHYTOPLANKTON

Phylum - Euglenophyta
Order Euglenales
Euglena sp.

Phylum - Chlorophyta
Class Chlorophyceae
Order Volvocales
Eudorina sp.
Volvox sp.

Order Chlorococcales
Pediastrum sp.

Order Zygnematales
Closterium sp.

Division - Chrysophyta
Class Bacillariophyceae
Order Pennales
Surirella sp.

INCIDENTAL FORMS

Phylum - Nematoda

Phylum - Annelida
Class Oligochaeta

Phylum - Ectoprocta
Class Phylactolaemata
Order Plumatellina
Family Plumatellidae (Floatoblasts)

Phylum - Mollusca
Class Pelecypoda
Family Unionidae (Glochidia)

Phylum - Arthropoda
Class Crustacea
Subclass Branchiura - *Argulus* sp.
Subclass Ostracoda
Subclass Malacostraca

Table 17. Continued

Order Decapoda
    Family Palaemonidae
        Palaemonetes larval form

Class Insecta
    Order Diptera
        Family Culicidae
            Subfamily Culicinae
            Subfamily Chaoborinae
                Chaoborus sp.

        Family Simulidae

        Family Tendipidae

        Family Ceratopogonidae

though more sampling in summer might give a different picture.

Zooplankton

The groups classically included in the zooplankton: rotifers, cladocera and copepods were found in reasonable numbers. The data are summarized in Figures 93 and 94 on two bases; concentration in numbers per liter, and total quantities passing the sampling point in numbers per second.

The general pattern is one of decreased concentration but increased total numbers from the upper to the lower stations. In other words there is a net downstream dillution, with water added faster than zooplankton. The data for the river stations are presented by station and major groups in Figures 95 through 104. The data for the tributaries are presented in Figures 105 through 110.

No numbers per second data are shown for river Station 4, since this station was below the Springfield Lake dam, and there was no outflow much of the time. The concentration figures thus represent populations in the pooled water below the dam.

At some of the other stations the concentration graph will show significant numbers, but there will be no numbers per second on the corresponding graph for that date. This is caused by zero flow conditions. The concentrations here also representing pool populations.

A. Rotifera

Numbers in the tributaries were low, and peaks do not occur at the same time as in the main channel. The three tributaries are in the lower 1/2 of the watershed, and the evidence is that tributaries in this region do not contribute signigificantly to the rotifer population in the main

COPEPODA and CLADOCERA, NAVASOTA RIVER

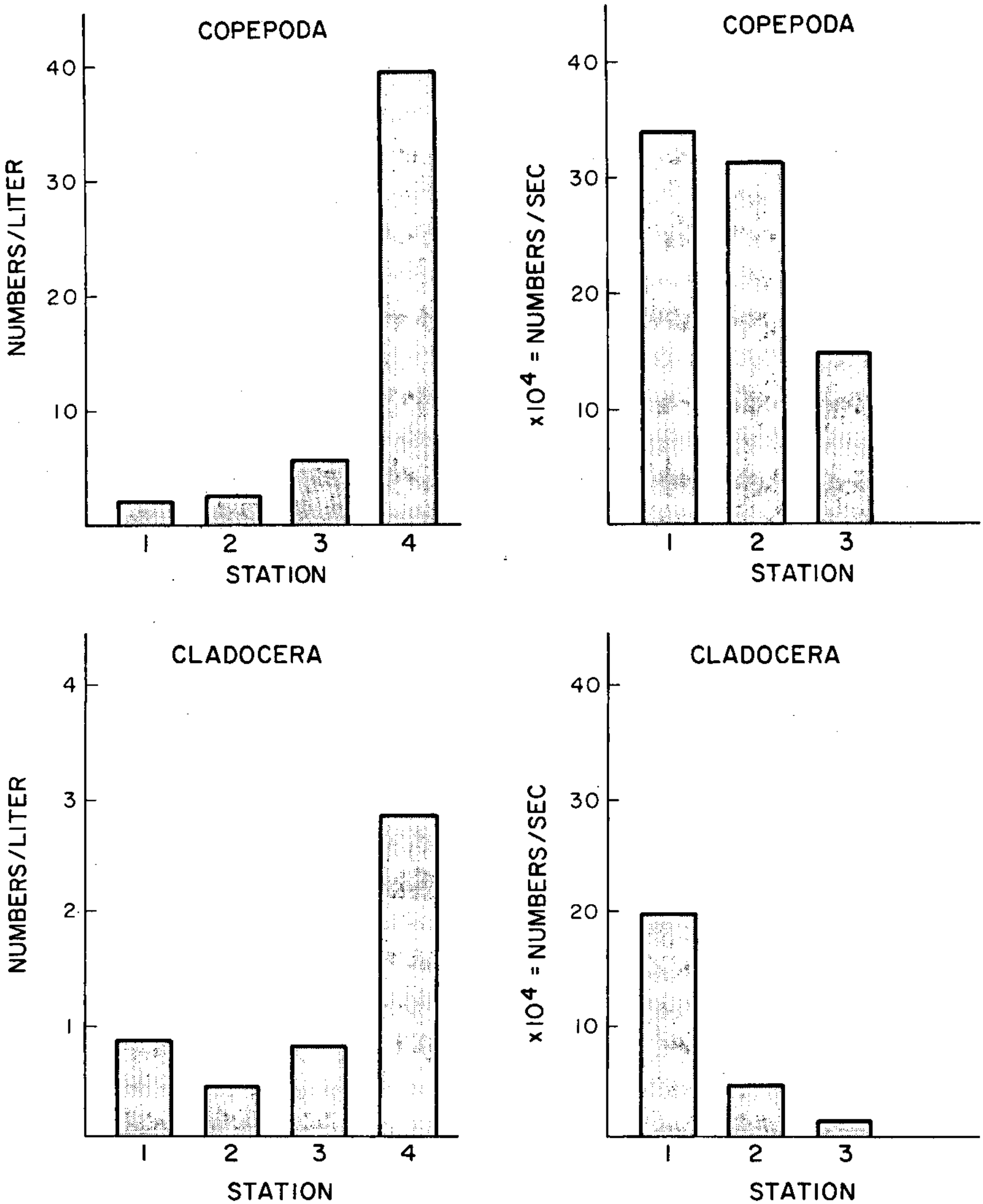


Figure 93

ROTIFERA and TOTAL ZOOPLANKTON, NAVASOTA RIVER

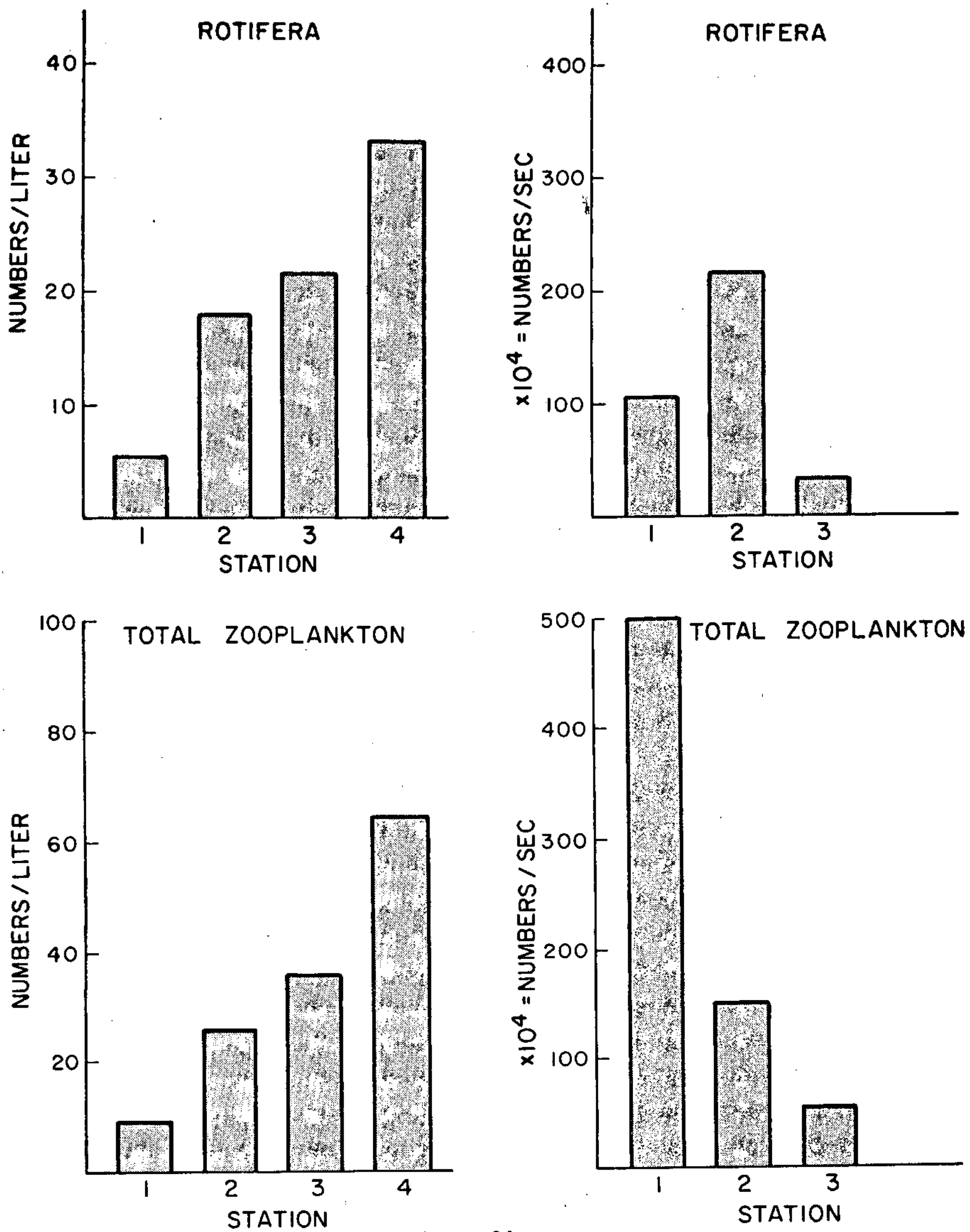


Figure 94

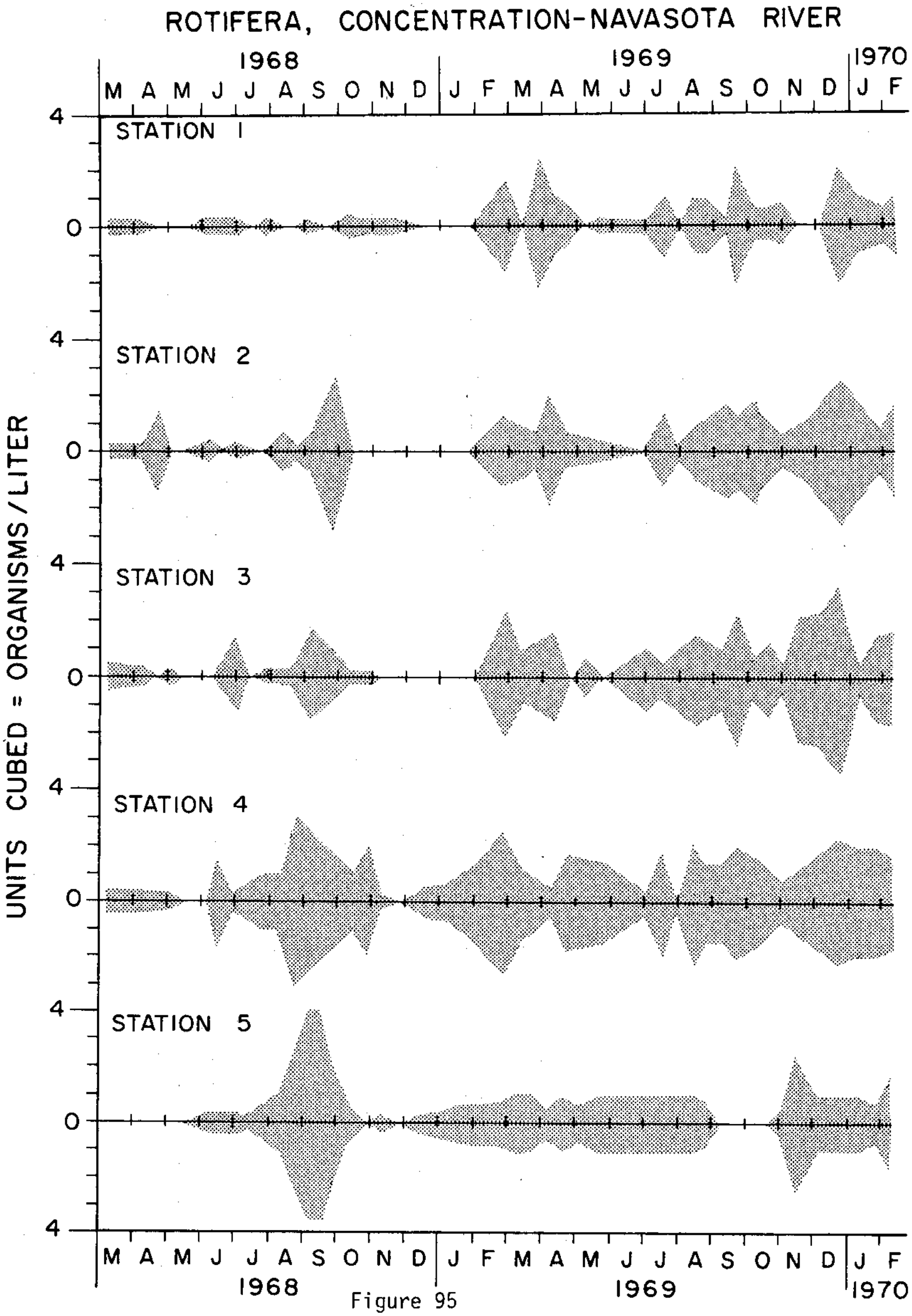

ROTIFERA, CONCENTRATION-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 4
STATION 5
4
0
UNITS CUBED = ORGANISMS/LITER

Figure 95

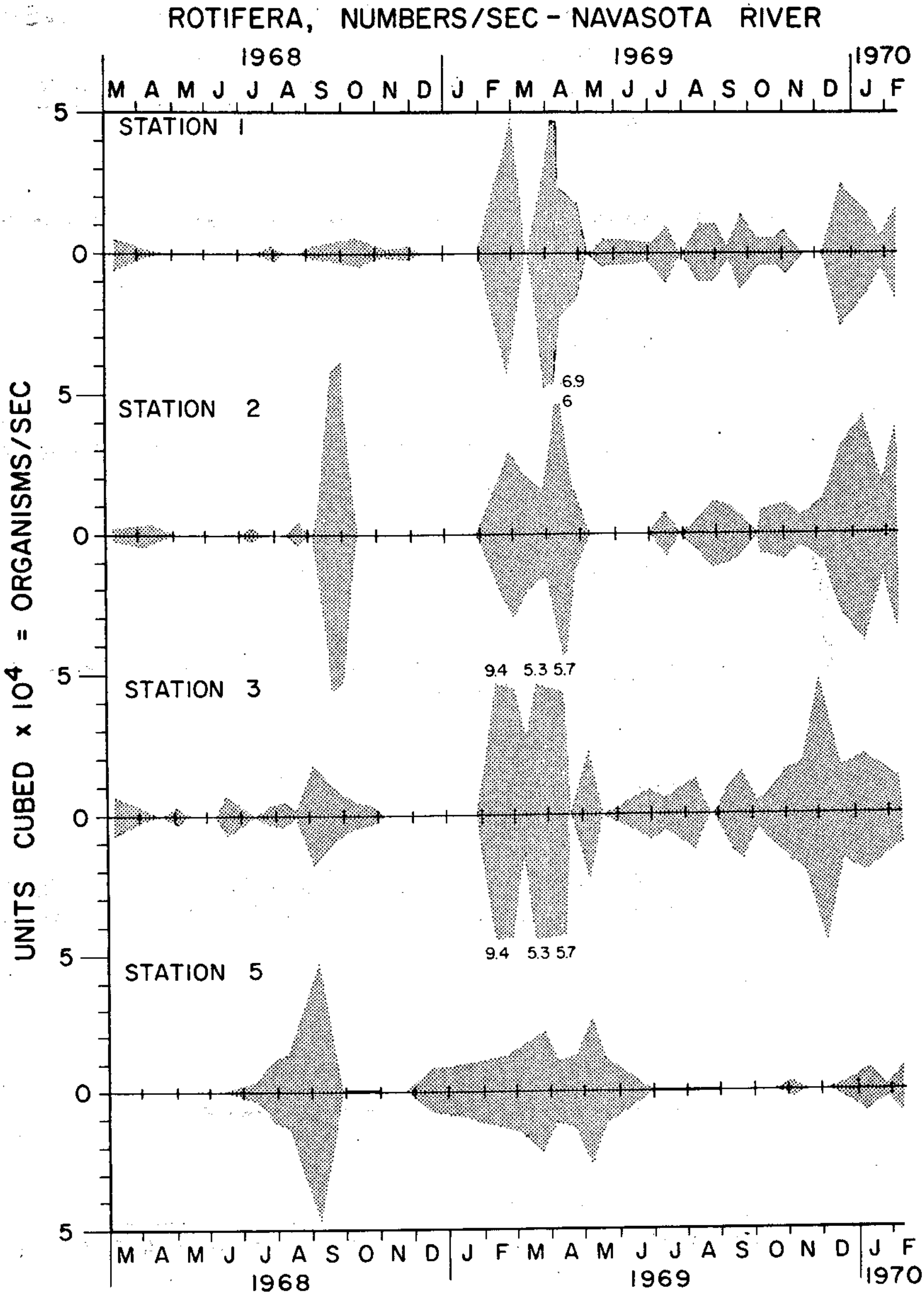

ROTIFERA, NUMBERS/SEC - NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 5
6.9
6
9.4 5.3 5.7
9.4 5.3 5.7
5
0
UNITS CUBED x 10⁴ = ORGANISMS/SEC

Figure 96

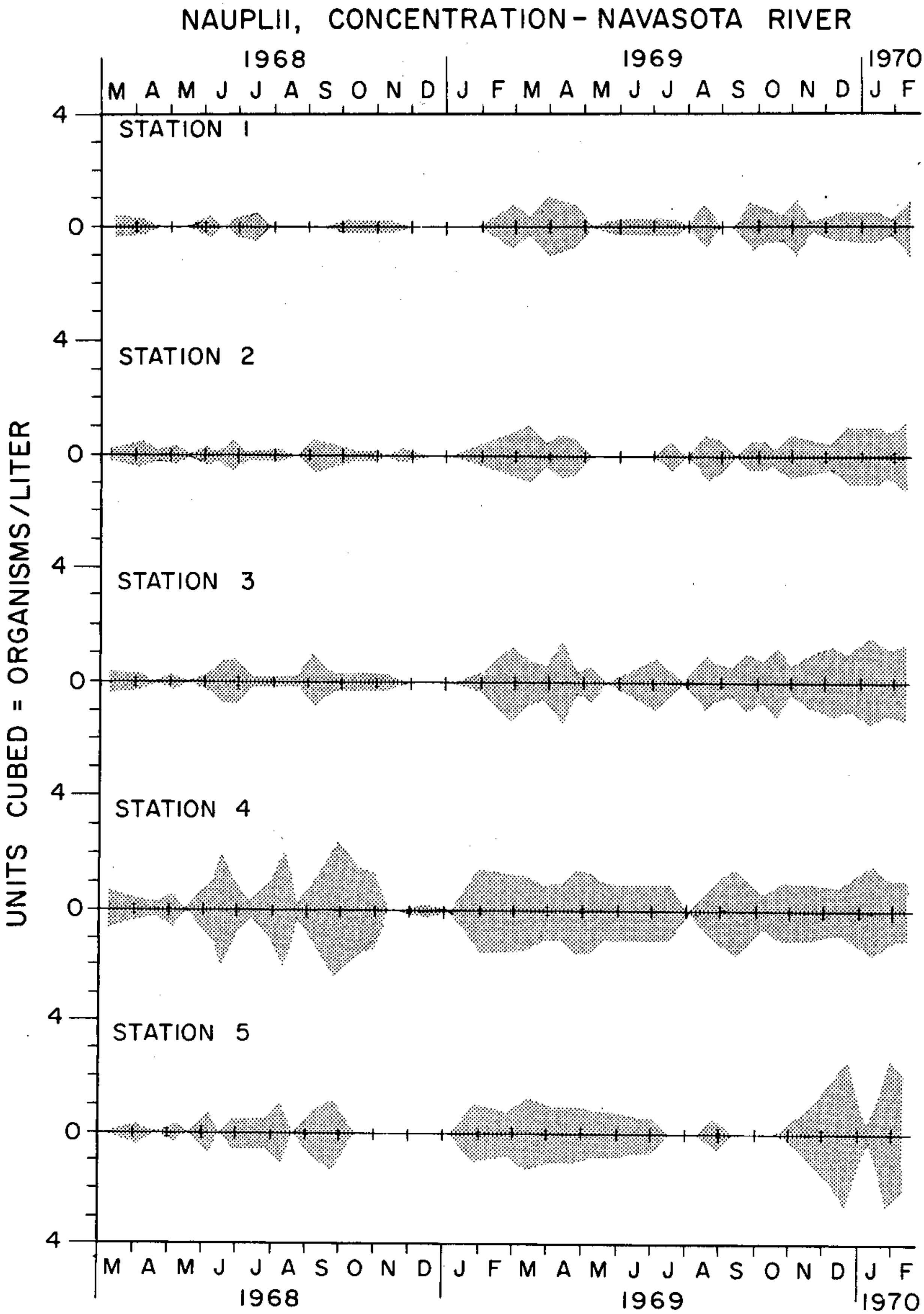

NAUPLII, CONCENTRATION - NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 4
STATION 5
4
0
UNITS CUBED = ORGANISMS/LITER

Figure 97

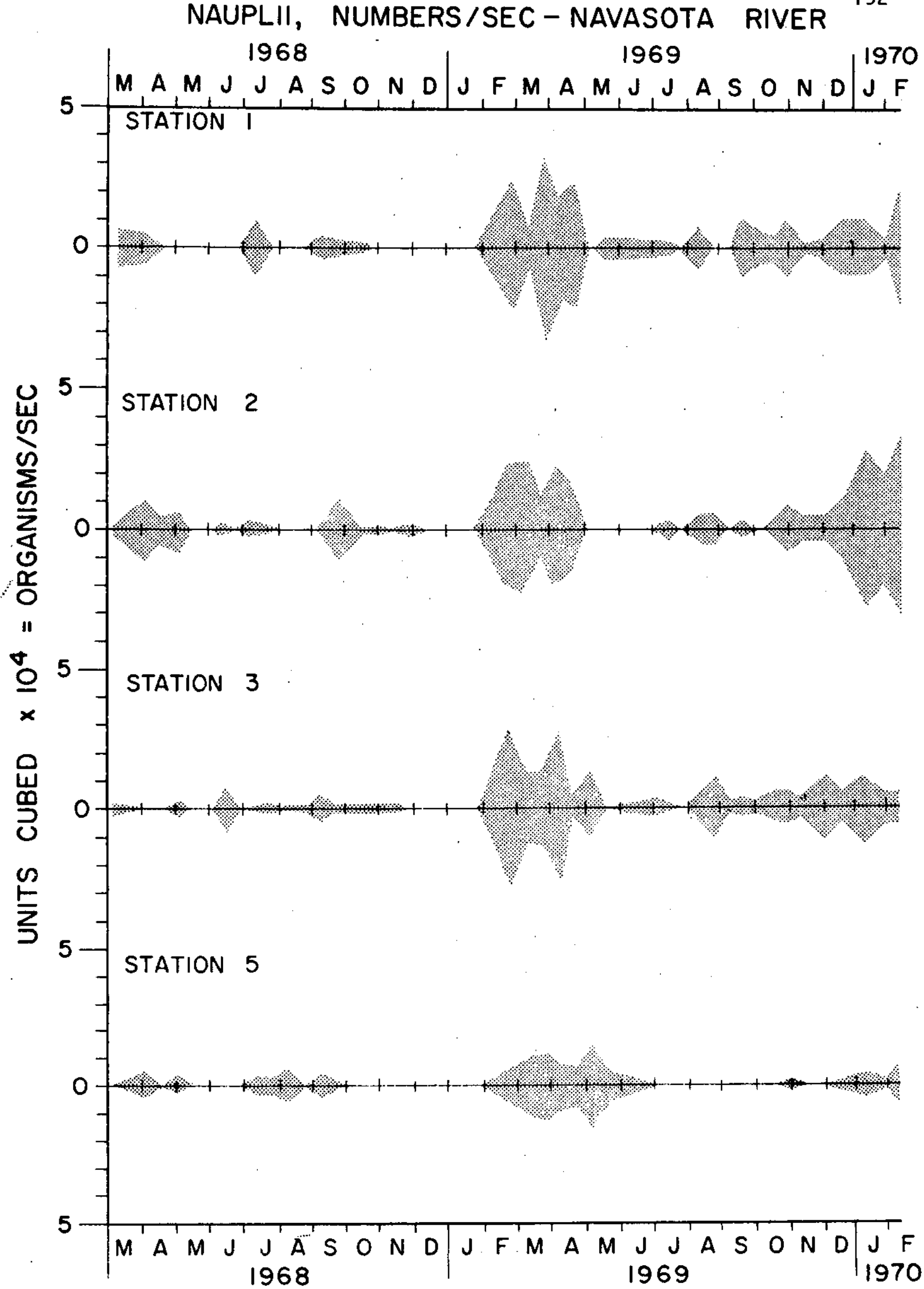

NAUPLII, NUMBERS/SEC - NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 5
UNITS CUBED x 10⁴ = ORGANISMS/SEC
5
0

Figure 98

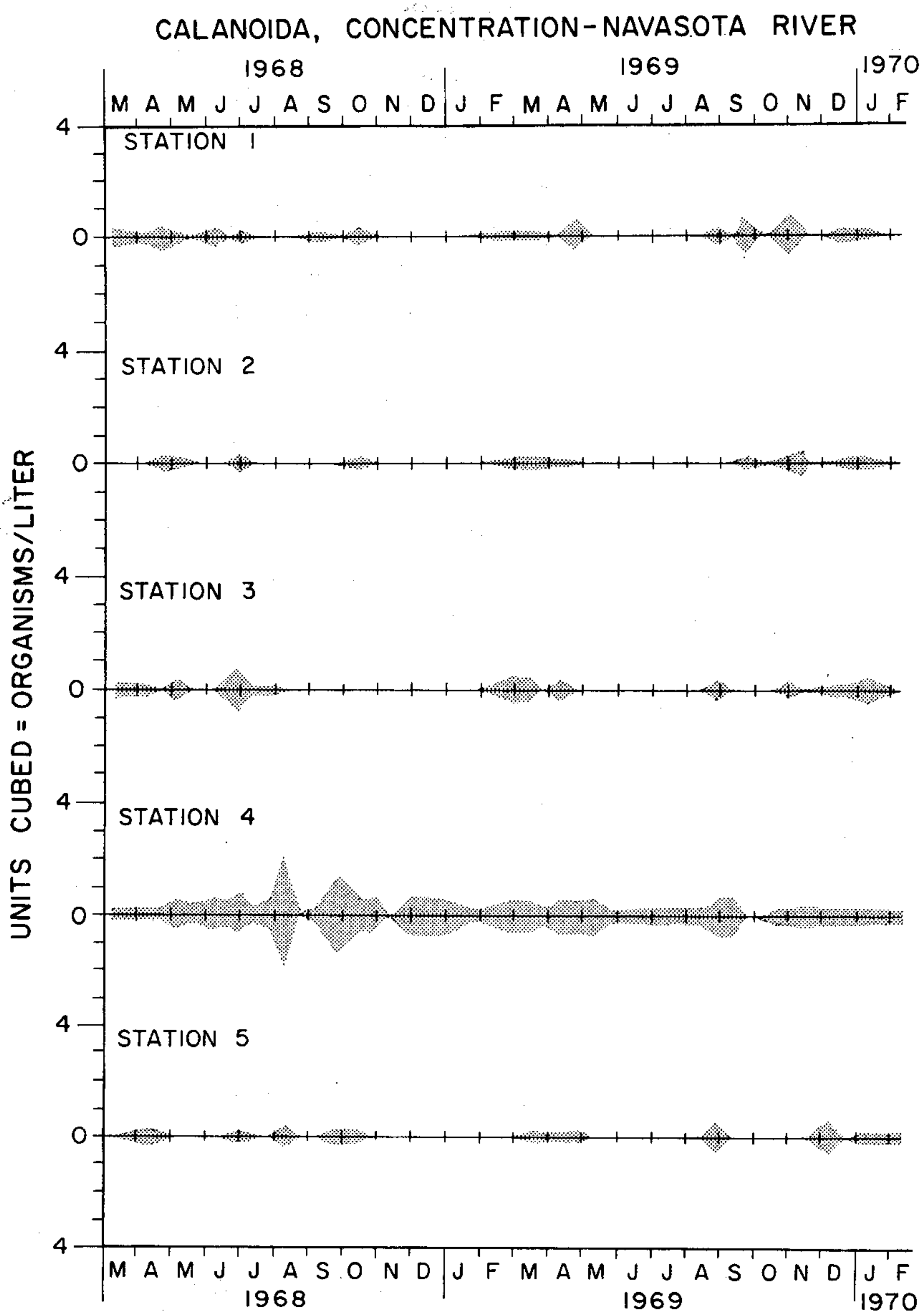

CALANOIDA, CONCENTRATION-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 4
STATION 5
4
0
UNITS CUBED = ORGANISMS/LITER

Figure 99

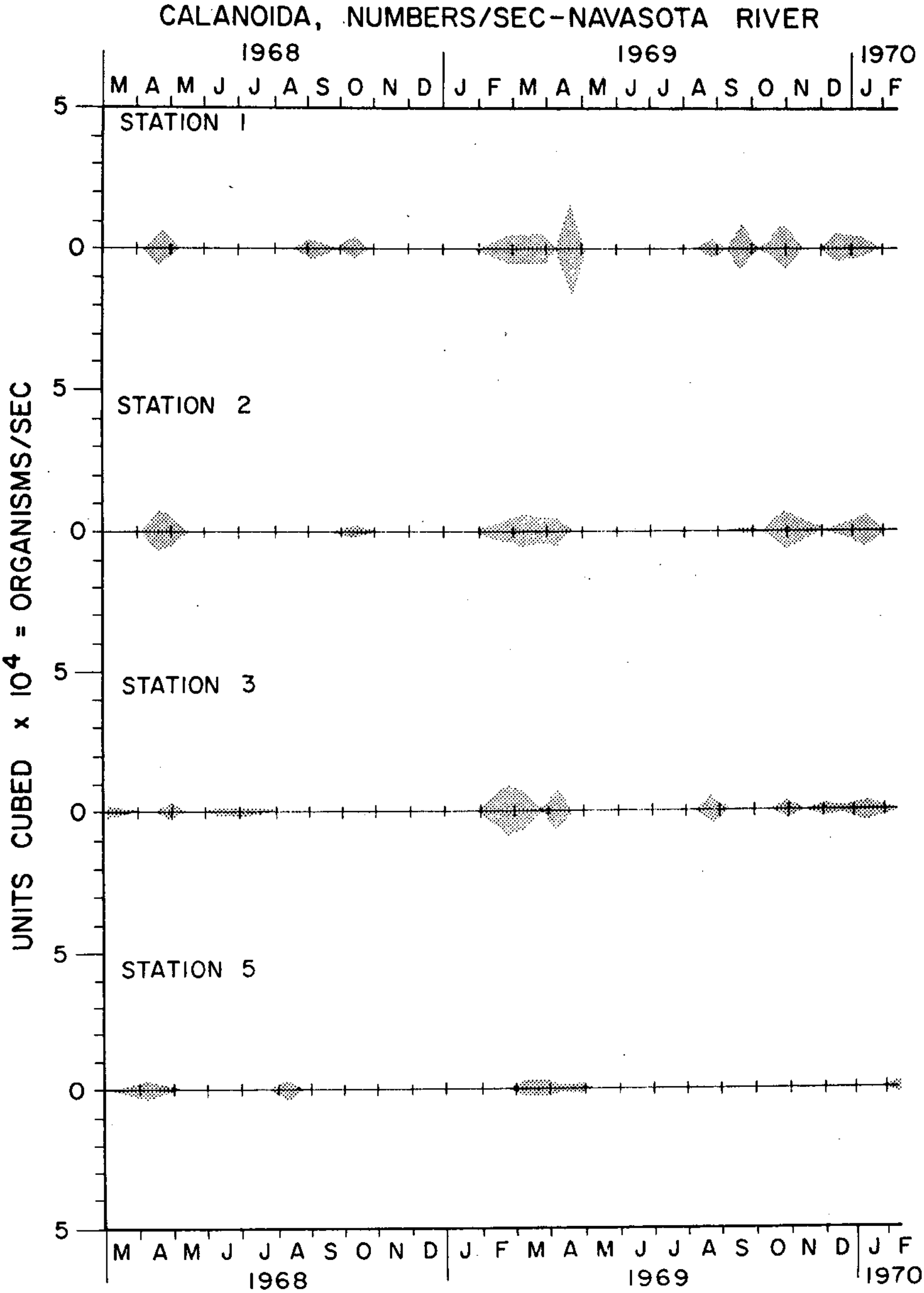

CALANOIDA, NUMBERS/SEC-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 5
5
0
UNITS CUBED x 10⁴ = ORGANISMS/SEC
M A M J J A S O N D J F M A M J J A S O N D J F
1968
1969
1970

Figure 100

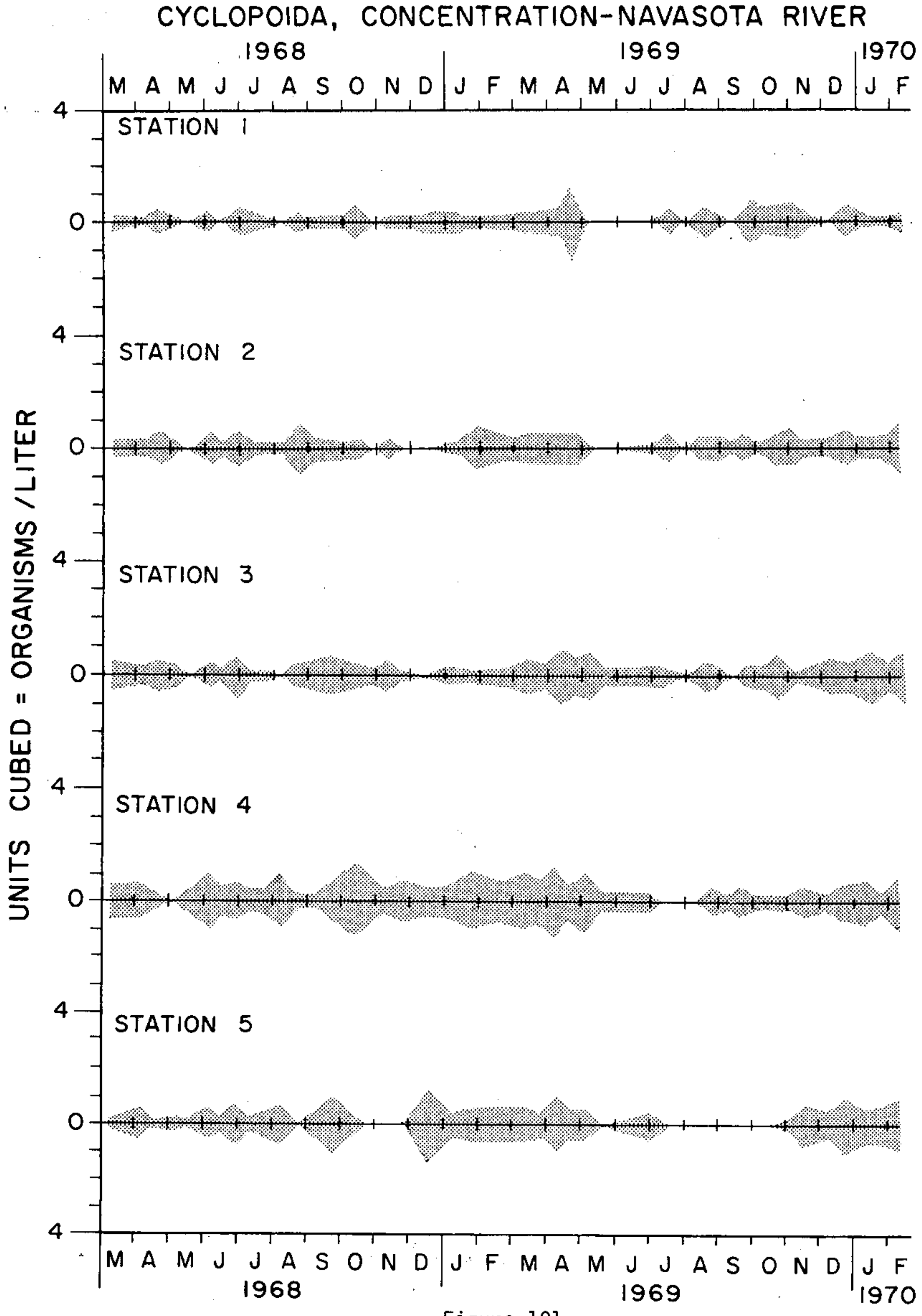

CYCLOPOIDA, CONCENTRATION-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 4
STATION 5
4
0
UNITS CUBED = ORGANISMS /LITER

Figure 101

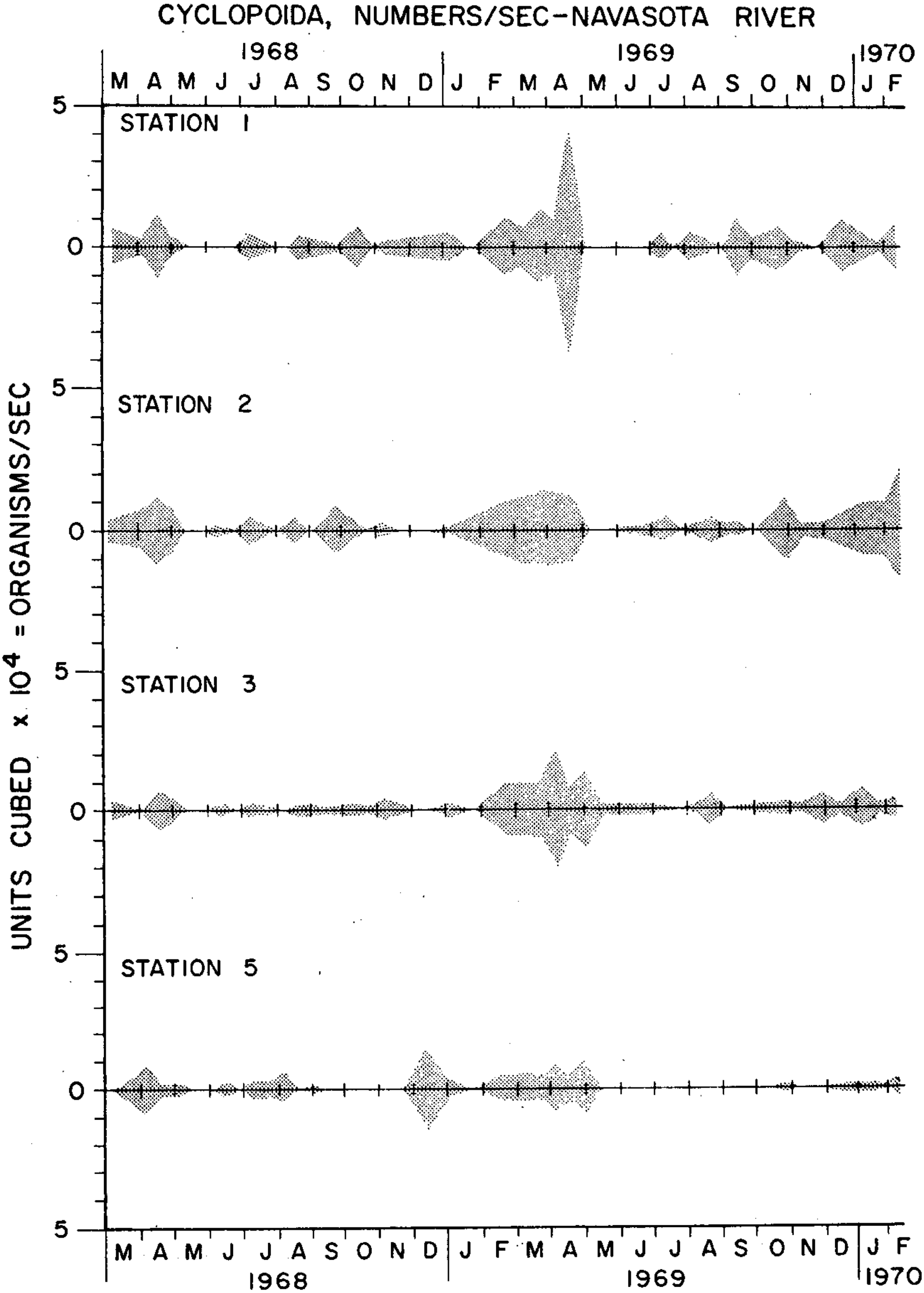

CYCLOPOIDA, NUMBERS/SEC-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 5
5
0
UNITS CUBED x 10⁴ = ORGANISMS/SEC

Figure 102

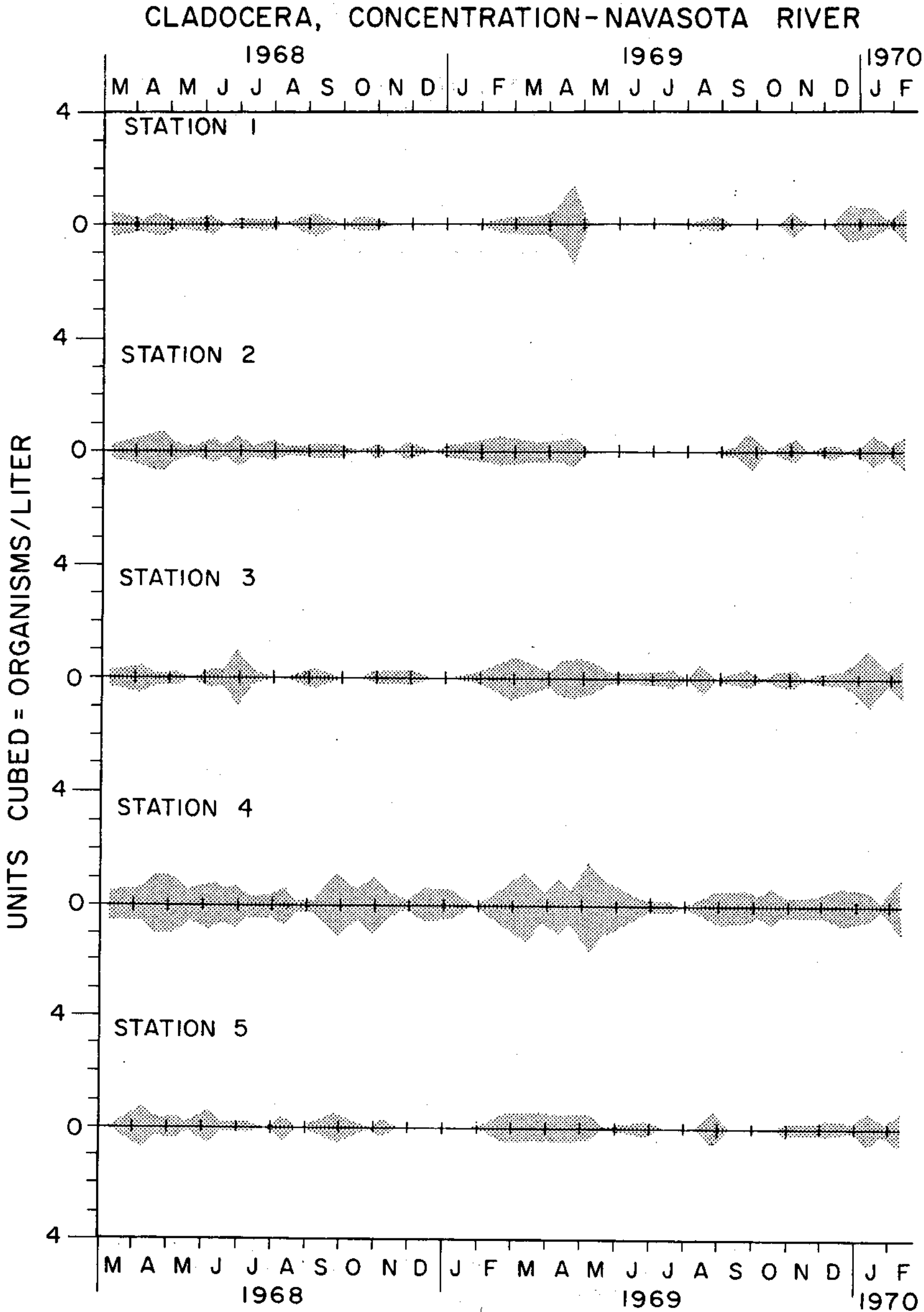

CLADOCERA, CONCENTRATION-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 4
STATION 5
4
0
UNITS CUBED = ORGANISMS/LITER

Figure 103

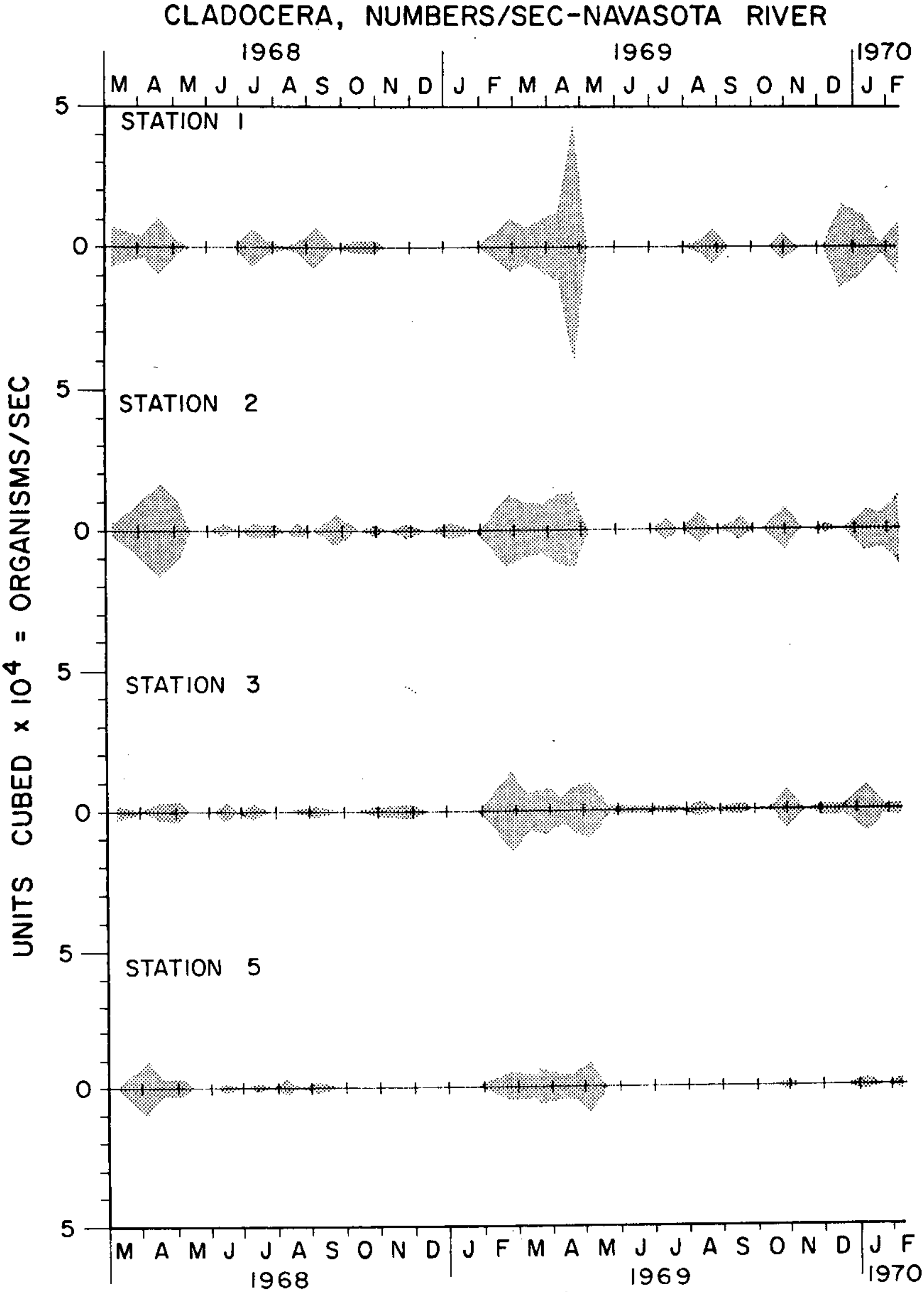

CLADOCERA, NUMBERS/SEC-NAVASOTA RIVER
1968
1969
1970
M A M J J A S O N D J F M A M J J A S O N D J F
STATION 1
STATION 2
STATION 3
STATION 5
UNITS CUBED x 10⁴ = ORGANISMS/SEC
5
0

Figure 104

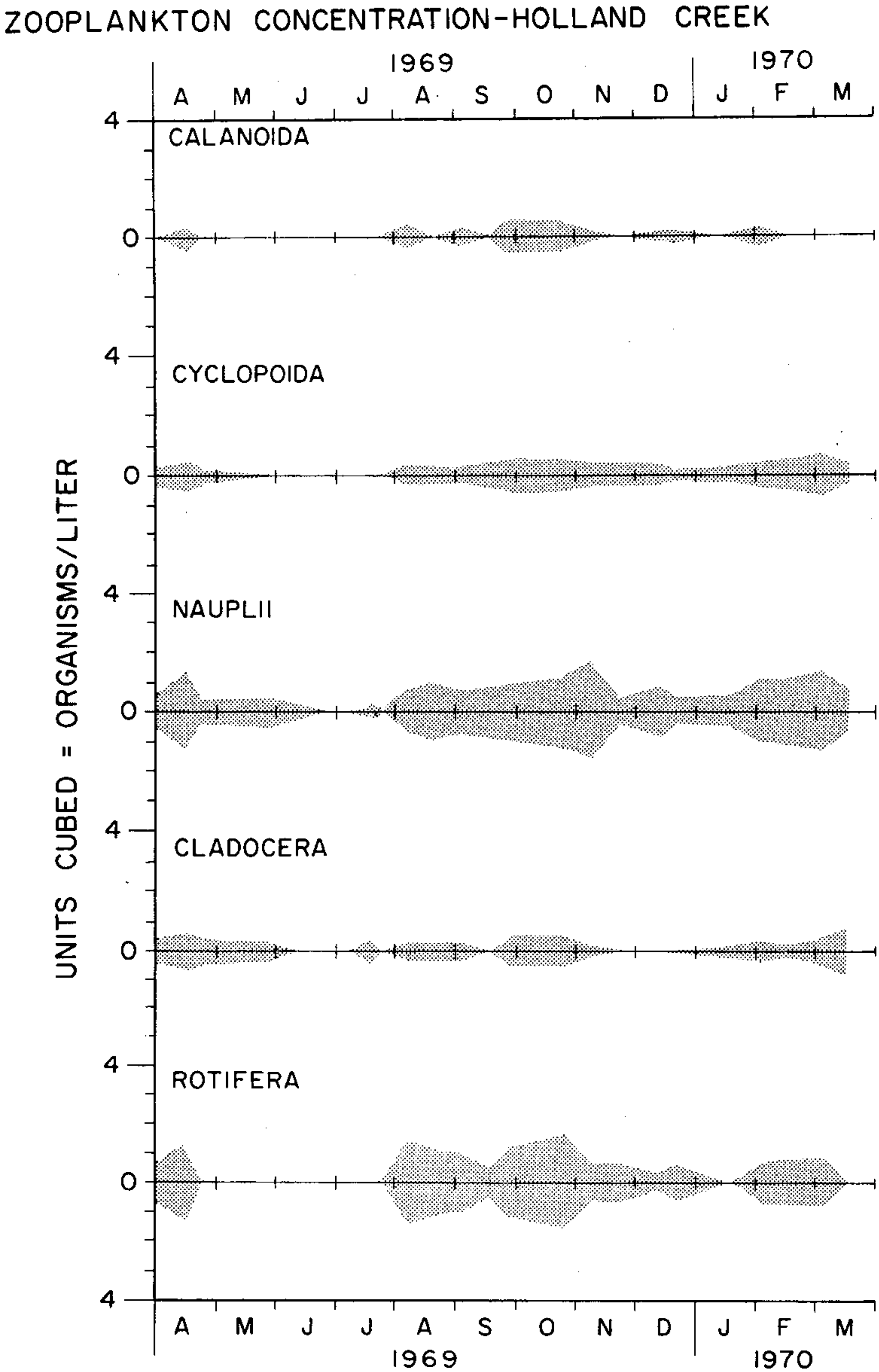

ZOOPLANKTON CONCENTRATION-HOLLAND CREEK
1969
1970
A M J J A S O N D J F M
CALANOIDA
CYCLOPOIDA
NAUPLII
CLADOCERA
ROTIFERA
UNITS CUBED = ORGANISMS/LITER
4
0
A M J J A S O N D J F M
1969
1970

Figure 105

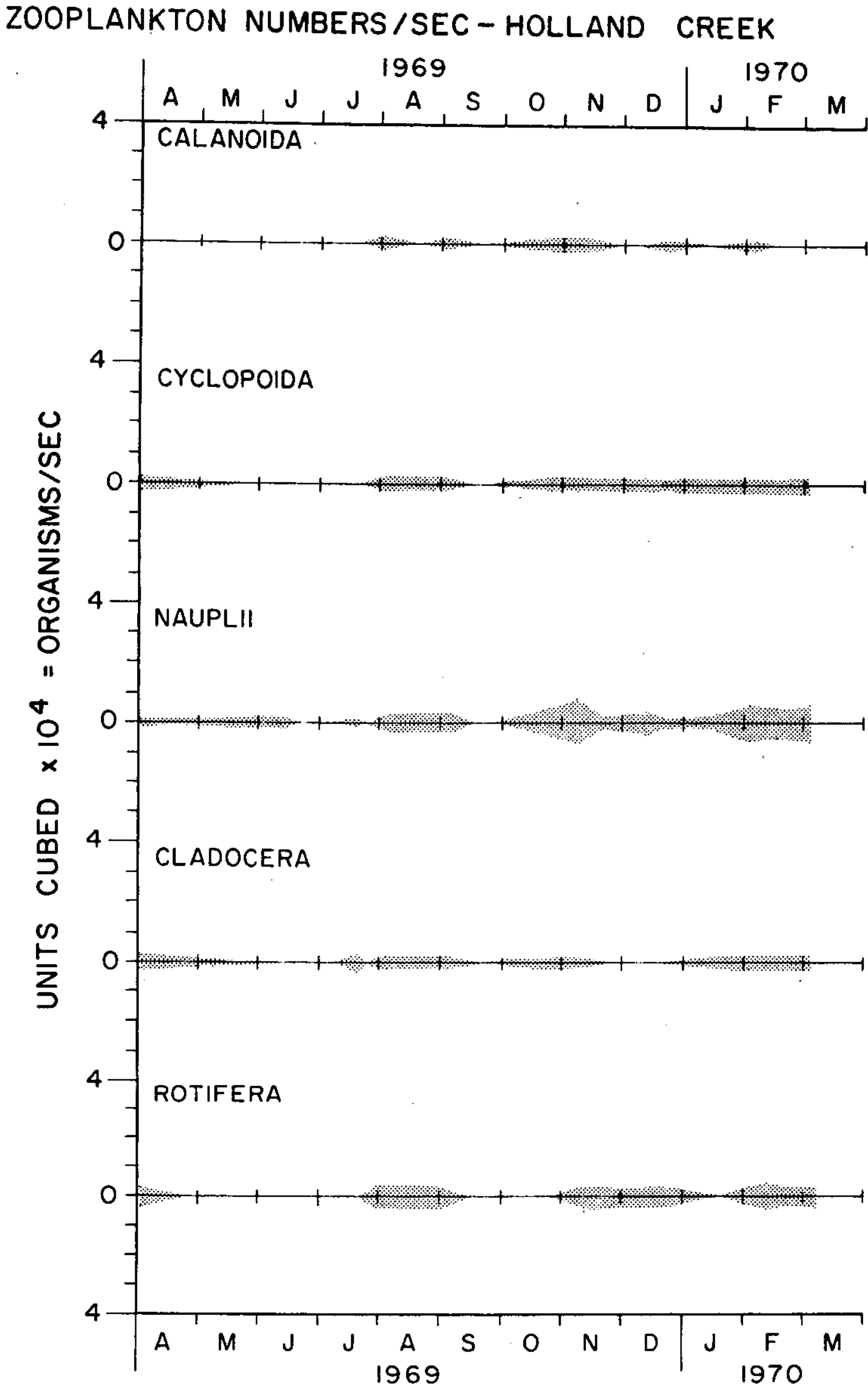

ZOOPLANKTON NUMBERS/SEC - HOLLAND CREEK
1969
1970
A
M
J
J
A
S
O
N
D
J
F
M
CALANOIDA
CYCLOPOIDA
NAUPLII
CLADOCERA
ROTIFERA
4
0
UNITS CUBED x 10^4 = ORGANISMS/SEC

Figure 106

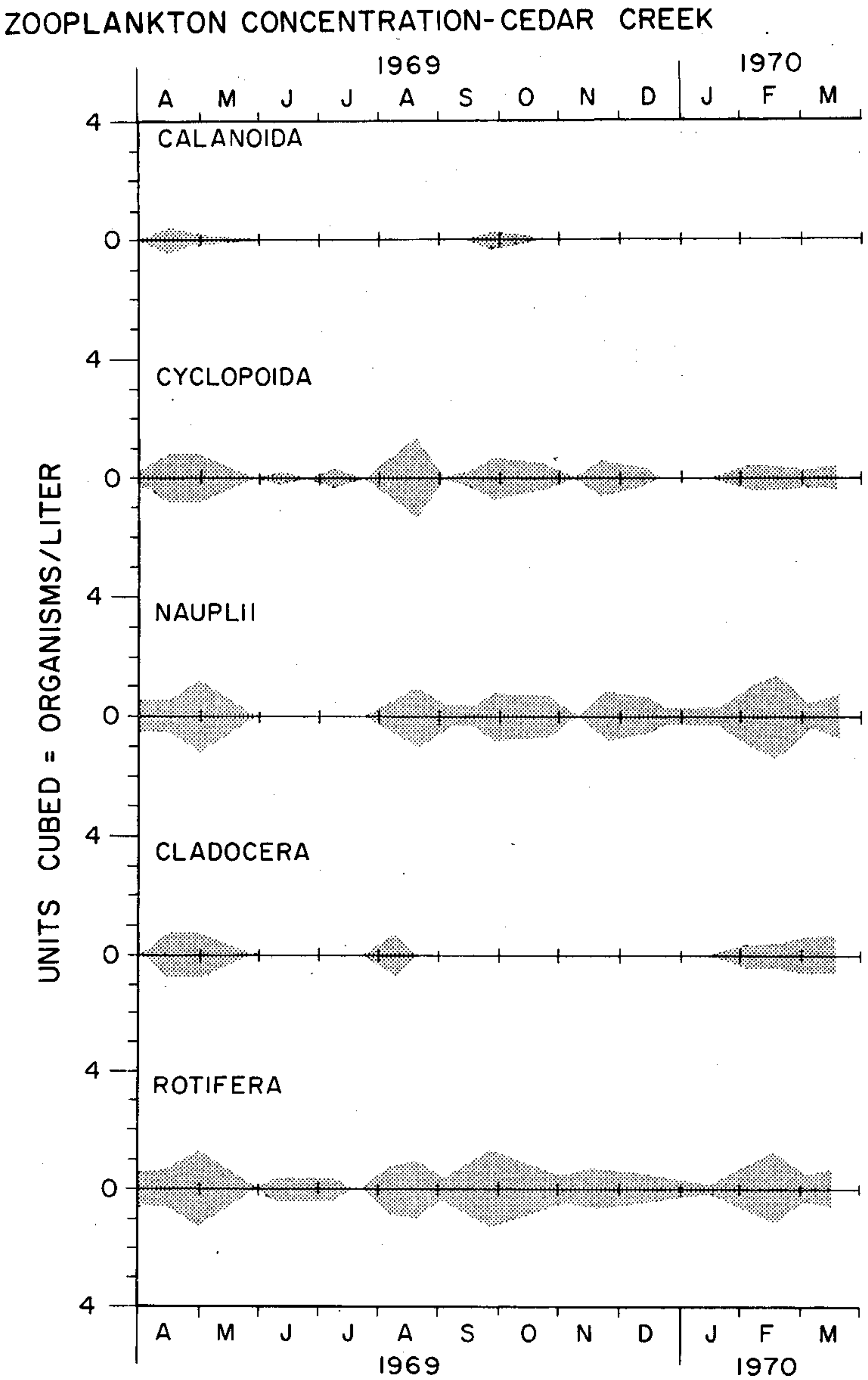

ZOOPLANKTON CONCENTRATION-CEDAR CREEK
1969
1970
A M J J A S O N D J F M
CALANOIDA
CYCLOPOIDA
NAUPLII
CLADOCERA
ROTIFERA
4
0
UNITS CUBED = ORGANISMS/LITER

Figure 107

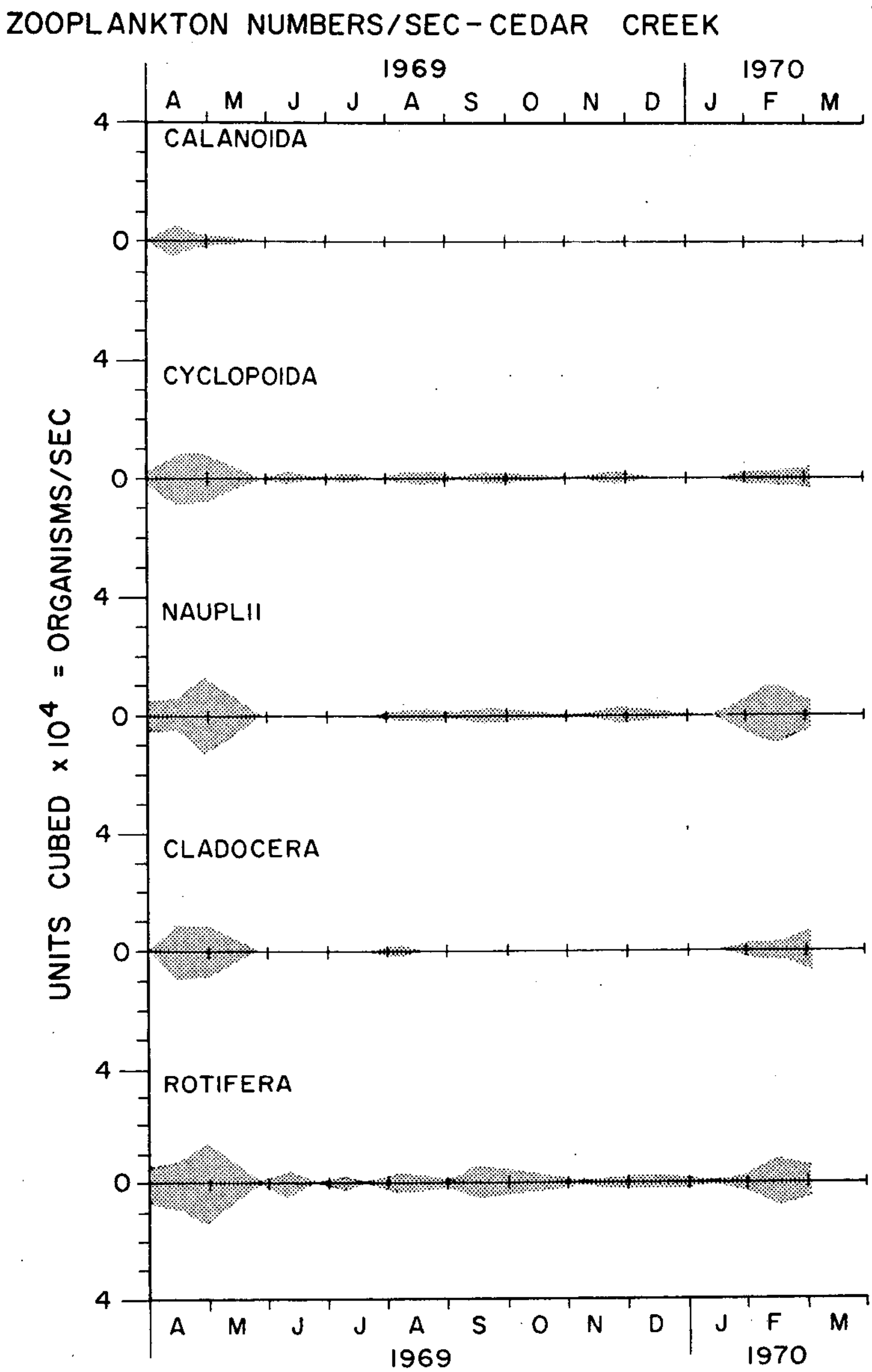

ZOOPLANKTON NUMBERS/SEC-CEDAR CREEK
1969
1970
A M J J A S O N D J F M
CALANOIDA
CYCLOPOIDA
NAUPLII
CLADOCERA
ROTIFERA
4
0
UNITS CUBED x 10^4 = ORGANISMS/SEC

Figure 108

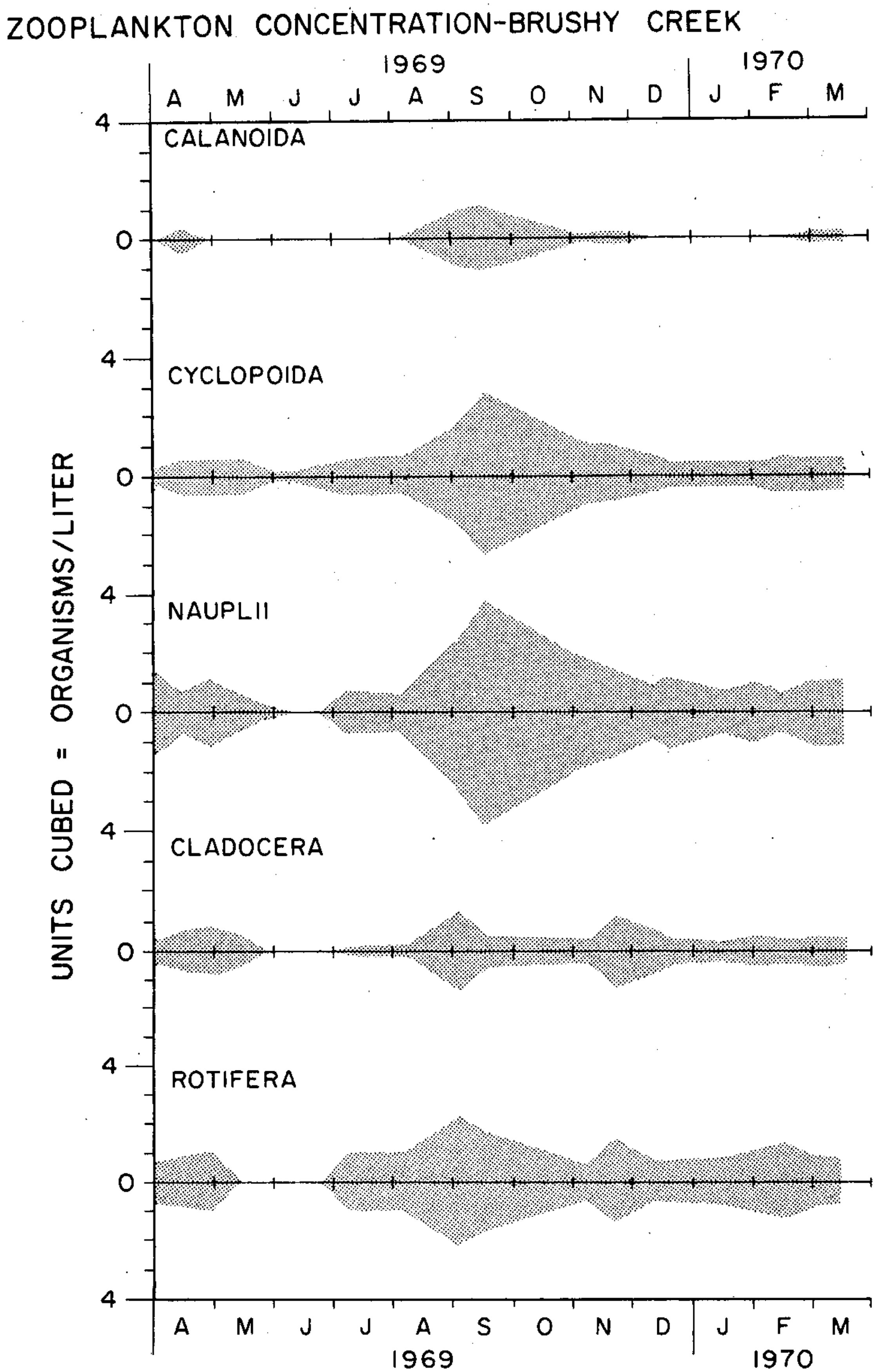

ZOOPLANKTON CONCENTRATION-BRUSHY CREEK
1969
1970
A M J J A S O N D J F M
4
CALANOIDA
0
4
CYCLOPOIDA
0
4
NAUPLII
0
4
CLADOCERA
0
4
ROTIFERA
0
4
UNITS CUBED = ORGANISMS/LITER
A M J J A S O N D J F M
1969
1970

Figure 109

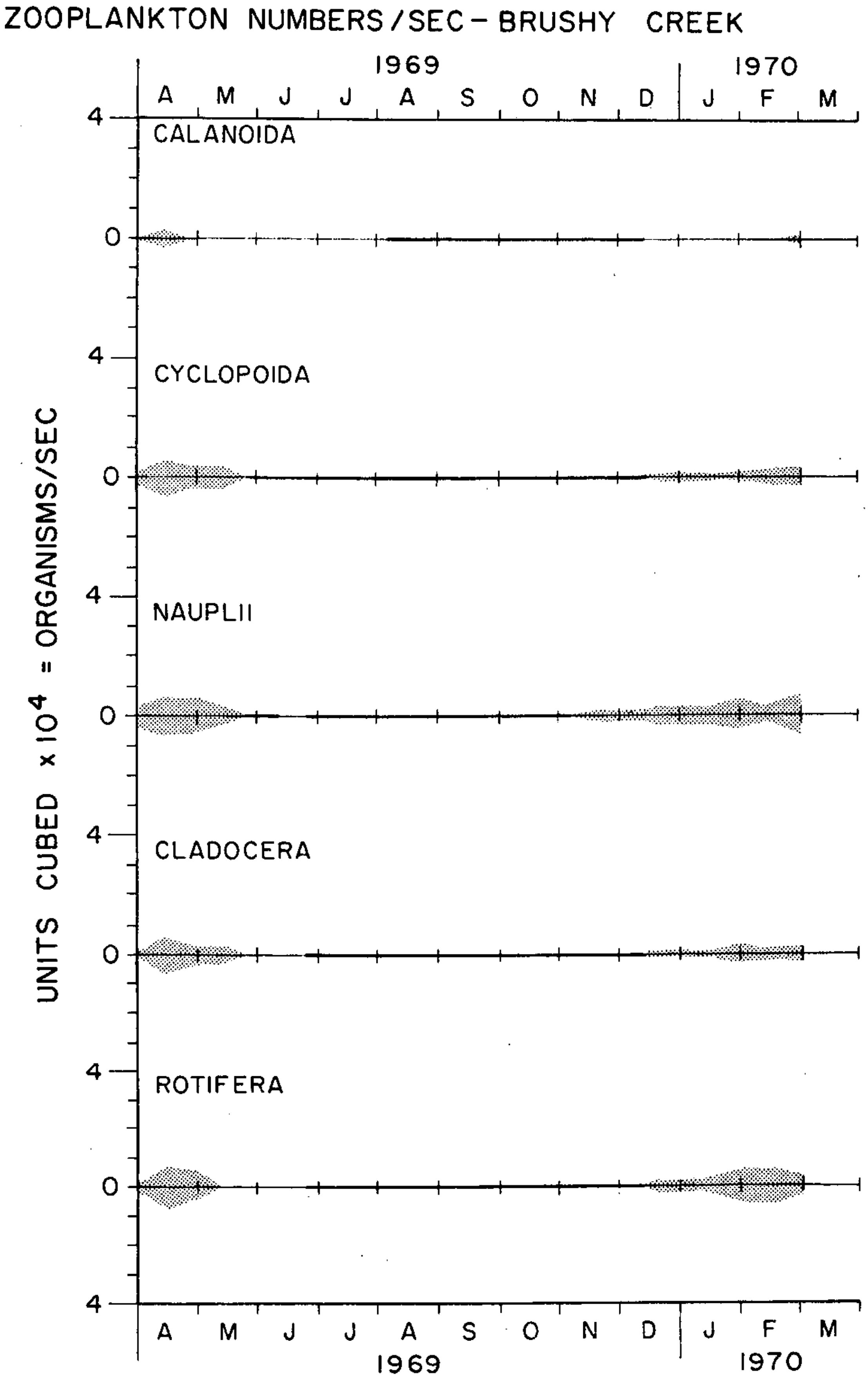

ZOOPLANKTON NUMBERS/SEC - BRUSHY CREEK
1969
1970
A
M
J
J
A
S
O
N
D
J
F
M
CALANOIDA
CYCLOPOIDA
NAUPLII
CLADOCERA
ROTIFERA
4
0
UNITS CUBED x 10^4 = ORGANISMS/SEC

Figure 110

channel. This is reflected in the general downstream decrease at the main channel stations in both concentration and numbers.

The seasonal pattern is obscure, maxima and minima did not occur at the same time for the two years.

B. Copepoda

In general, abundance patterns followed those of the rotifers, with the late winter and spring maximum of 1969 reflected in most stations. Nauplii were widely distributed, calanoid forms were less abundant than cyclopoid, concentrations were higher in quiet water situations such as Station 4 and Brushy Creek, the tributaries sampled contributed small numbers to the main channel, and there was a general downstream decrease in numbers at the main channel stations.

C. Cladocera

With Station 4 excluded the Cladocera do not show the downstream decrease in concentration shown by the other zooplankton. Station 1 has significant concentrations, and the highest peak numbers. The tributaries show maxima generally corresponding to those in the lower river, and could have contributed significantly to the main channel population, but it is doubtful that they were responsible for the April, 1969, pulse at Station 1, this must have been a main channel reaction.

Since patterns of physical and chemical conditions are erratic from year to year it is unreasonable to expect the biological patterns to be otherwise.

This means that many years data would be necessary to permit a meaningful analysis of relationships between the biological populations and environmental conditions. No single years data in a river such as this is either representative or adequate. Short term studies permit only the most general conclusions to be drawn.

Fishes

The first years data on the fishes has been reported on in a preliminary report (Rozenburg, Strawn & Clark 1972).

The basic conclusions of that report have not been modified by the additional years collecting, and those conclusions are quoted at the end of this section.

One identification has been changed. The fish reported as Erimyzon oblongus, creek chubsucker, in the intrim report has been found to be E. sucetta, lake chubsucker. The Percina sp. has been found to be P. macrolepida.

Two additional species have been collected; Roccus chrysops (Morone chrysops) - white bass and Notropis oxyrhynchus - sharpnose shiner.

The data presented here are the combined data for both collecting years. A list of the fishes with reference numbers is given in Table 18.

The data are presented in Table 19 according to an East-West division of the watershed. "East" includes all collections from tributaries on the east side of the watershed at locations above the floodplain. "Floodplain" includes collections from all tributaries, east and west, from sites within the floodplain. "Channel" includes only collections from the main river channel. "West" includes all collections on tributaries on the west side of the channel from sites above the floodplain.

Table 20 presents the data divided according to the three north-south zones as previously defined.

Table 21 presents the data by bottom type.

Collection locations and descriptions are given in Table 22.

Collection locations are shown by number in Figures 111, 112, 113; and distribution data by species are shown in Figures 114 through 148.

Parasites

Some parasite data were collected during the project (Table 22). Other parasite data can be found in Allison 1964, 1967; Allison and McGraw 1967; Brown 1940; McGraw 1964 and Slagle 1966.

The following summary is quoted from the interim report (Rozenburg, Strawn and Clark 1972)

> The fauna of the Navasota River drainage is different from that of other parts of the Brazos River drainage. It contains some components found only in Austroriparian drainages, while components found commonly in the Brazos and Colorado drainages are absent or found rarely in scattered localities in the Navasota River drainage. The western limits of several fishes are at or near the Navasota drainage. This caused Knapp (1953) to conclude that the Navasota fauna should be discussed with more eastern drainages rather than with the rest of the Brazos. These fishes, he believed, are present due to immigration from the north and east and the muddy waters of the Brazos keeps these eastern fishes confined to the Navasota drainage.
>
> Knapp's ideas concerning this difference in faunas are supported in part by Darlington's idea (1957) that the fish fauna of a region of transition between two biotic provinces will show progressive additions and subtractions from each fauna as the transitory region is crossed. The Navasota River as mentioned in the introduction, is located in such a region. Generally, those fishes associated with more eastern or Austroriparian streams thin out or disappear from collections toward the western boundary of the drainage. The number of species is most numerous in the southeast drainage and channel. The fewest species occur in the northwestern part of the Navasota drainage where it drains part of the Blackland Prairie.

Another hypothesis to explain the eastern affinities of the Navasota fish fauna would involve stream piracy. Stream piracy occurs when the headwaters of one stream system "pirates" or "captures" the headwaters of an adjacent stream system by headward erosion of its channel into the channels of the adjacent drainages. The Navasota drainage is the sort of area where stream piracy can easily occur.

Dr. Alan Lohse, of the geology department, of the University of Houston, has informed us that the U.S.G.S. topographic sheets of this region indicate headwater erosion by the tributary streams of the Navasota River along an escarpment, the Kisatchie Bajada. He says there are several apparent "wind gaps" along the eastern limits of the drainage. These "gaps" indicate capture by the Navasota of tributaries of the San Jacinto and Trinity tributaries (personal communication). Fishes in these captured headwaters could have spread through the capturing streams to other streams in the Navasota drainage in times of high water and flooding.

Possible Changes in the Navasota River Fish Fauna as a Result of the Proposed Impoundments

The building of the proposed dams and the resultant reservoirs is certain to cause some changes in the local fish fauna. Populations of riffle-dwelling and other lotic fishes will suffer as the reservoir fills and flowing streams are replaced by lakes. Many gravel-riffles and sandbar areas will be either inundated or destroyed by construction. Fishes such as *Percina sciera* which frequent these riffle areas face probable extermination in this area. Population of several smaller fishes such as *Notripis fumeus*, *N. shumardi*, *N. buchanani*, *Hybognathus nuchalis*, *Noturus gyrinus*, *Etheostoma chlorosomum*, and *E. gracile* which were found almost exclusively in lotic habitats, will probably suffer.

Alterations of the river channel below the dam at river mile 24.1 may alter the Holland-Spring Creek drainage and may cause the disappearance of the most southeastern population of *Campostoma anomalum* recorded from Texas.

The most abundant species in gill net sets in Lake Springield were *Dorosomum cepedianum*, *Pomoxis annularis*, and *Ictiobus bubalus* in that order. *Lepomis megalotis*, *L. humilis*, and *L. macrochirus* all were very numerous in seine collections. *L. megalotis* was especially common in shallow water during breeding season. The only darter taken in Lake Springfield was the undescribed logperch which apparently readily adapts to a lentic environment. *Micropterus salmoides* and *Aplodinotus grunniens* were also common in this reservoir.

It is therefore probable that these latter species will become more numerous as the species less well adapted to a lentic environment disappear from areas flooded by the filling of the reservoir. The resulting reservoir will probably develop a large population of ictalurids and centrarchids which are widely sought by fishermen. As the lakes mature the fauna will also develop large populations of various species of *Lepisosteus*, as well as *Cyprinus carpio* and *Ictiobus bubalus* which are common in large reservoirs in this area.

Table 18

A List of Fishes Taken from the
Navasota River, Texas, with Reference Numbers

Scientific Names	Common Names
1. Amia calva	Bowfin
2. Lepisosteus spatula	Alligator gar
3. L. oculatus	Spotted gar
L. productus	
4. L. osseus	Longnose gar
5. Dorosoma cepedianum	Gizzard shad
6. D. petenense	Threadfin shad
7. Esox americanus	Redfin pickerel
8. Cyprinus carpio	Carp
9. Notemigonus crysoleucas	Golden shiner
10. Opsopoeodus emiliae	Pugnose minnow
Notropis emiliae	
11. Notropis fumeus	Ribbon shiner
12. N. shumardi	Silverband shiner
13. N. lutrensis	Red shiner
14. N. venustus	Blacktail shiner
15. N. oxyrhynchus	Sharpnose shiner
16. N. atrocaudalis	Blackspot shiner
17. N. buchanani	Ghost shiner
18. Hybognathus nuchalis	Silvery minnow
19. Pimephales vigilax	Bullhead minnow
20. P. promelas	Bluntnose minnow
21. Campostoma anomalum	Stoneroller
22. Ictiobus niger	Black buffalo fish
23. I. bubalus	Smallmouth buffalo fish
24. Carpiodes carpio	River carpsucker
25. Minytrema melanops	Spotted sucker
26. Erimyzon sucetta	Lake chubsucker
called E. oblongus in Interim	
27. Ictalurus punctatus	Channel catfish
28. I. furcatus	Blue catfish
29. I. melas	Black bullhead
30. I. natalis	Yellow bullhead
31. Pylodictis olivaris	Flathead catfish
32. Noturus gyrinus	Tadpole madtom
33. Aphredoderus sayanus	Pirateperch
34. Fundulus notti	Starhead top minnow
35. F. notatus	Black stripe top minnow
36. F. olivaceus	Black spotted top minnow
37. Gambusia affinis	Mosquito fish
38. Roccus chrysops	White bass
Morone chrysops	

Table 18. Continued

Scientific Names	Common Names
39. Micropterus salmoides	Largemouth bass
40. M. punctulatus	Spotted bass
41. Chaenobryttus gulosus Lepomis gulosus	Warmouth sunfish
42. Lepomis cyanellus	Green sunfish
43. L. symmetricus	Bantam sunfish
44. L. punctatus	Spotted sunfish
45. L. microlophus	Redear sunfish
46. L. marginatus	Dollar sunfish
47. L. megalotis	Longear sunfish
48. L. humilis	Orange spotted sunfish
49. L. macrochirus	Bluegill sunfish
50. Pomoxis nigromaculatus	Black crappie
51. P. annularis	White crappie
52. Elassoma zonatum	Banded pigmy sunfish
53. Percina sciera	Dusky darter
54. P. macrolepida	Logperch
55. Etheostoma chlorosomum	Bluntnose darter
56. Etheostoma parvipinne	Goldstripe darter
57. Etheostoma gracile	Slough darter
58. Aplodinotus grunniens	Freshwater drum

Table 19

East-West Occurrence of Fish Species in the Navasota River Drainage Presented as Number of Specimens Collected.

Species No.	East	Floodplain	Channel	West
1.	---	5	1	---
2.	---	12	5	2
3.	1	27	25	3
4.	---	6	---	---
5.	12	153	578	47
6.	---	56	26	---
7.	50	8	2	32
8.	40	70	136	40
9.	316	67	171	312
10.	104	80	597	133
11.	815	58	475	967
12.	---	---	79	---
13.	2455	38	4738	1044
14.	142	---	19	377
15.	---	---	6	---
16.	168	---	---	500
17.	---	---	101	5
18.	565	20	66	566
19.	317	5	692	69
20.	---	---	---	1
21.	252	---	---	23
22.	---	---	1	---
23.	2	24	14	1
24.	12	16	20	11
25.	13	---	5	13
26.	4	---	---	3
27.	22	18	100	8
28.	---	---	3	---
29.	198	108	351	152
30.	2	45	102	17
31.	1	62	12	---
32.	94	14	13	12
33.	53	41	2	28
34.	100	---	---	---
35.	12	2	2	4
36.	658	115	174	820
37.	3849	1246	3903	1513
38.	---	---	1	---
39.	167	20	140	87
40.	4	---	6	7
41.	180	120	91	145

Table 19. Continued

Species No.	East	Floodplain	Channel	West
42.	628	52	203	358
43.	14	---	---	1
44.	13	---	---	3
45.	69	3	7	28
46.	---	---	---	2
47.	442	65	326	349
48.	11	86	183	64
49.	683	585	297	754
50.	---	13	2	1
51.	151	336	300	111
52.	20	1	---	---
53.	35	---	56	52
54.	---	---	6	14
55.	51	12	104	50
56.	3	---	---	16
57.	129	21	52	182
58.	---	1	13	---

Table 20

North-South Occurrence of Fish Species in the Navasota River Drainage Presented as Number of Specimens Collected.

Species No.	Lower	Middle	Upper
1.	6	---	---
2.	19	---	---
3.	49	4	3
4.	4	---	---
5.	353	24	386
6.	80	---	---
7.	28	64	---
8.	251	44	11
9.	603	77	186
10.	815	75	24
11.	1253	903	153
12.	59	---	---
13.	6976	407	892
14.	46	490	5
15.	6	---	---
16.	153	511	34
17.	106	---	---
18.	704	20	---
19.	811	200	126
20.	1	---	---
21.	252	22	---
22.	---	---	1
23.	28	1	12
24.	55	3	1
25.	14	16	---
26.	---	6	---
27.	99	18	30
28.	3	---	---
29.	324	148	337
30.	96	---	70
31.	75	1	---
32.	77	39	16
33.	51	66	7
34.	---	100	---
35.	15	5	1
36.	658	927	236
37.	7901	851	1805
38.	1	---	---
39.	164	92	192
40.	6	9	---
41.	311	125	89

Table 20. Continued

Species No.	Lower	Middle	Upper
42.	667	265	309
43.	1	14	---
44.	3	12	1
45.	5	64	10
46.	2	---	---
47.	718	378	188
48.	195	38	119
49.	1292	583	494
50.	14	---	2
51.	590	121	187
52.	10	5	6
53.	52	61	1
54.	9	---	11
55.	141	37	16
56.	---	19	---
57.	175	153	56
58.	10	---	4

Table 21

Occurrence of Fish Species in the Navasota River Drainage by Bottom Type Presented as Number of Specimens Collected.

Species No.	Mud	Mud & Sand	Sand	Sand & Gravel	Bedrock
1.	6	---	---	---	---
2.	8	---	2	9	---
3.	33	3	2	18	21
4.	6	---	---	---	---
5.	239	40	41	340	21
6.	56	---	22	2	---
7.	37	1	45	9	---
8.	167	19	51	69	---
9.	409	111	129	172	45
10.	462	33	144	265	---
11.	26	55	1351	883	4
12.	19	60	---	---	---
13.	891	1821	1675	3660	228
14.	---	---	388	180	---
15.	---	---	6	---	---
16.	1	5	363	284	15
17.	28	---	66	12	---
18.	97	78	517	489	37
19.	39	175	312	514	43
20.	1	---	---	---	---
21.	---	---	55	198	21
22.	1	---	---	---	---
23.	34	---	2	5	---
24.	33	7	8	10	1
25.	1	4	10	15	1
26.	7	---	---	---	---
27.	73	6	15	54	---
28.	1	---	1	1	---
29.	629	60	59	60	1
30.	103	---	---	63	---
31.	65	---	1	9	---
32.	25	8	1	99	---
33.	95	14	8	7	---
34.	14	---	86	---	---
35.	2	---	1	17	---
36.	187	61	1039	480	---
37.	4903	2150	1156	2180	122
38.	---	---	1	---	---
39.	172	106	51	81	4
40.	6	---	7	4	---
41.	387	47	22	80	---

Table 21. Continued

Species No.	Mud	Mud & Sand	Sand	Sand & Gravel	Bedrock
42.	448	50	499	219	15
43.	6	1	8	---	---
44.	14	---	2	---	---
45.	69	8	18	12	---
46.	---	2	---	---	---
47.	190	62	519	411	---
48.	179	47	54	62	2
49.	1204	300	435	360	20
50.	15	1	---	---	---
51.	525	150	104	116	3
52.	3	15	3	---	---
53.	---	5	45	93	---
54.	3	---	---	17	---
55.	60	2	59	96	---
56.	---	---	---	19	---
57.	140	28	79	137	---
58.	13	---	---	1	---

Table 22

Fish Collection Sites, Navasota River Drainage

Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
1. Navasota R. 2/10 mi above mouth	Brazos Grimes	96-10-50 30-20-0	sand-mud	5	8/6/70	8
2. Navasota R. 2 mi S Texas 90	Brazos Grimes	96-08-54 30-23-43	sand-mud	12	7/29/67	10
3. Navasota R. on Texas 90	Brazos Grimes	96-08-30 30-22-00	sandstone and sand	12	7/28/67 7/28/68 1/30/69 8/6/70	22
4. Navasota R. on Texas 6	Brazos Grimes	96-06-24 30-25-05	mud	12	7/28/67 10/3/67 1/30/69 7/18/69	7
5. Pothole aside locality 3	Brazos	96-06-24 30-25-05	mud	--	7/17/68	7
6. Borrow pit on Texas 6, 3 mi N of Navasota	Brazos	96-06-36 30-25-36	mud	--	10/31/67 3/17/68 3/22/68	11
7. Holland Creek, mouth, 2 1/2 mi N of Navasota	Grimes	96-05-12 30-26-10	mud	10	9/10/68 1/30/69 5/14/70	20

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
8.	Holland Creek, 3 1/2 mi N of Navasota on FM 244	Grimes	96-03-44 30-26-12	sand, sand-mud	10	1/30/69 7/18/69 10/14/70	20
9.	Spring Creek on Texas 90	Grimes	96-02-24 30-23-54	sand, gravel, bedrock	25	12/2/67 1/13/68 3/2/68 6/4/68 8/28/68 1/30/69 2/17/69 6/13/69 6/17/69 2/12/70 9/23/70	20
10.	Branch of Spring Creek, Purvis Ranch, 3/4 mi S Texas 90	Grimes	96-01-54 30-25-38	sand, rock	25	6/4/68 6/10/69 6/17/69	6
11.	Spring Creek 1 mi s Texas 90	Grimes	96-01-30 30-25-50	rock	24	3/2/68 6/4/68 6/10/69 6/11/69 6/18/69	11
12.	Thomas Creek, low water crossing, 2 mi S Anderson	Grimes	96-00-03 30-26-55	mud	17	3/3/68 6/18/69	4
13.	Upshur Branch on FM 2154, 1 1/2 mi S Millican	Brazos	96-10-30 30-37-11	sand	27	7/17/68	9

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
14.	Branch of Turkey Creek, 4 1/4 mi N of Navasota on dirt road	Grimes	96-05-20 30-27-50	sand, gravel	50	5/14/70	1
15.	Honey Creek on Texas 90	Grimes	96-00-28 30-28-16	sand	28	12/2/67 5/14/70	6
16.	Holland Creek on dirt road 1 1/2 mi S of Anderson	Grimes	95-54-30 30-23-06	sand	20	7/18/69 1/24/70 1/26/70 10/14/70	12
17.	Holland Creek on FM 1774 1 1/4 mi SE of Anderson	Grimes	95-52-55 30-24-18	sand-mud, mud	20	7/18/69 7/19/69	5
18.	Branch of Turkey Creek 6 mi N Navasota, 1 mi S FM 244	Grimes	96-05-52 30-05-08	sand, mud	15	1/13/68	8
19.	Honey Creek 1 1/2 mi W Anderson on FM 149	Grimes	96-00-28 30-29-33	sand	35	6/19/68 5/14/70	5
20.	Nebbits Creek on FM 149, E Anderson	Grimes	95-58-24 30-29-53	sand	35	6/19/68	5
21.	Rocky Creek 5 mi N Anderson on FM 244	Grimes	96-05-54 30-30-34	mud	6	12/2/67 12/2/69 5/14/70 10/14/70	20
22.	Rocky Creek 3.8 mi N Anderson	Grimes	96-00-01 30-30-34	mud	11	12/2/67	10

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
23.	Pine Creek N Anderson	Grimes	96-00-18 30-30-55	sand	36	6/6/68 4/3/69	5
24.	Branch of Rocky Creek, 2 4/10 mi SW of Roans Prairie on HWY 90	Grimes	95-57-50 30-33-15	sand	40	8/28/68	6
25.	Peach Creek on Texas 6, 6 mi S College Station	Brazos	96-12-18 30-30-54	sand	17	7/17/68 4/7/70	17
26.	Peach Creek, 1/2 mi N of Hwy 6 at Millican cut-off	Brazos	96-11-55 30-30-58	sand	15	4/7/70	3
27.	Rocky Creek 1 mi S Roans Prairie on Texas 90	Grimes	95-56-54 30-34-29	sand	30	4/26/68	10
28.	Branch of Lick Creek at Hwy 6	Brazos	96-16-21 30-34-23	sand, bed-rock	15	4/7/70	3
29.	Lick Creek 3 1/2 mi N of Hwy 6 at Millican cut-off	Brazos	96-11-09 30-33-08	sand-mud, gravel	15	4/7/70	11
30.	Potholes at Sulphur Springs	Brazos Grimes	96-10-00 30-34-14	mud	--	3/3/68 6/19/68 7/9/68 4/3/69 9/27/69 8/20/70	30
31.	Gibbons Creek 1 mi S Carlos on FM 244	Grimes	96-03-55 30-34-12	mud, sand	7	12/2/67 9/10/68 10/7/70	12

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
32.	Gibbons Creek at Hwy 30	Grimes	96-03-51 30-35-38	sand, sand-mud	10	9/10/68 5/4/70 10/7/70	13
33.	Navasota R., Sulphur Springs 12 mi S College Station	Brazos Grimes	96-05-50 30-35-55	mud, sand, gravel	12	5/24/67 7/29/67 11/3/67 3/22/68 6/19/68 6/27/68 7/19/68 7/30/68 10/3/68 4/3/69 9/27/69 8/20/70	33
34.	Spring Creek on Hwy 6, 6 mi S College Station	Brazos	96-15-42 30-34-00	mud, sand	17.5	3/23/68 4/7/70	11
35.	Navasota R., just above mouth of Carters Creek	Brazos	96-10-15 30-24-50	sand, sand-mud, mud	12	10/3/68 9/27/69	22
36.	Rock Lake Creek 1 mi W Carlos on Texas 30	Grimes	96-10-00 30-35-55	bedrock	25	10/27/67	3
37.	Sulphur Creek 2.7 mi N Roans Prairie on Texas 90	Grimes	95-57-18 30-38-12	sand, mud	15	4/26/68	6
38.	Pothole by Navasota R. at Texas 30	Brazos	96-10-42 30-36-25	mud	--	10/27/67	9

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
39.	Navasota R. at Texas 30, 8 mi N Carlos	Grimes	96-10-42 30-36-22	mud	12	10/27/67 4/3/69 10/27/69	11
40.	Cat Creek on Texas 90, 1 mi N Singleton	Grimes	95-57-35 30-39-46	sand, gravel	37	6/20/68 8/28/68	13
41.	Small borrow pit near Carter's Creek on Lake Placid Road, 6 mi E College Station	Brazos	96-15-03 30-35-54	mud	--	10/17/67 4/7/70	10
42.	Hog Creek off FM 244	Grimes	95-05-30 30-28-42	sand	13.5	6/20/68	11
43.	Pond on Bee Creek in the edge of College Station, Texas	Brazos	96-19-17 30-36-18	mud	10	4/7/70	1
44.	Branch of Hog Creek 1 7/10 mi N of Keith, Texas on FM 244	Grimes	96-05-58 30-40-20	mud	25	10/7/70	1
45.	Country Club Lake on South College Ave., Bryan	Brazos	95-21-36 30-38-38	mud	18	7/4/68 4/16/70	7
46.	Wickson Creek 5 mi E on Weedon Road	Brazos	96-13-00 30-41-46	sand, mud	13	11/2/67	11
47.	Bull Creek on dirt road 1 4/10 mi E of Channey Crossing on the Navasota R.	Grimes	96-08-51 30-42-49	mud	15	10/7/70	6
48.	Bull Creek 10 mi N Carlos	Grimes	96-05-00 30-44-00	mud, sand	17	6/19/68	7

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
49.	Carter's Creek by Junction off FM 158 and FM 1179	Brazos	96-19-13 30-40-11	mud	15	7/4/68 4/7/70 4/16/70	14
50.	Old River channels Navasota R. at Democrat's Crossing	Brazos Grimes	96-10-30 30-40-16	mud	12	10/27/67 8/19/69 8/30/70	8
51.	Wickson Creek and slough 1/4 mi off FM 1179, 8 mi E Bryan	Brazos	96-15-00 30-43-16	sand, mud	13	1/6/68 7/15/69 4/16/70	21
52.	Bowman Creek on FM 1179, 10 mi E Bryan	Brazos	96-13-54 30-44-54	mud-under culvert	17.8	1/6/68 7/15/69 4/16/70	12
53.	Wickson Creek on U.S. 190, 6 mi NE Bryan	Brazos	96-18-54 30-44-39	sand, mud	17.5	3/8/68	2
54.	Mathis Creek at U.S. 190, 7 mi NE Bryan	Brazos	96-17-45 30-45-25	mud	15	3/8/68	1
55.	Navasota R. on dirt road 5 mi below Hwy 21	Brazos Grimes	96-10-31 30-48-40	sand, sand-mud	10	8/19/69 4/16/70 8/20/70	10
56.	Mathis Creek FM 974	Brazos	96-20-06 30-40-27	mud	15	11/3/67	12
57.	Cedar Creek at U.S. 190, NE Bryan	Brazos	96-12-52 30-49-59	sand gravel	11	3/8/68 1/30/69	26

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
						7/15/69 6/11/70 9/23/70	
58.	Slough off Old Cedar Creek 400 yards E Locality #57	Brazos	96-12-52 30-49-59	mud	--	3/8/68	7
59.	Navasota R. at U.S. 190 near Easterly	Brazos Grimes	96-11-24 30-52-11	mud	12	8/4/67 2/23/68 7/15/69 6/11/70	14
60.	Spark Creek at FM 974	Brazos	96-18-38 30-51-56	mud	15	11/3/67	10
61.	Shepherd Creek at Hwy 21 3 mi SW of North Zulch, Texas	Madison	96-09-13 30-53-36	sand-mud, mud	10	4/16/70	2
62.	Cedar Creek, 1 1/10 mi SW of Edge, Texas on FM 974	Brazos	96-18-16 30-52-37	sand, mud	5	1/30/69	8
63.	Navasota R. at Twin Lake Ranch	Madison	96-12-42 30-54-38	mud	12	7/23/68	17
64.	(a) Pothole on Twin Lake Ranch	Madison	96-11-45 30-55-15	mud	--	7/23/68	25
	(b) Sassafras Lake on Twin Lake Ranch	Madison	96-12-00 30-55-00	mud	--	7/23/68	10
	(c) Bog on Twin Lake Ranch	Madison	96-12-42 30-54-38	mud	--	9/31/68	2
	(d) Twin Lake on Twin Lake Ranch	Madison	96-12-48 30-55-10	mud detritus	--	8/1/68	14

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
65.	Tributary of Sand Branch, 3 mi W of North Zulch, Texas on dirt road	Madison	96-09-50 30-54-50	sand, sand-mud	20	4/16/70	2
66.	Cedar Creek on OSR near Wheelock	Robert.	96-21-30 30-54-11	sand	11	11/4/67 12/16/67 2/18/69 6/14/69 7/15/69 6/11/70 10/24/70	18
67.	Little Cedar Creek at FM 974	Brazos	96-16-00 30-35-38	sand	15	11/3/67	8
68.	Cedar Creek, 3/4 mi N of OSR on dirt road	Robert.	96-21-53 30-54-22	sand	10	1/30/69	2
69.	Caney Creek on dirt road 2 mi S of OSR	Madison	96-11-43 30-57-55	sand	20	4/16/70	7
70.	Caney Creek on dirt road 1 1/2 mi S of OSR	Madison	96-10-37 30-58-39	sand, gravel	25-30	4/6/70	1
71.	(a) Navasota R. at OSR	Brazos Madison Robert. Leon	96-14-30 30-58-33	sand, mud	12	8/5/67 12/16/67 7/16/69 6/11/70	18
	(b) Navasota R. overflow beside # 71	Brazos	96-14-30 30-58-33	mud	12	11/4/67	2

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
	(c) Pothole beside Navasota R. at #71	Brazos	96-14-30 30-58-33	mud	--	12/16/67	5
72.	Devil's Jump Creek at FM 1946, 2 mi N OSR	Robert.	96-17-01 30-55-52	sand, gravel	34	2/9/68 9/19/68 3/19/70 10/24/70	13
73.	Running Creek below Normangee City Lake	Leon	96-12-24 31-01-16	sand	16.5	5/4/68	3
74.	Beneath culvert 2.1 mi N locality #72 on FM 1947	Robert.	96-18-02 31-00-36	sand, gravel	34	2/9/68	9
75.	Normangee City Lake	Leon	96-12-24 31-01-16	mud	--	5/3/68 5/10/68	13
76.	Cedar Creek, second crossing at FM 46 below Franklin	Robert	96-26-09 31-58-47	sand, gravel	23	12/16/67 5/11/68 7/28/69 2/19/70 7/23/70	18
77.	Branch of Cobb Creek on FM 1940	Robert.	96-19-50 31-03-36	sand, gravel	35	12/16/68	6
78.	Running Creek on FM 3	Leon	96-14-20 31-00-36	sand	16.5	2/23/68 5/3/68	15
79.	Cedar Creek at FM 46, 1 mi S of Franklin, Texas	Robert.	96-27-30 31-00-18	sand, sand-mud, mud	40	7/28/69 2/19/70 7/23/70	18

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
80.	Headwaters of Camp Creek 2 mi S New Baden	Robert.	96-24-22 31-02-15	sand, gravel	24	7/3/68 3/19/70	13
81.	Camp Creek on FM 1940	Robert.	96-19-51 30-03-06	sand	15	11/4/67 3/19/70	6
82.	Camp Creek Lake behind dam	Robert.	96-17-14 31-03-42	sand, gravel	--	2/10/67	11
83.	South Mineral Creek 1 mi N New Baden	Robert.	96-26-31 31-03-58	mud	15	2/10/68	4
84.	Clear Creek at FM 3	Leon	96-14-39 30-07-15	gravel, sand	15	2/11/68 1/31/69	24
85.	Clear Creek at FM 977	Leon	96-14-00 30-07-50	sand	15	2/24/68 1/31/69	9
86.	Duck Creek Hwy 79, 1 mi E of Easterly, Texas	Robert.	96-21-27 31-07-16	sand, sand-mud	--	3/19/70	9
87.	North Mineral Creek 6 mi N New Baden	Robert.	96-27-54 31-07-10	gravel, sand	30	7/3/68 3/19/70	15
88.	Mineral Creek 2.5 mi N Easterly	Robert.	96-23-12 31-08-08	sand	15	2/1/68	12
89.	Pothole by Navasota R. at U.S. 79	Leon	96-17-58 31-10-10	mud	--	7/11/68	17

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
90.	Brushy Creek on FM 977, 4 mi S Marquez	Leon	96-16-21 30-40-34	sand, gravel	11	2/11/68 1/31/69 7/23/69 6/25/70	26
91.	Brushy Creek on dirt road 1 3/4 mi ESE of Marquez, Texas	Leon	96-13-36 31-13-22	sand, sand-mud	5	1/31/69	4
92.	Duck Creek on FM 2096 S Bald Prairie, 6 mi NW Easterly	Robert.	96-25-09 31-10-26	sand	15	7/11/68 3/19/70	14
93.	Brushy Creek on dirt road 2 mi E of Marquez, Texas	Leon	96-13-18 31-14-10	sand-mud, mud	5	1/31/69	3
94.	Brushy Creek at Hwy 7, 2 1/2 mi E of Marquez, Texas	Leon	96-12-58 31-14-59	gravel, sand-mud, mud (90%)	10	1/31/69 2/17/69 8/13/69	17
95.	Duck Creek at FM 979, 7 mi NNE of Easterly, Texas	Robert.	96-27-11 31-11-29	sand-mud, mud	--	3/19/70	3
96.	Navasota R. at Texas 7	Robert.	96-19-47 31-15-17	sand	12	7/11/68 6/24/70 7/2/70	10
97.	Brushy Creek on dirt road 3 mi NW of Concord, Texas	Leon	96-11-54 31-17-26	sand	10	2/14/69 7/23/70	8
98.	Duck Creek on dirt road S of Hwy 7	Leon	96-30-35 31-13-20	sand, sand-mud	10	10/12/68	13

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
99.	Steele Creek at Hwy 7, 7 mi W of Marquez, Texas	Robert.	96-30-35 31-15-40	mud, gravel	20	2/15/69 1/28/70 2/19/70	8
100.	Willow Creek on Texas 7 W Navasota R.	Robert.	96-24-25 31-16-18	mud	14	7/11/68	5
101.	Brushy Creek at Hwy 79, 2 mi W of Jewett, Texas	Leon	96-10-03 31-20-41	mud, some sand	30	7/15/69 1/28/70 6/25/70	9
102.	Lambs Creek at FM 1512, 11 mi N of Marquez, Texas	Lime-stone	96-16-56 31-24-04	sand-mud, mud	20	7/23/70	1
103.	Lynn Creek on FM 3	Free-stone	96-14-42 31-25-26	sand, gravel	20+	7/4/68	13
104.	Tributary of Davis Creek 1 mi E of Thornton, Texas on FM 1246	Lime-stone	96-33-22 31-24-22	mud, sand-mud	15	10/24/70	2
105.	Davis Creek 2 mi E of Thorton, Texas on FM 1246	Lime-stone	96-32-14 31-24-10	sand-mud	10	10/24/70	9
106.	Old Channel and ditch along road by Navasota R. at edge of Oletha Oil Field	Lime-stone	96-22-36 31-26-20	mud	12	7/11/68 7/23/70 10/24/70	17
107.	Big Creek at FM 164	Lime-stone	96-19-36 31-30-08	sand, sand-mud	10-15	7/23/70	11
108.	Rocky Creek at Texas 14, 4 mi S Groesbeck	Lime-stone	96-29-27 31-30-19	bedrock	14	2/17/68 4/5/68	5

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
109.	Spring Creek at FM 164 8 mi E of Groesbeck, Texas	Lime-stone	96-22-30 31-30-36	sand, small areas of bedrock	15	7/23/70	9
110.	Ezelle Branch at FM 164 9 1/2 mi E of Groesbeck, Texas	Lime-stone	96-21-15 31-30-33	mud	15	7/23/70	7
111.	Faulkenberry Creek on Texas 14.1 mi S Groesbeck	Lime-stone	96-32-38 31-30-39	mud	15	4/5/68 10/24/70	6
112.	Old River channel 4.8 mi E Groesbeck	Lime-stone	96-27-26 30-30-47	mud	10	2/2/68	5
113.	Navasota R. at Texas 164, 5 mi E Groesbeck	Lime-stone	96-27-02 30-30-45	sand, mud	10	6/ /68 7/20/68 10/24/70	14
114.	Middle Creek on Texas 164, 6.5 mi E Groesbeck	Lime-stone	96-25-43 31-30-42	sand, gravel	25	2/2/68	5
115.	Cedar Creek 6 mi S of Teague, Texas on dirt road	Free-stone	96-17-45 31-22-50	sand	15	7/23/70	2
116.	Frost Creek 1/2 mi N Texas 164, 3 1/2 mi W Groesbeck	Lime-stone	96-35-55 31-32-09	mud	15	6/11/68	9
117.	Holman Creek 2 1/2 mi SW of Teague, Texas on dirt road	Free-stone	96-19-15 31-25-13	sand, mud	25	7/23/70	5
118.	Cat Creek 1 mi S Teague on FM 80	Free-stone	96-17-09 31-35-06	mud	15	7/9/68	10

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
119.	Baines Creek 4 1/2 mi WNW Groesbeck	Lime-stone	96-35-06 31-33-23	sand	20+	4/5/68	6
120.	Baines Creek off Texas 164, NW Groesbeck	Lime-stone	96-35-06 31-33-25	sand	15	6/11/68	3
121.	Springfield Lake, 1/2 mi S across from concession stand	Lime-stone	96-32-23 31-35-37	mud	--	7/11/68	9
122.	Springfield Lake, by concession stand	Lime-stone	96-32-14 31-35-47	sand, gravel	--	12/11/67 4/4/68 6/11/68 7/11/68	17
123.	Plummers Creek, 2 1/2 mi E of Springfield Lake	Lime-stone	96-28-29 31-35-40	sand	10	10/23/70	5
124.	Branch of Prairie Creek E Shiloh	Free-stone	96-24-16 31-36-48	mud	15	7/11/68	8
125.	Holman Creek on FM 1365	Free-stone	96-19-42 31-37-44	sand	25	7/9/68	4
126.	Plummers Creek 1 mi W Texas 34, 4 mi S Mexia	Lime-stone	96-28-40 31-37-43	sand	13	6/13/68 10/23/68	4
127.	Springfield Lake, 1 mi N concession stand	Lime-stone	96-32-45 31-26-23	mud	--	4/4/68	7
128.	Branch Plummers Creek 3 mi S Springfield Community	Free-stone	96-29-31 31-37-22	mud	15	6/13/68	4

Table 22. Continued

	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
129.	Christmas Creek on FM 1245	Lime-stone	96-39-12 31-37-58	mud, sand	13	4/5/68 6/8/70	10
130.	Jacks Creek by Confederate Reunion Grounds	Lime-stone	96-33-21 31-38-25	bedrock	13	6/11/68	10
131.	Christmas Creek 3 mi SE U.S. 84, 11.7 mi WSW Mexia	Lime-stone	96-38-33 31-37-39	sand, gravel	5	6/13/68	6
132.	Lake Mexia accross from concession stand	Lime-stone	96-35-30 31-39-58	mud	--	12/22/67	4
133.	Christmas Creek on FM 339	Lime-stone	96-44-38 31-38-02	sand	13.1	4/4/68	6
134.	Navasota R. at U.S. 84, 11.3 mi WSW Mexia	Lime-stone	96-39-36 31-39-49	sand	12	12/21/67 6/12/68 7/10/69 2/25/70	8
135.	Old river channel 11 mi WSW Mexia on U.S. 84	Lime-stone	96-39-16 31-39-54	mud	12	4/5/68	5
136.	Lake Mexia by concession stand	Lime-stone	96-53-30 31-39-13	mud	--	12/21/67	12
137.	Culvert on FM 73, 200 yards SW locality #138	Lime-stone	96-43-21 31-42-06	mud	--	6/12/68	6

Table 22. Continued

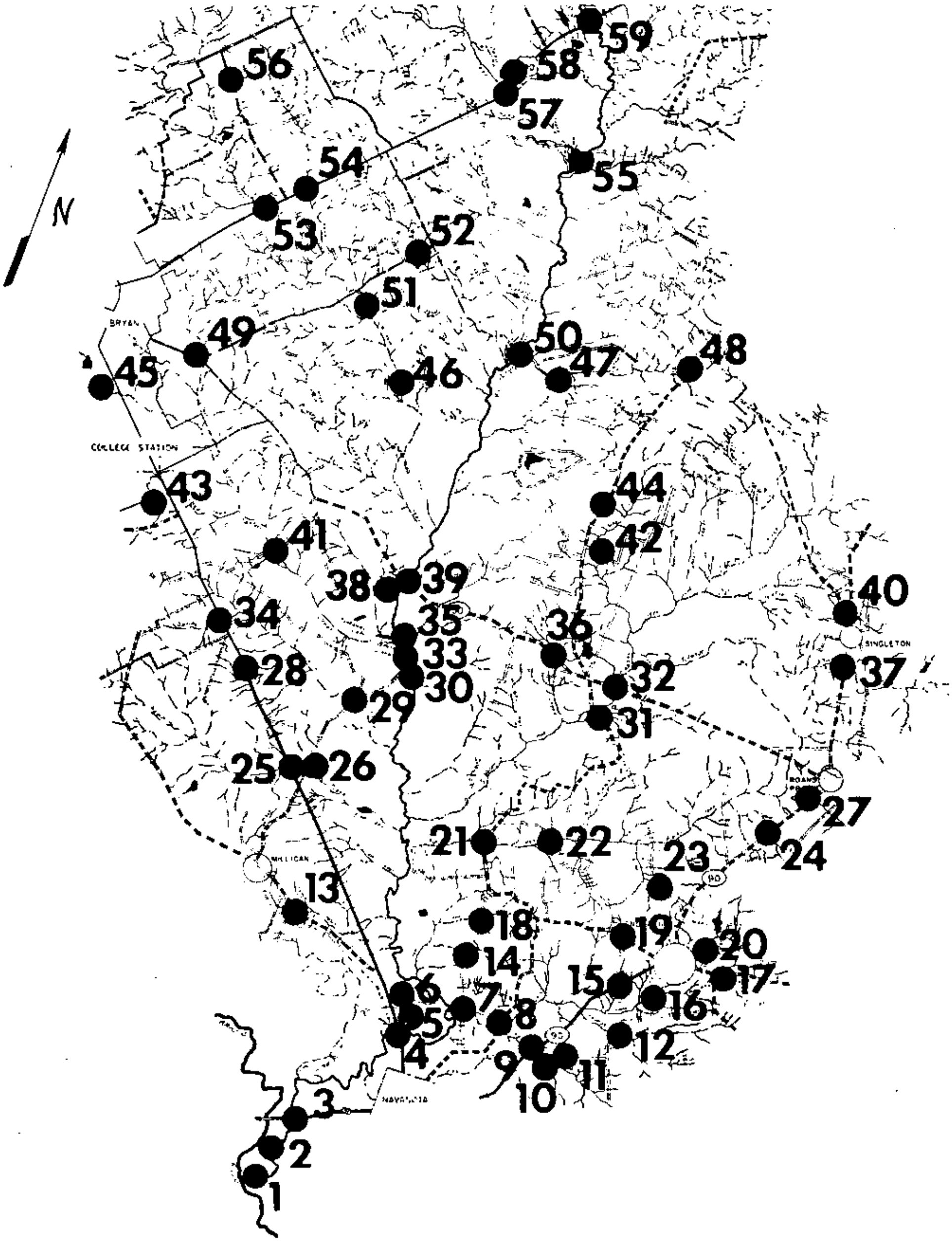
	Location	County	Long & Lat	Bottom	Ft./Mile Gradient	Date	No. of Species
138.	Navasota R. at FM 73, 6.7 mi NE Prairie Hill	Lime-stone	96-43-21 31-42-06	sand	12	7/2/70	9
139.	Keitt Creek 1.5 mi E Navasota R.	Lime-stone	96-45-06 31-44-07	mud	17.5	6/12/68	12
140.	Navasota R. 1 2/10 mi N of Delia, Texas	Lime-stone	96-46-07 31-43-30	sand, sand-mud	10	7/2/70	6
141.	Navasota R. 1 7/10 mi E of Mt. Calm, Texas	Hill	96-50-41 32-20-00	sand, sand-mud	35	7/2/70	7
142.	Navasota R. 1 2/10 mi S of Texas Hwy 31	Hill	96-51-18 31-46-50	sand, sand-mud	35	7/2/70	8
143.	Navasota R. at Texas 31, 1 mi NE Mt. Calm	Hill	96-52-26 31-46-19	mud	12	6/12/68 7/3/70 8/2/70	8
144.	Headwaters, Navasota R., 1.5 mi NE Mt. Calm	Hill	96-52-39 31-46-50	mud	12	6/12/68	5

Table 23

Parasites of Fishes of the Navasota River from Collections in 1969.

Parasite		Host: Lepisosteus oculatus	L. oculatus	L. oculatus	L. oculatus	L. oculatus	L. spatula	Cyprinus carpio	Gambusia affinis	Micropterus salmoides	Micropterus salmoides
Trematoda											
Macroderoides spiniferus	Gravid	1	7	0	32	19	65				
	Not Gravid	4	5	0	1	0	2				
Paramacroderoides echinus	Gravid	0	0	3	3	0	0				
	Not Gravid	0	0	1	0	0	0				
Cestoda											
Protocephalus sp.		15	5	32	5	38	10				
Nematoda											
Dichelyne lepisosteus	Male	2	1	4	2	1					
	Female	1	2	7	4	2					
Contracaeum spiculigerum						1					
Crustacea											
Argulus nobilis						3	13				
Lernaea sp.								2	1	1	1

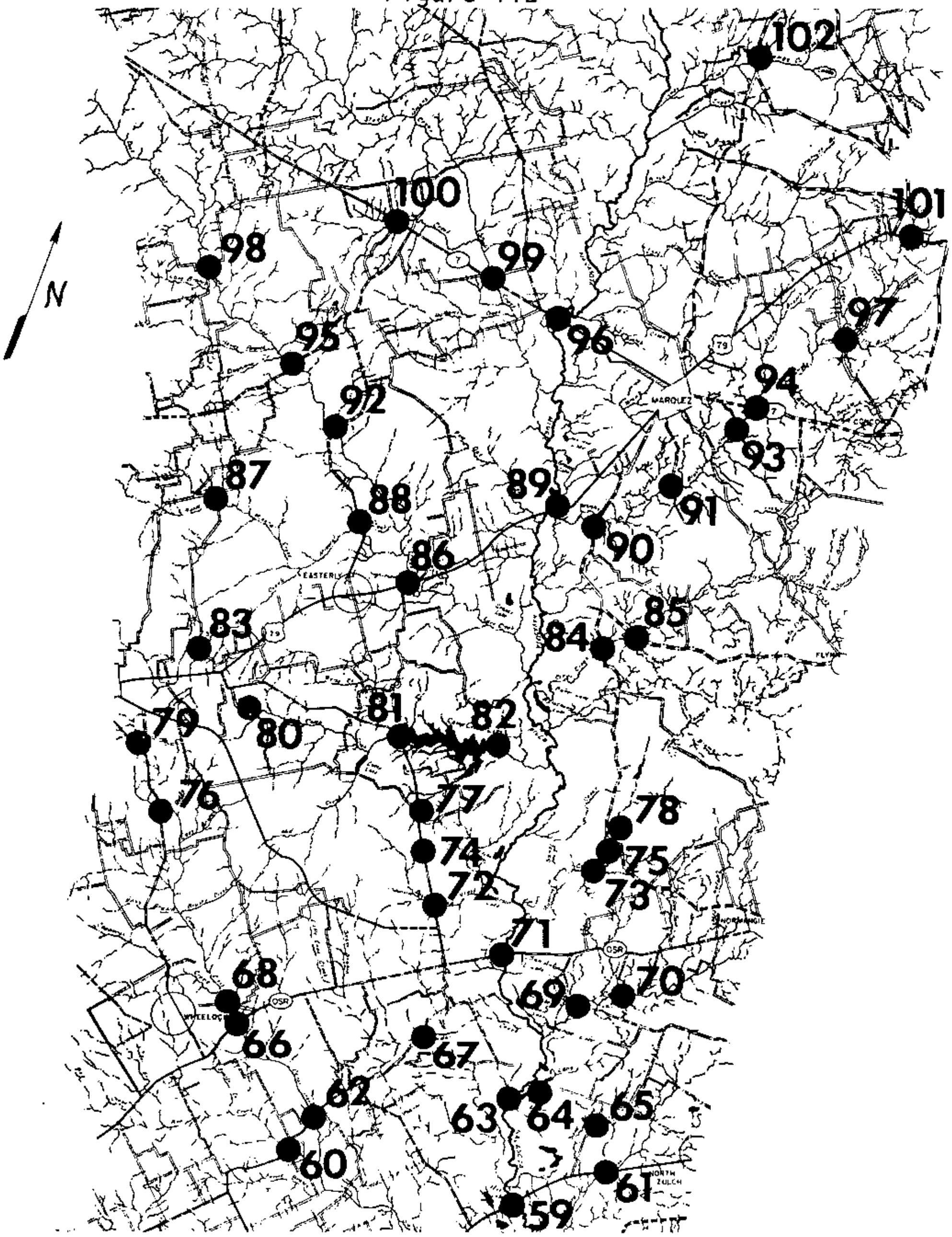
Figure 111



FISH COLLECTION STATIONS
LOWER NAVASOTA RIVER, TEXAS

SCALE

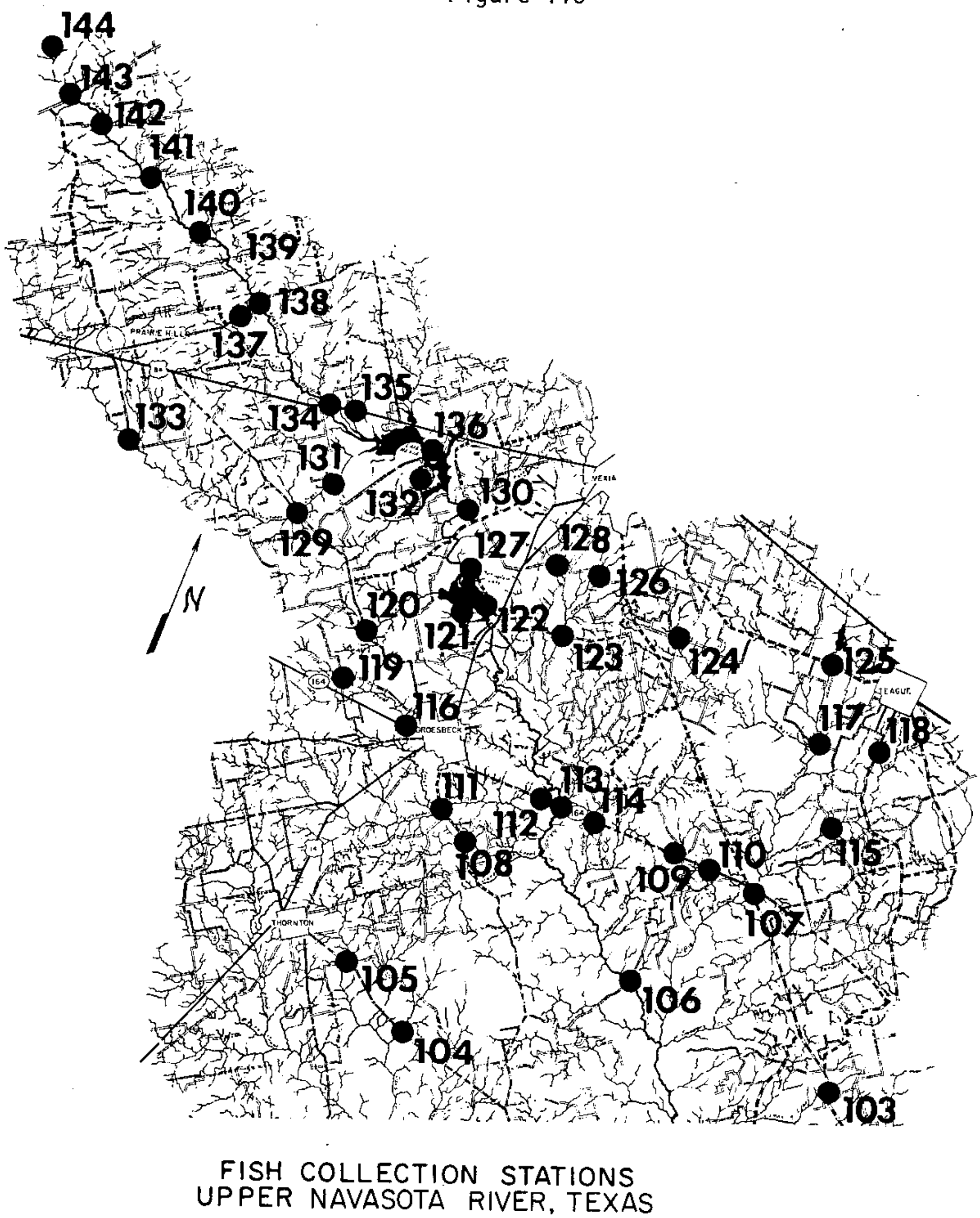
Figure 112



FISH COLLECTION STATIONS
CENTRAL NAVASOTA RIVER, TEXAS

SCALE 0 1 2 3 4 MILES

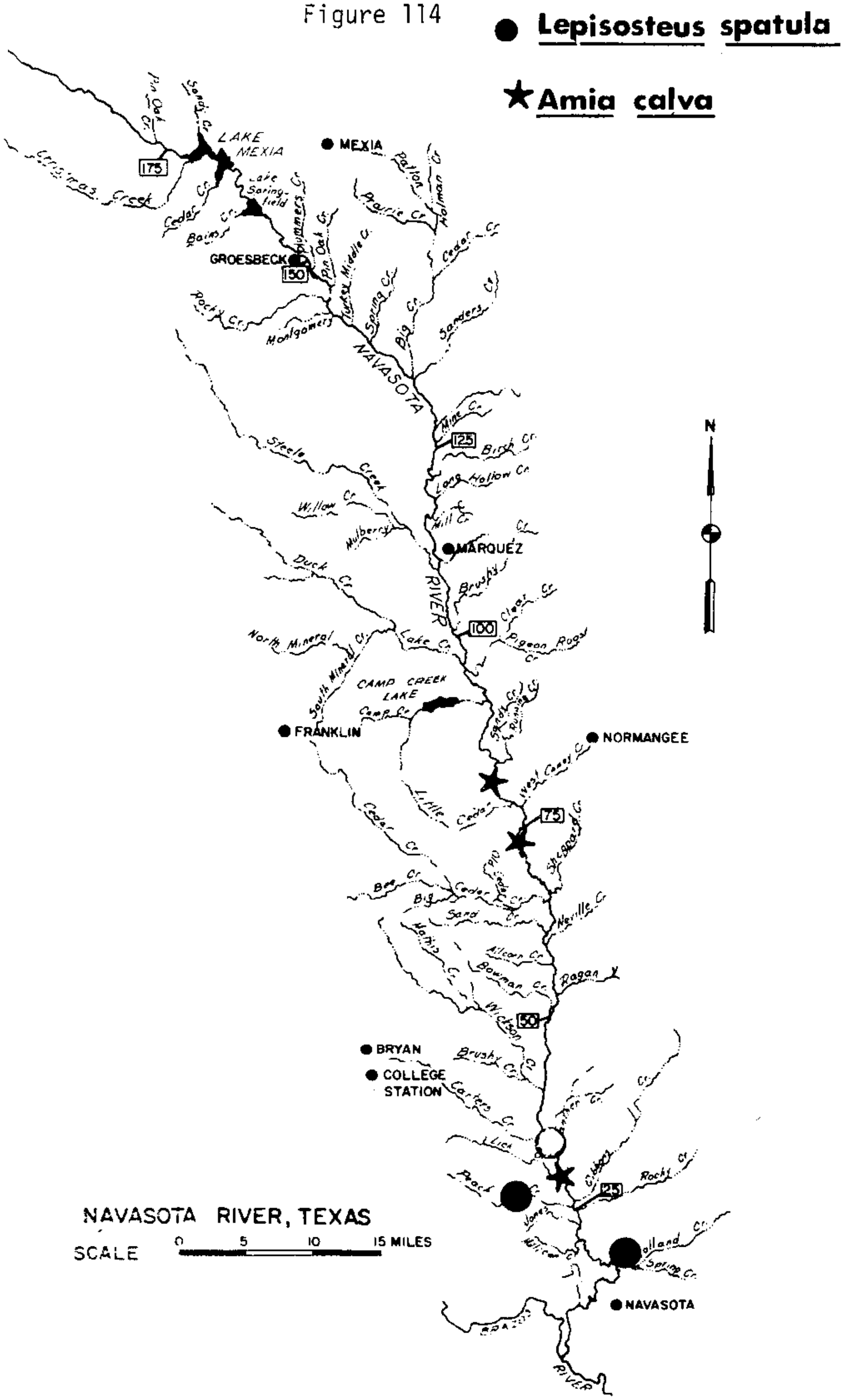
Figure 113



FISH COLLECTION STATIONS
UPPER NAVASOTA RIVER, TEXAS

SCALE 4 MILES

Figure 114



● Lepisosteus spatula
★ Amia calva
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 115

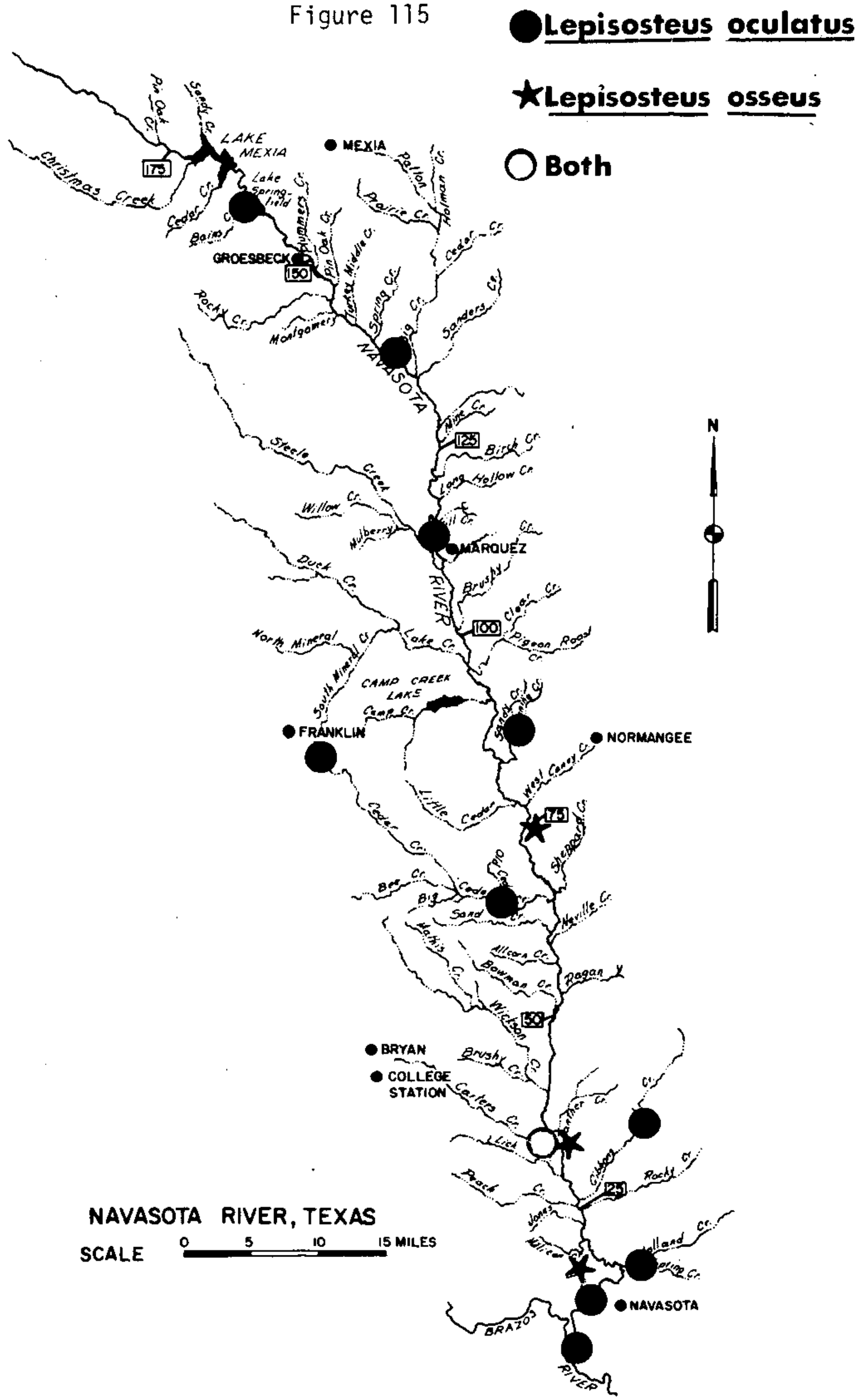

Lepisosteus oculatus
Lepisosteus osseus
Both
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
NAVASOTA RIVER
CAMP CREEK LAKE
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 116

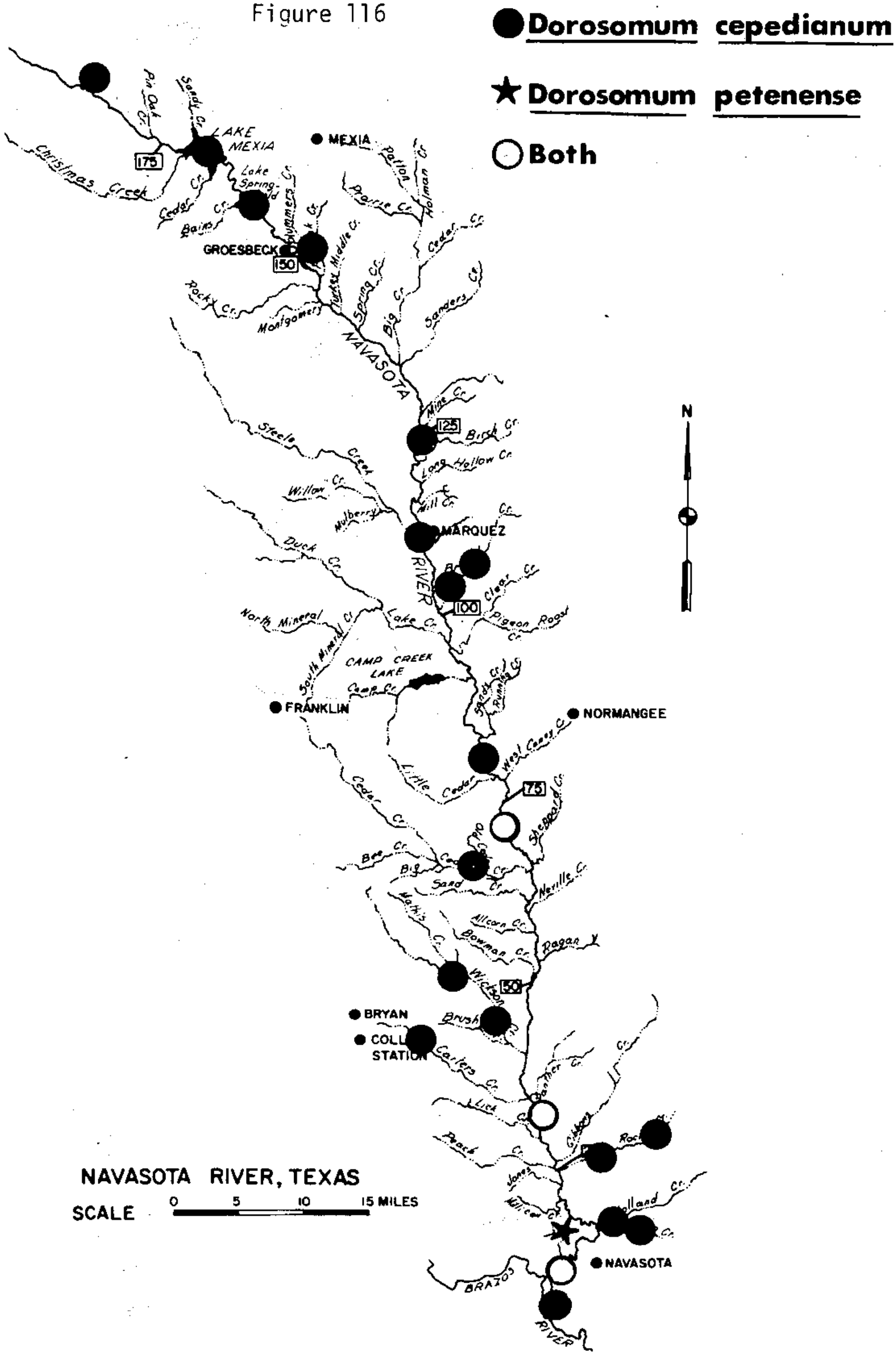

Dorosomum cepedianum
Dorosomum petenense
Both
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
NAVASOTA
BRAZOS RIVER
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES
N

Figure 117

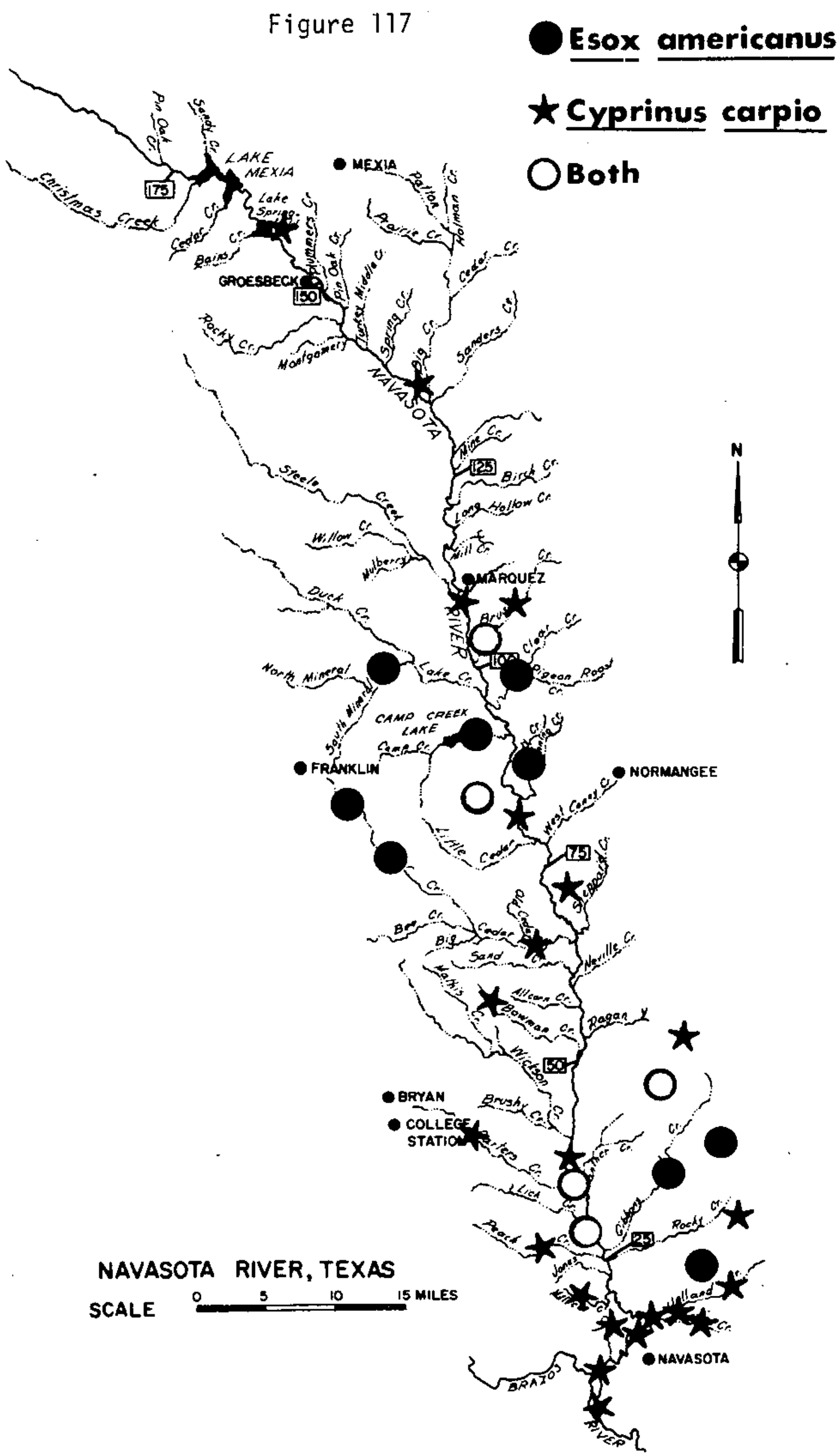

Esox americanus
Cyprinus carpio
Both
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
MARQUEZ
RIVER
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS
RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0
5
10
15 MILES

Figure 118

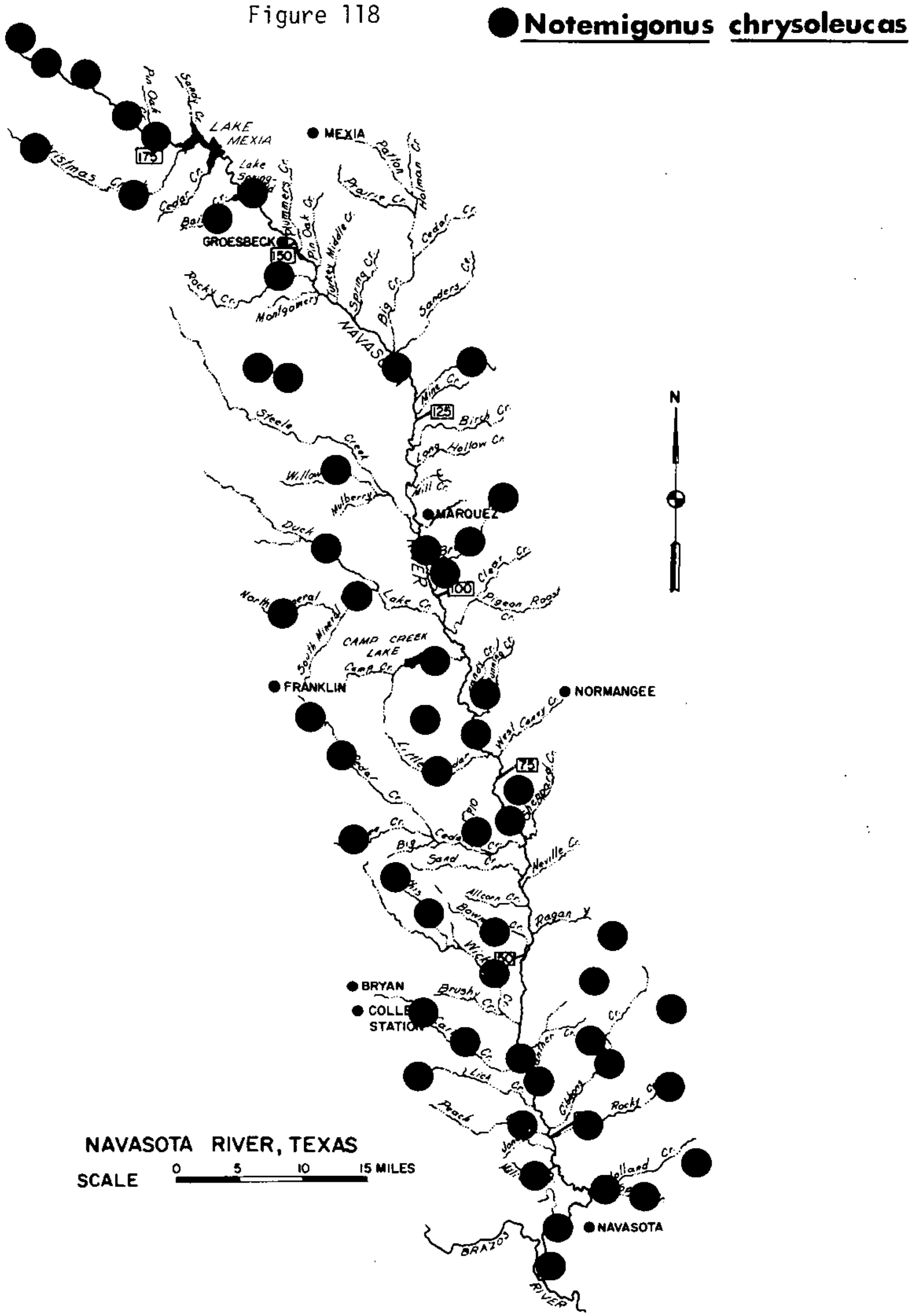

Notemigonus chrysoleucas
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
NAVASOTA
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 119

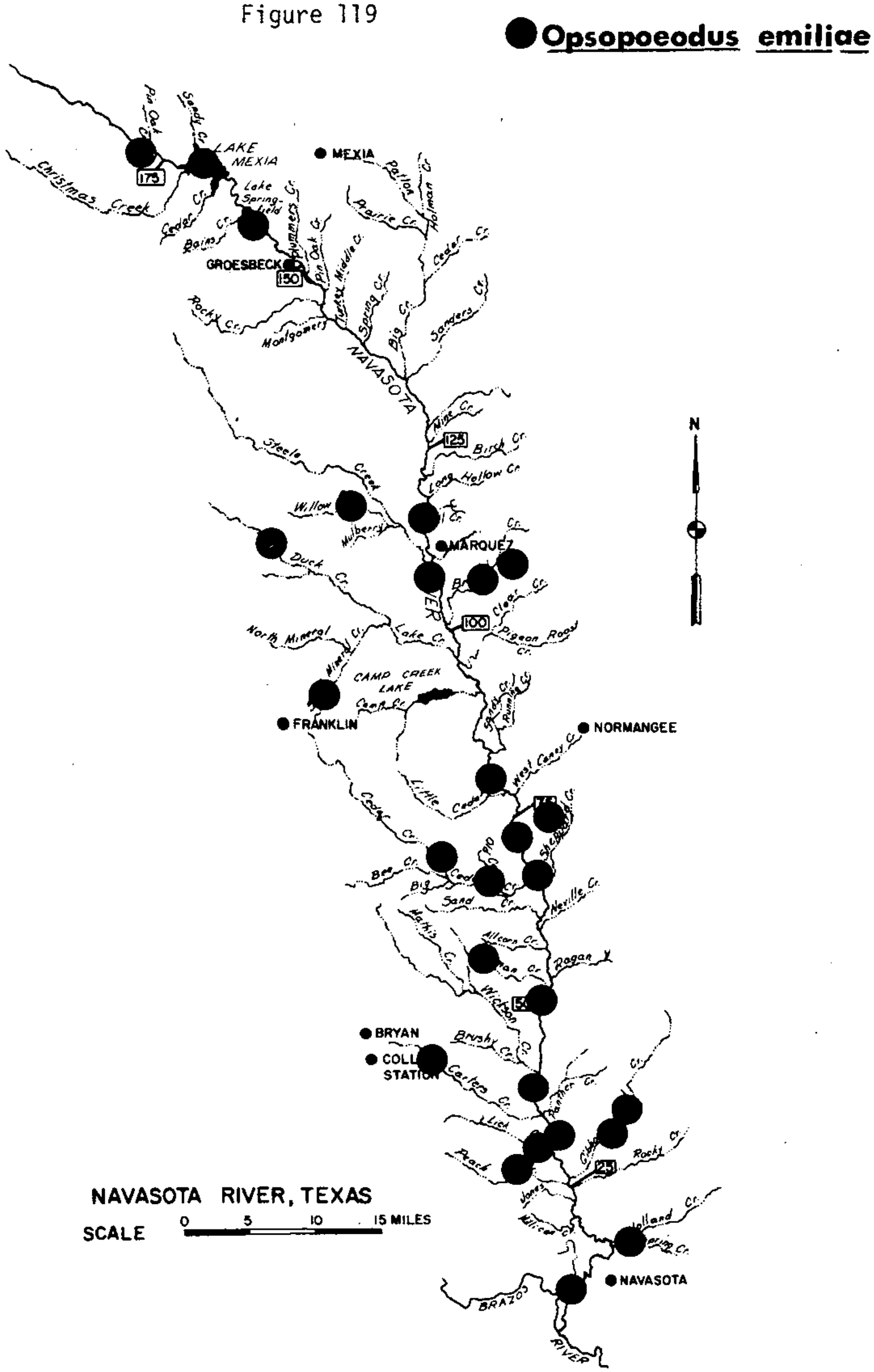

Opsopoeodus emiliae
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
NAVASOTA
BRAZOS RIVER
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES
N

Figure 120

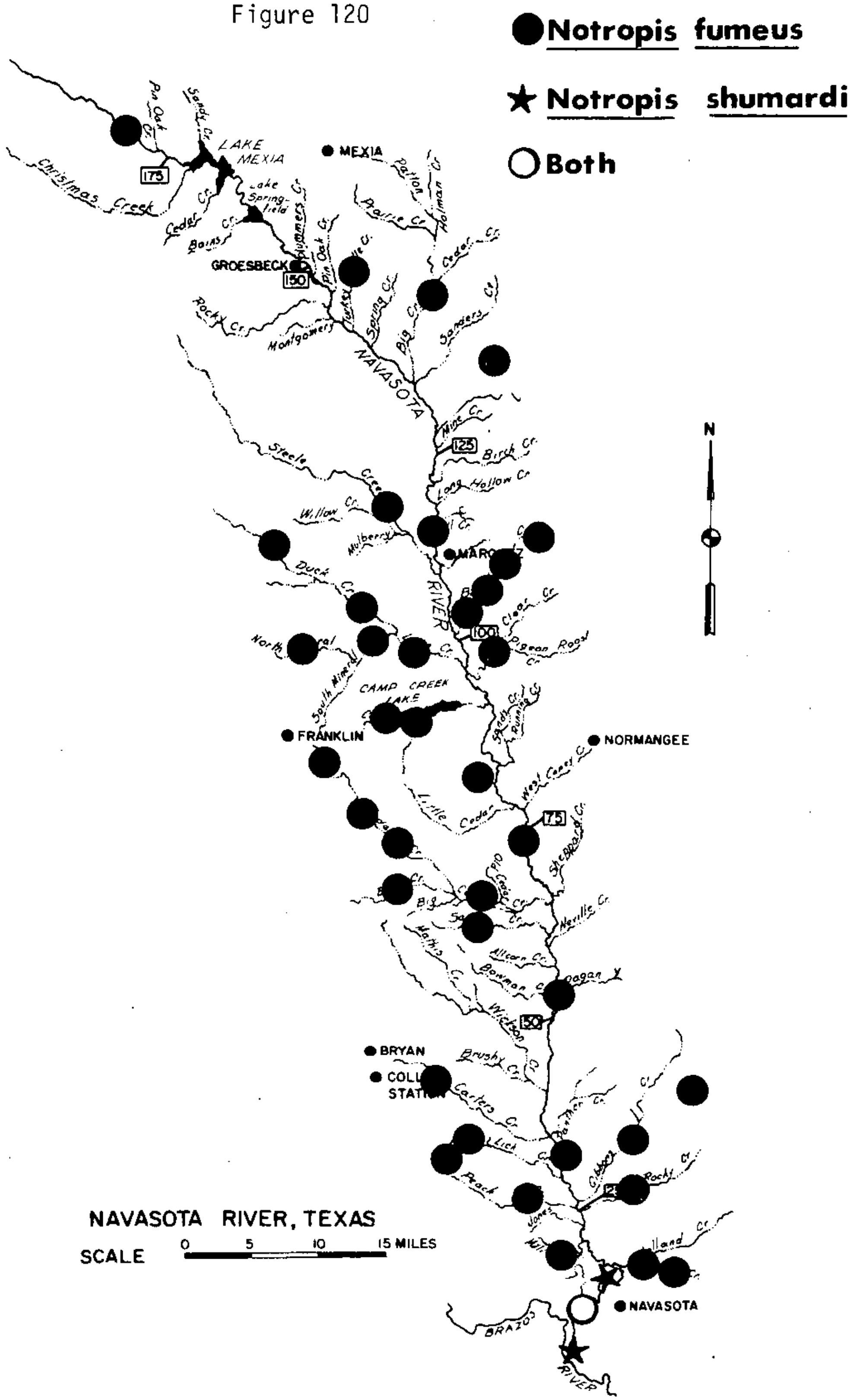

Notropis fumeus
Notropis shumardi
Both
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES
N
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
NAVASOTA
BRAZOS
RIVER
Christmas Creek
Steele Cr.
Willow Cr.
Duck Cr.
Birch Cr.
Long Hollow Cr.
Clear Cr.
Little Cedar
Neville Cr.
Carters Cr.
Brushy Cr.
Allcorn Cr.
Peach
Rocky Cr.

Figure 121

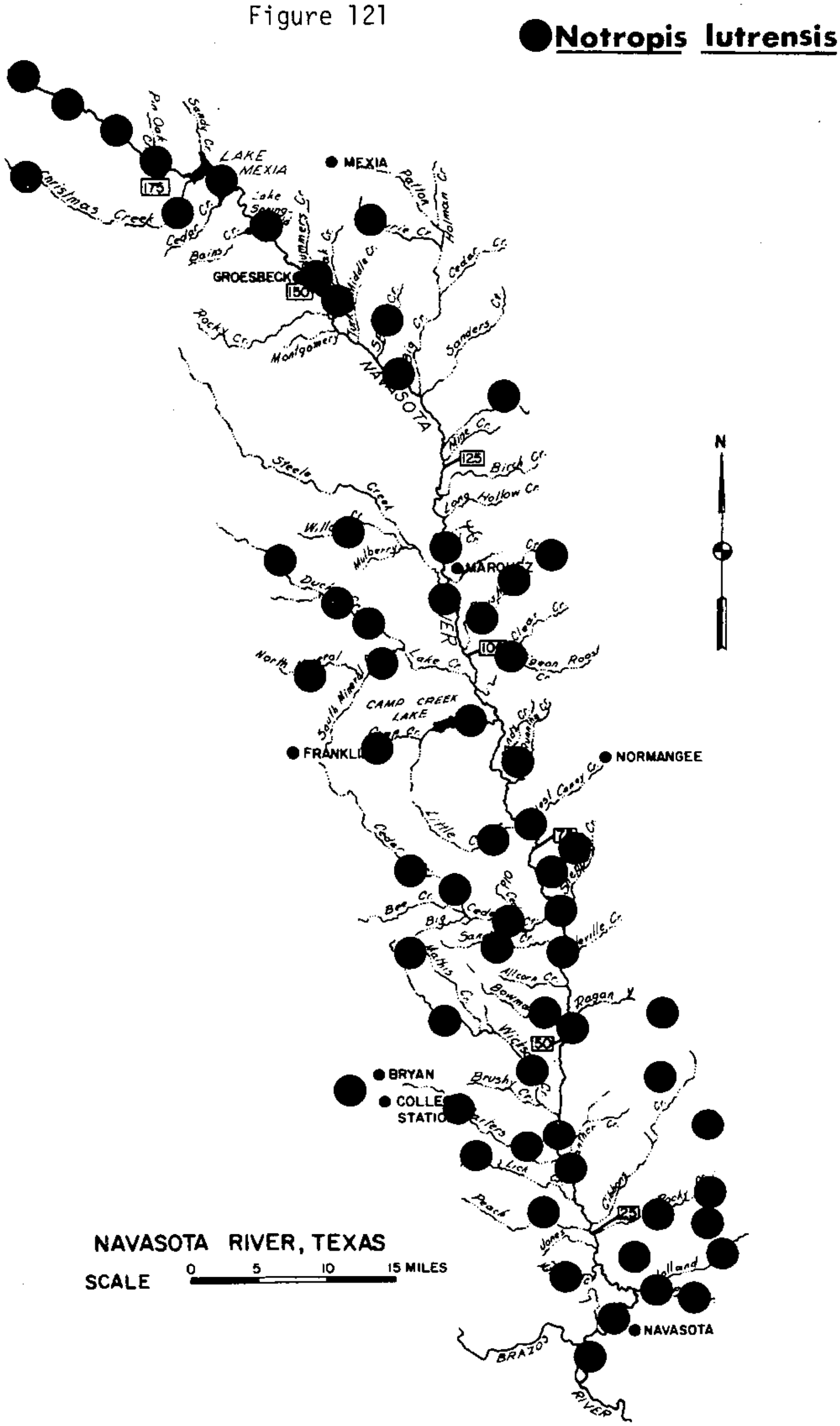

Notropis lutrensis
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
NORMANGEE
CAMP CREEK LAKE
BRYAN
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 122

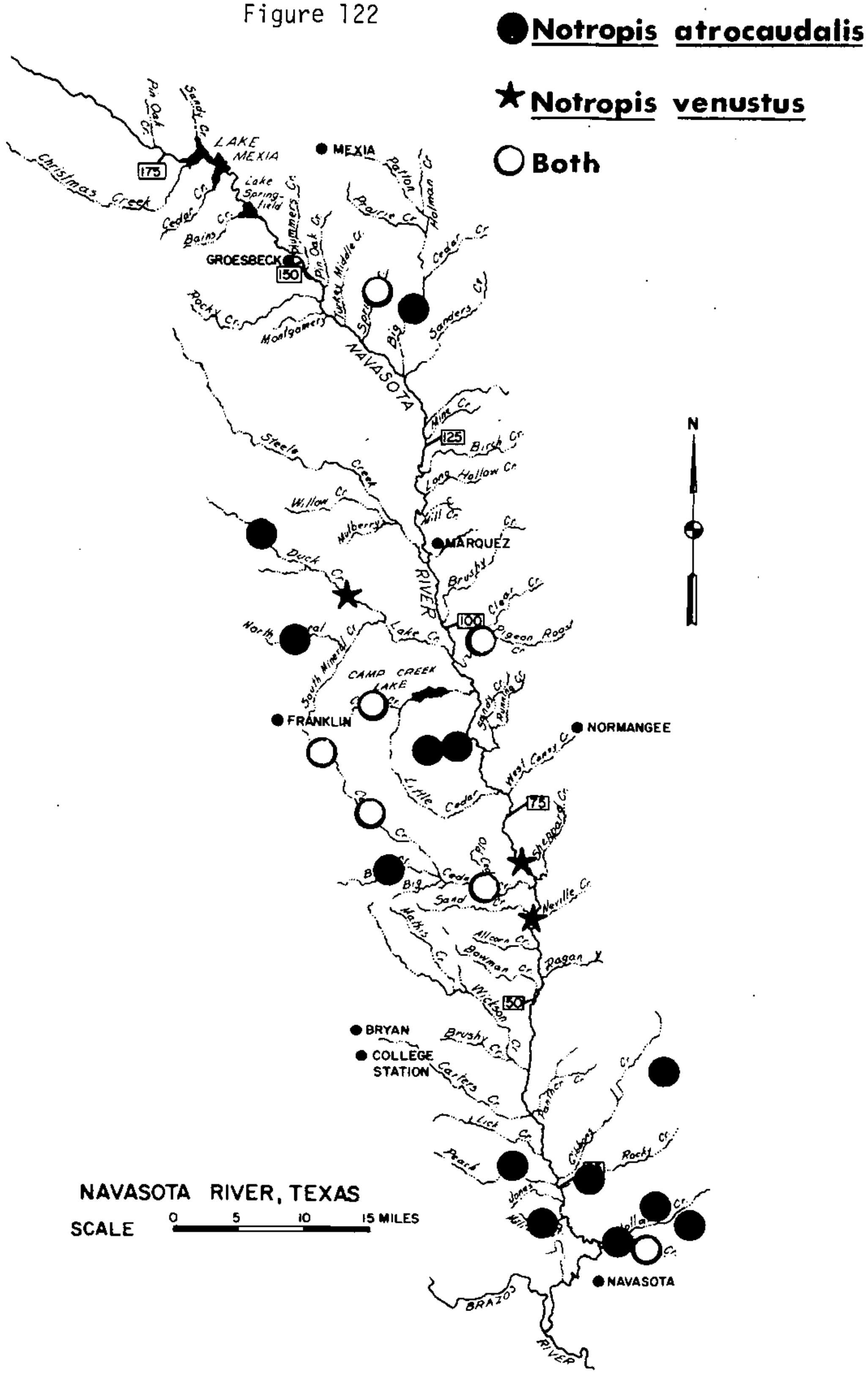
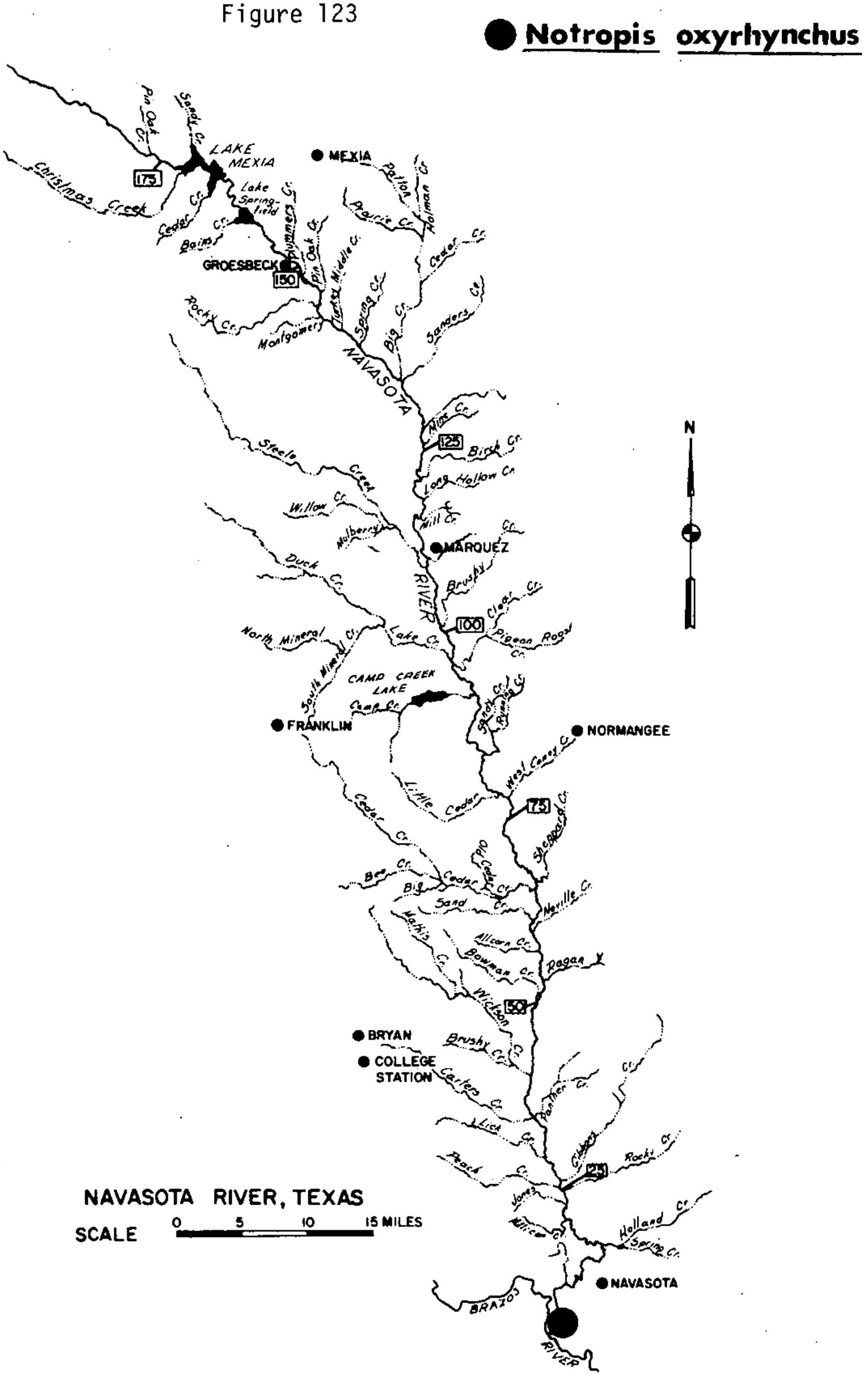
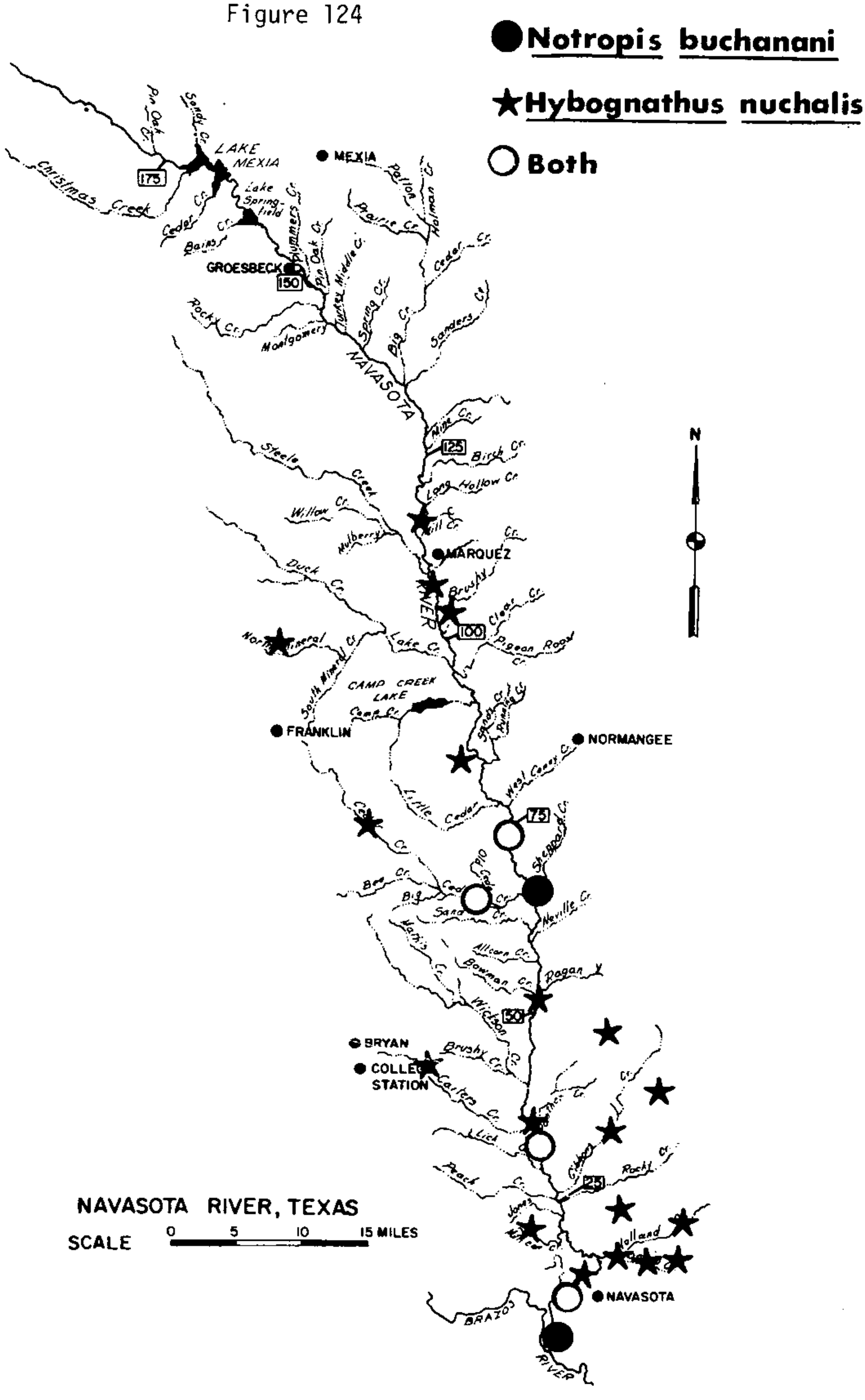

Notropis atrocaudalis
Notropis venustus
Both
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 123



Notropis oxyrhynchus
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
NAVASOTA RIVER
BRAZOS RIVER
CAMP CREEK LAKE
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES
N

Figure 124



●Notropis buchanani
★Hybognathus nuchalis
○Both
LAKE MEXIA
MEXIA
GROESBECK
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
MARQUEZ
CAMP CREEK LAKE
NAVASOTA RIVER
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 125

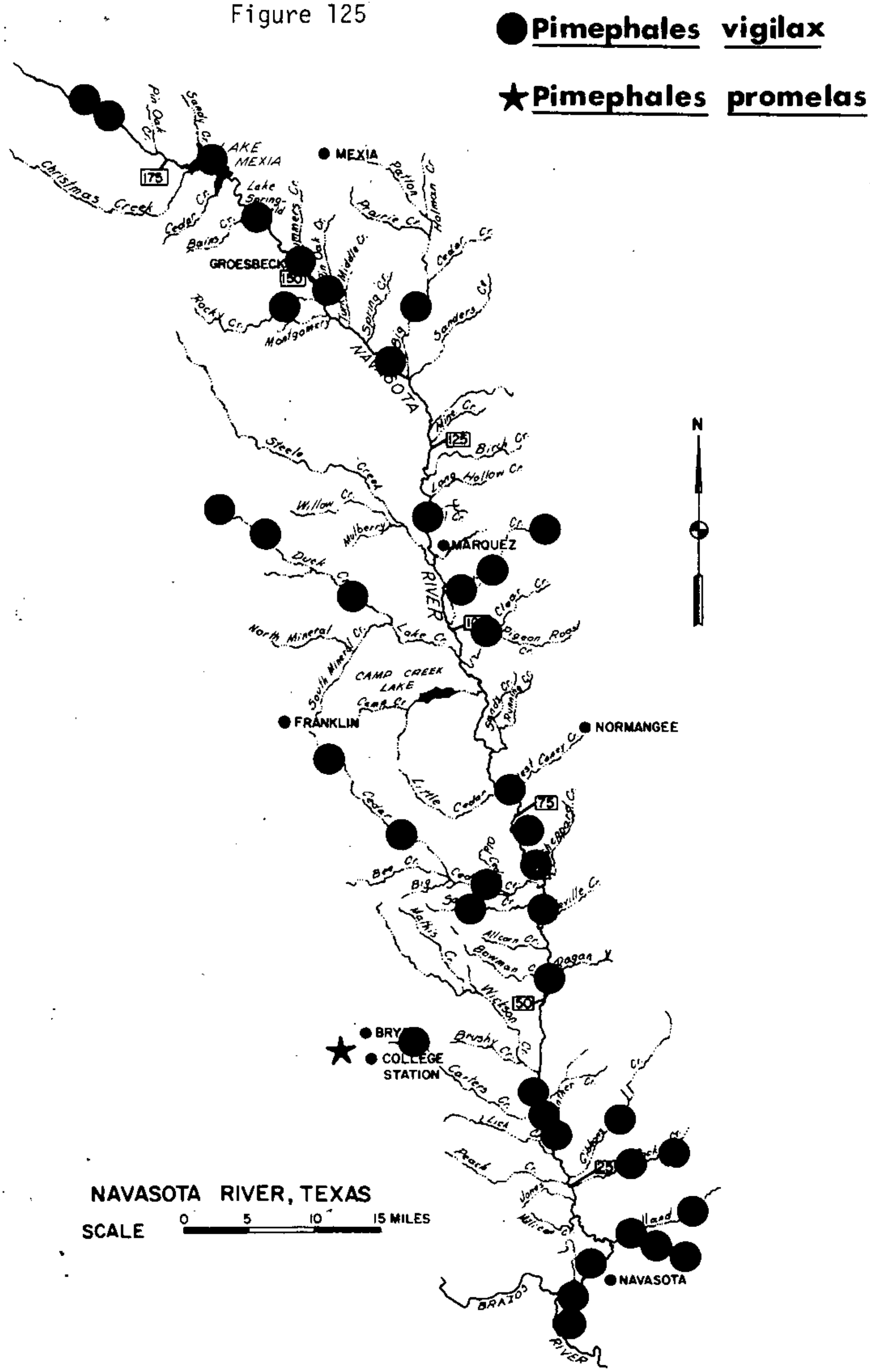

Pimephales vigilax
Pimephales promelas
LAKE MEXIA
MEXIA
GROESBECK
Christmas Creek
Steele Creek
Willow Cr.
Duck Cr.
North Mineral Cr.
Lake Cr.
Clear Cr.
Birch Cr.
Long Hollow Cr.
Pine Cr.
Sanders Cr.
Rocky Cr.
Prairie Cr.
Cedar Cr.
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
Camp Cr.
FRANKLIN
NORMANGEE
COLLEGE STATION
Brushy Cr.
Carters Cr.
NAVASOTA
BRAZOS
RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 126

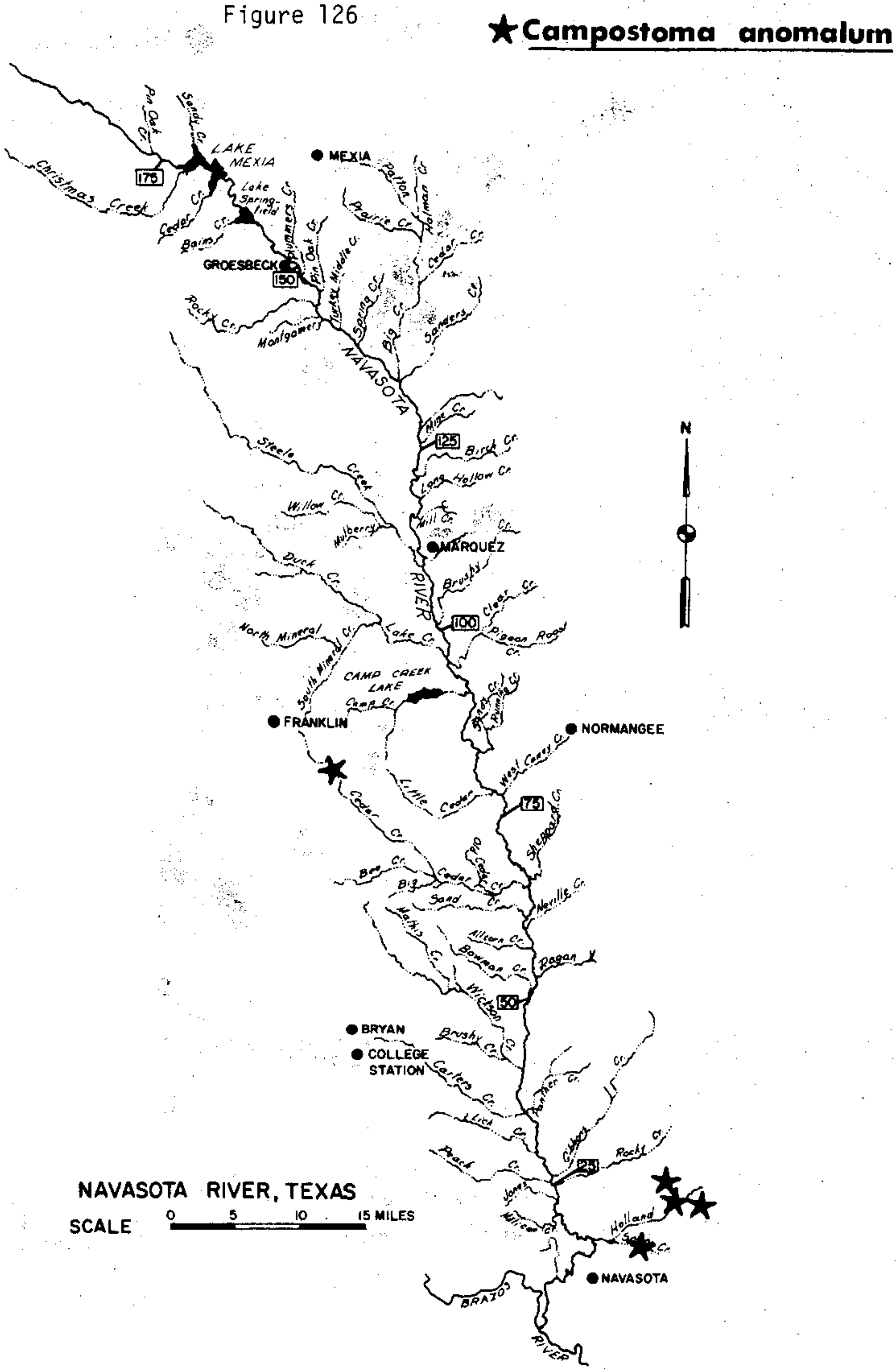
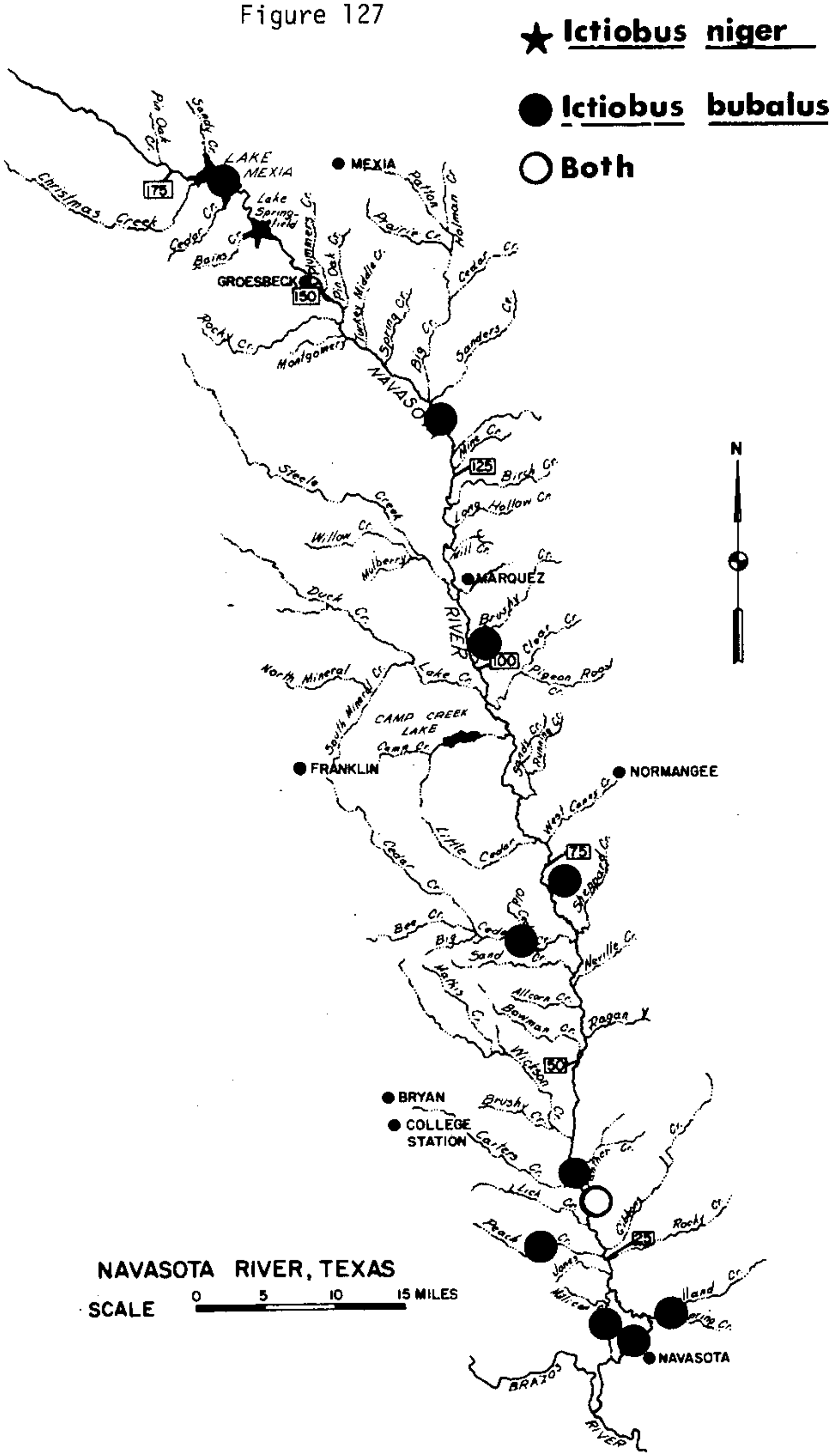

★Campostoma anomalum
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 127



★ Ictiobus niger
● Ictiobus bubalus
○ Both
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
NAVASOTA RIVER
BRAZOS RIVER
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 128

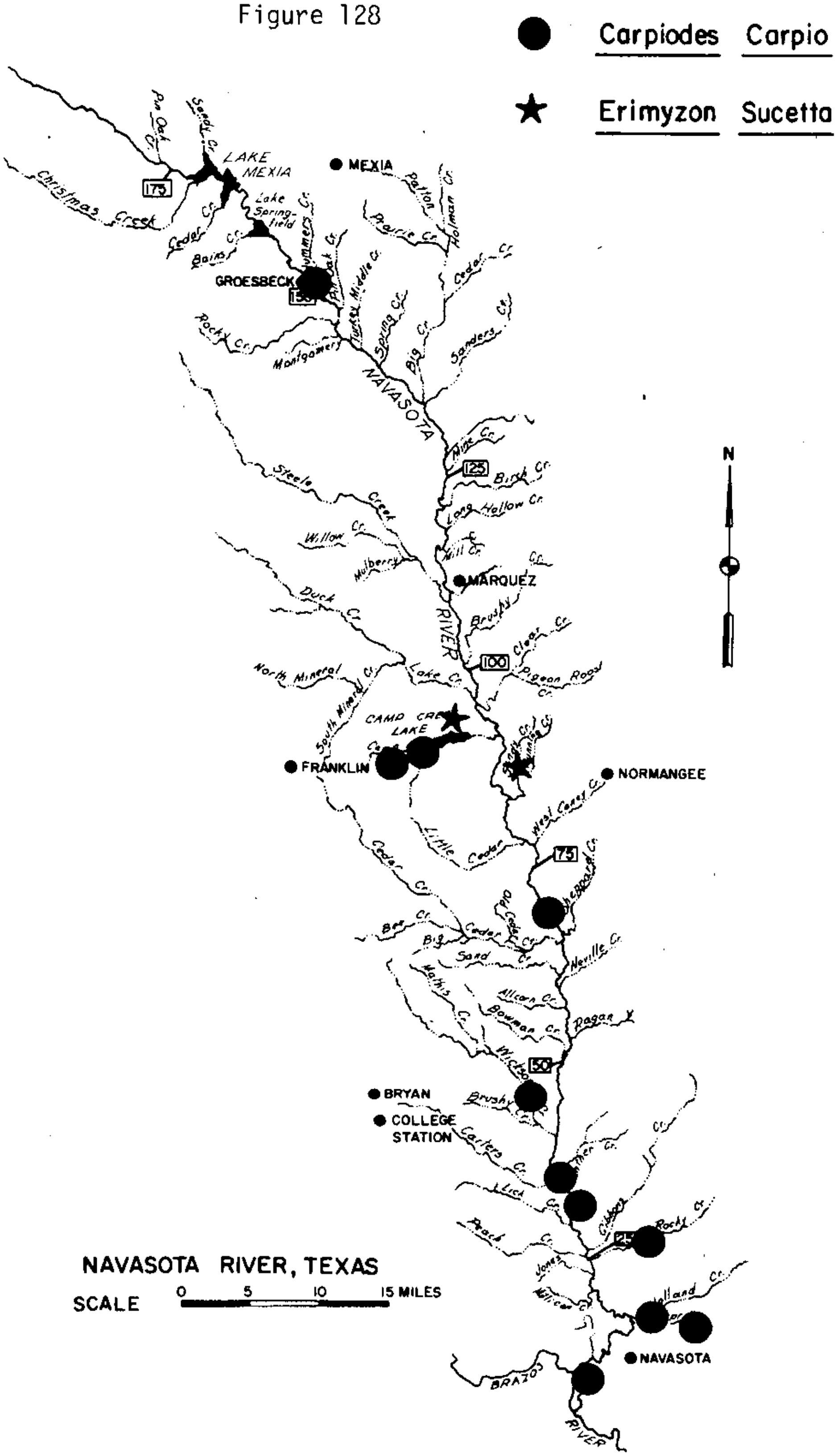

Carpiodes Carpio
Erimyzon Sucetta
LAKE MEXIA
MEXIA
Lake Springfield
Christmas Creek
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS
RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 129

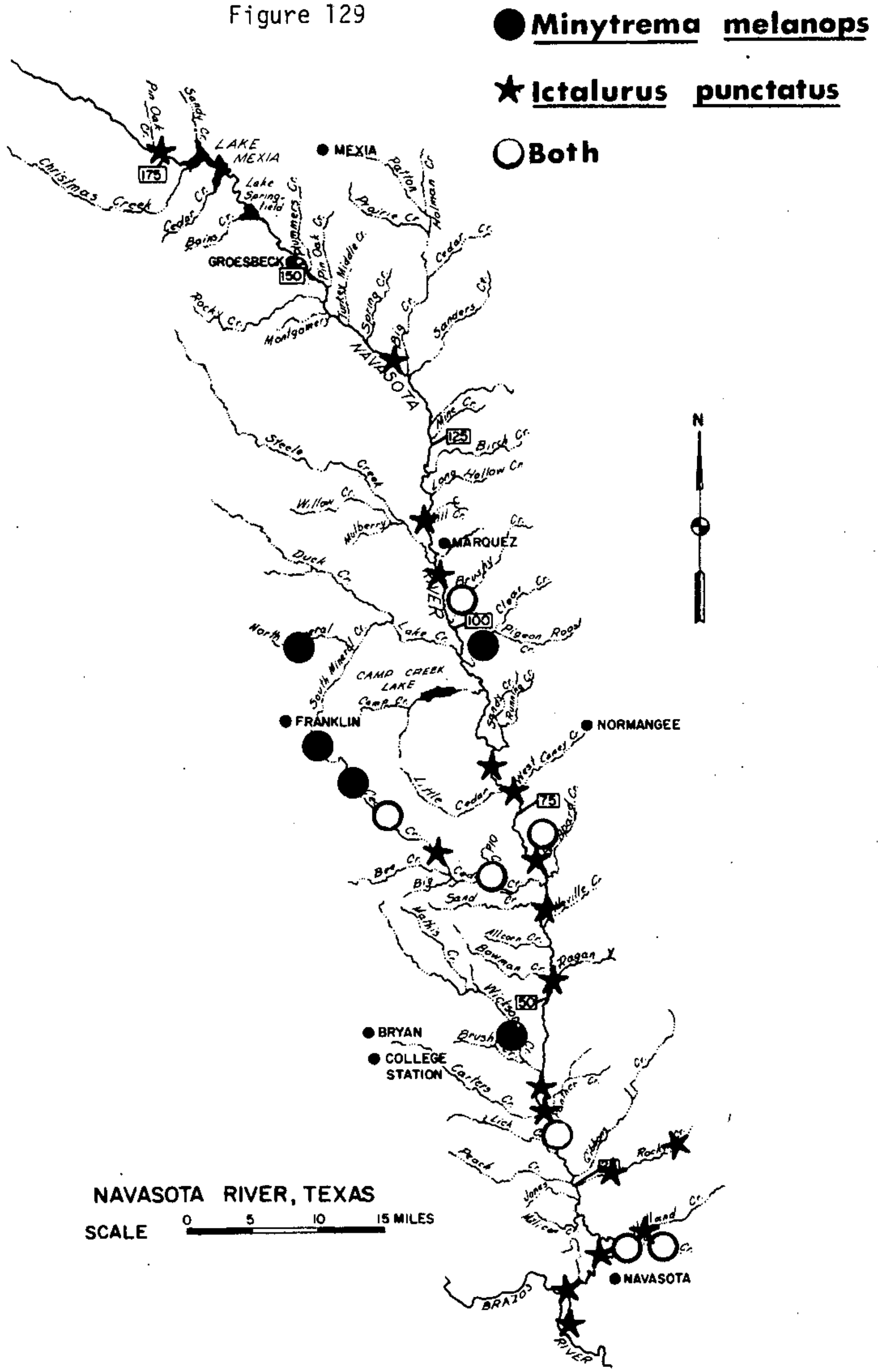

Minytrema melanops
Ictalurus punctatus
Both
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
NORMANGEE
FRANKLIN
CAMP CREEK LAKE
BRYAN
COLLEGE STATION
NAVASOTA
NAVASOTA RIVER
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 130

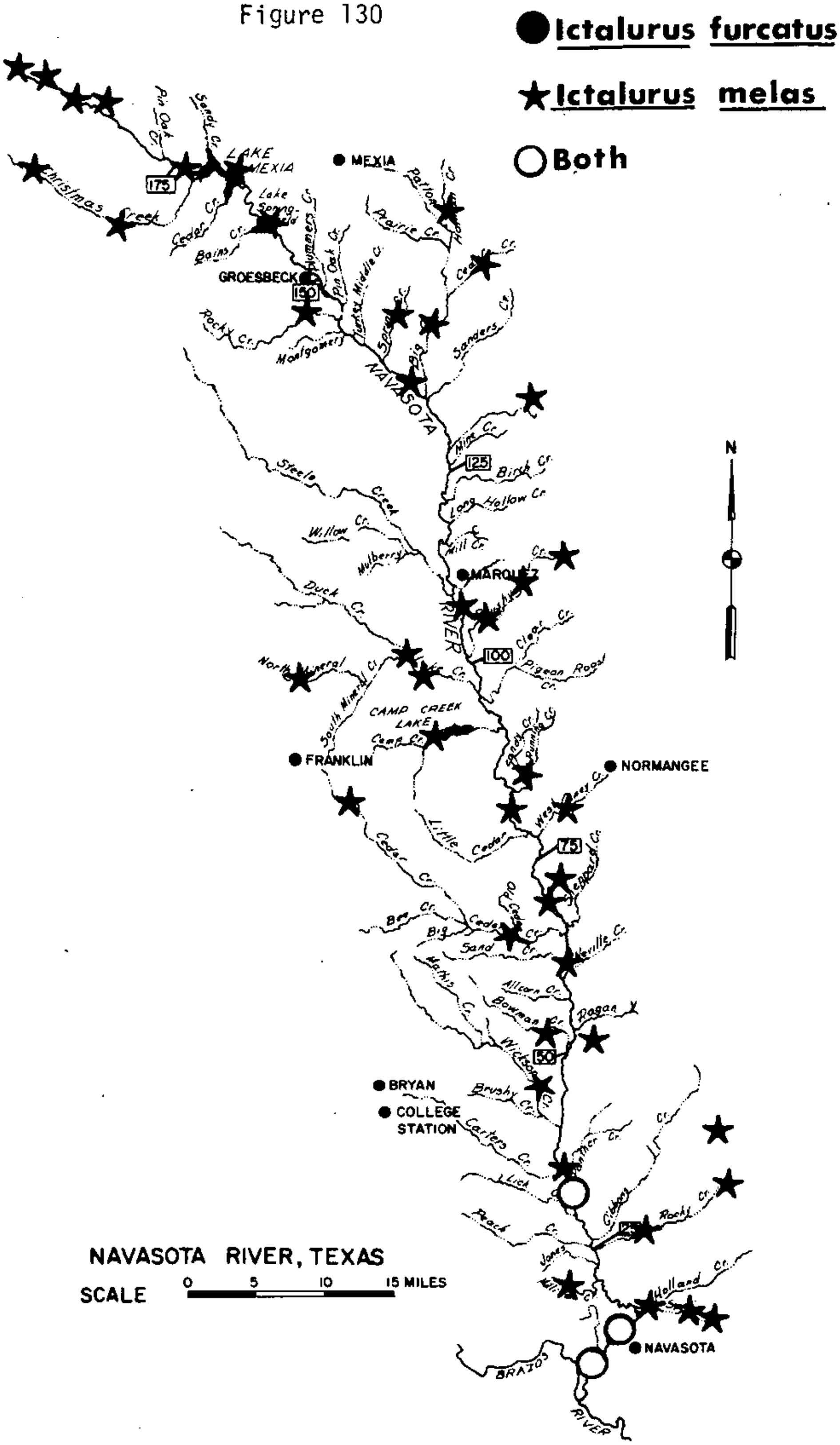
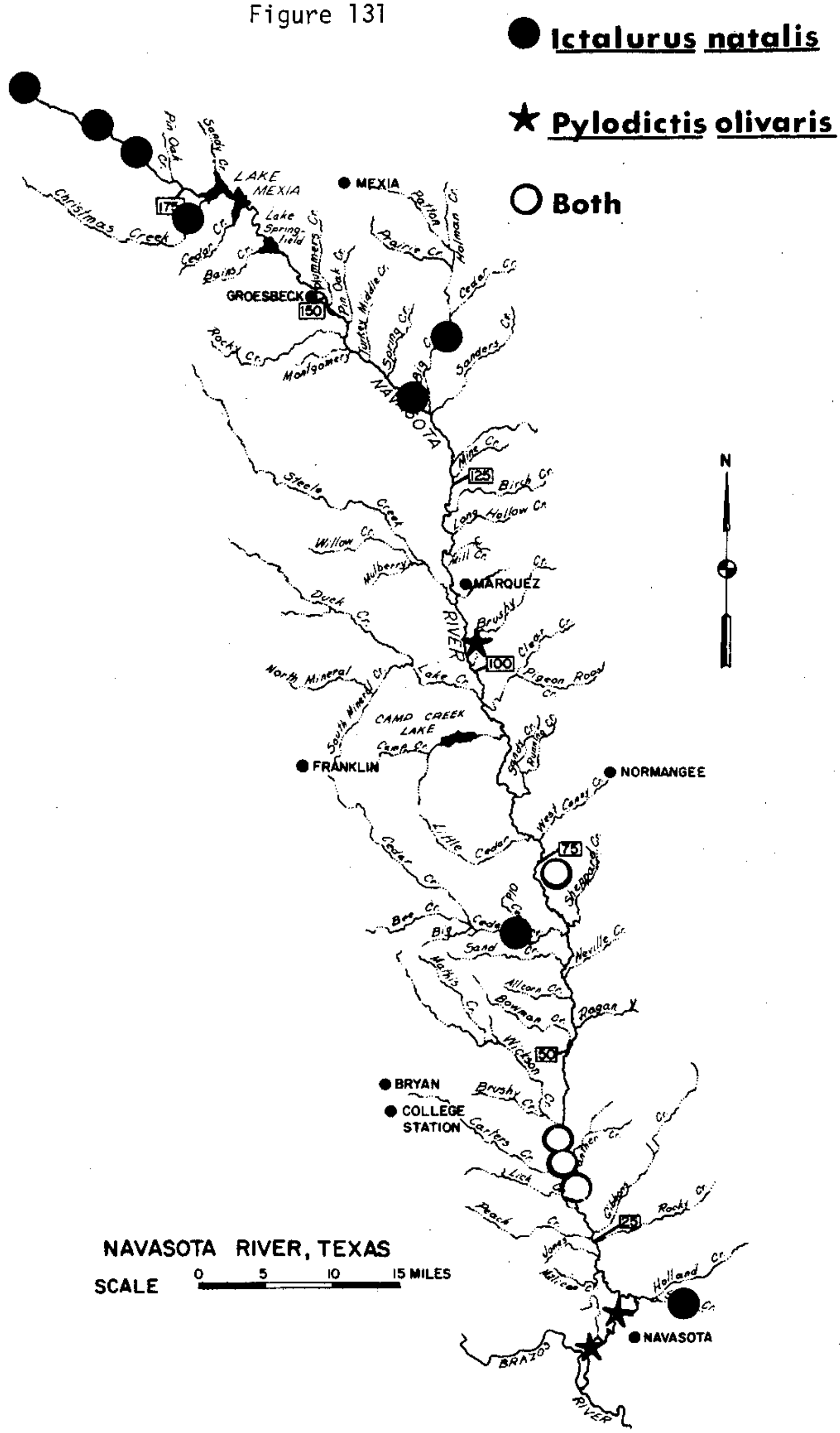

Ictalurus furcatus
Ictalurus melas
Both
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS
RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0
5
10
15 MILES

Figure 131



Ictalurus natalis
Pylodictis olivaris
Both
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
NAVASOTA RIVER
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 132

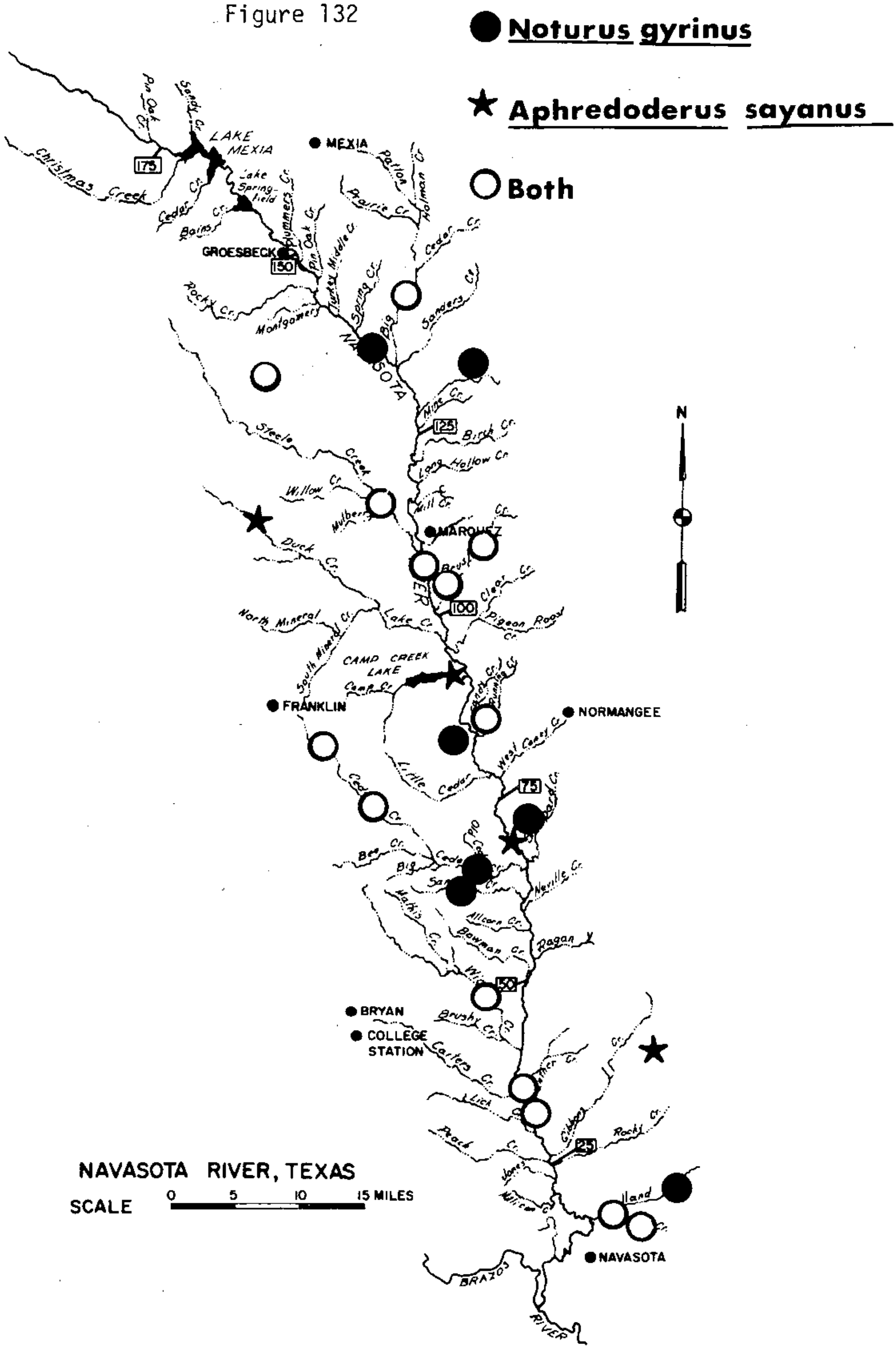

Noturus gyrinus
Aphredoderus sayanus
Both
NAVASOTA RIVER, TEXAS
SCALE
0
5
10
15 MILES
N
LAKE MEXIA
MEXIA
GROESBECK
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS
RIVER
NAVASOTA
175
150
125
100
75
50
25
Christmas Creek
Steele
Creek
Willow Cr.
Duck Cr.
North Mineral Cr.
Lake Cr.
Little Cedar
Bee Cr.
Allcorn Cr.
Bowman Cr.
Brushy Cr.
Carters Cr.
Lick
Peach
Rocky Cr.
Long Hollow Cr.
Birch Cr.
Nine Cr.
Pigeon Roost
West Caney Cr.
Neville Cr.
Rogan
Sanders
Spring Cr.
Montgomery
Rocky Cr.
Prairie Cr.
Holman Cr.
Patton
Cedar Cr.

Figure 133

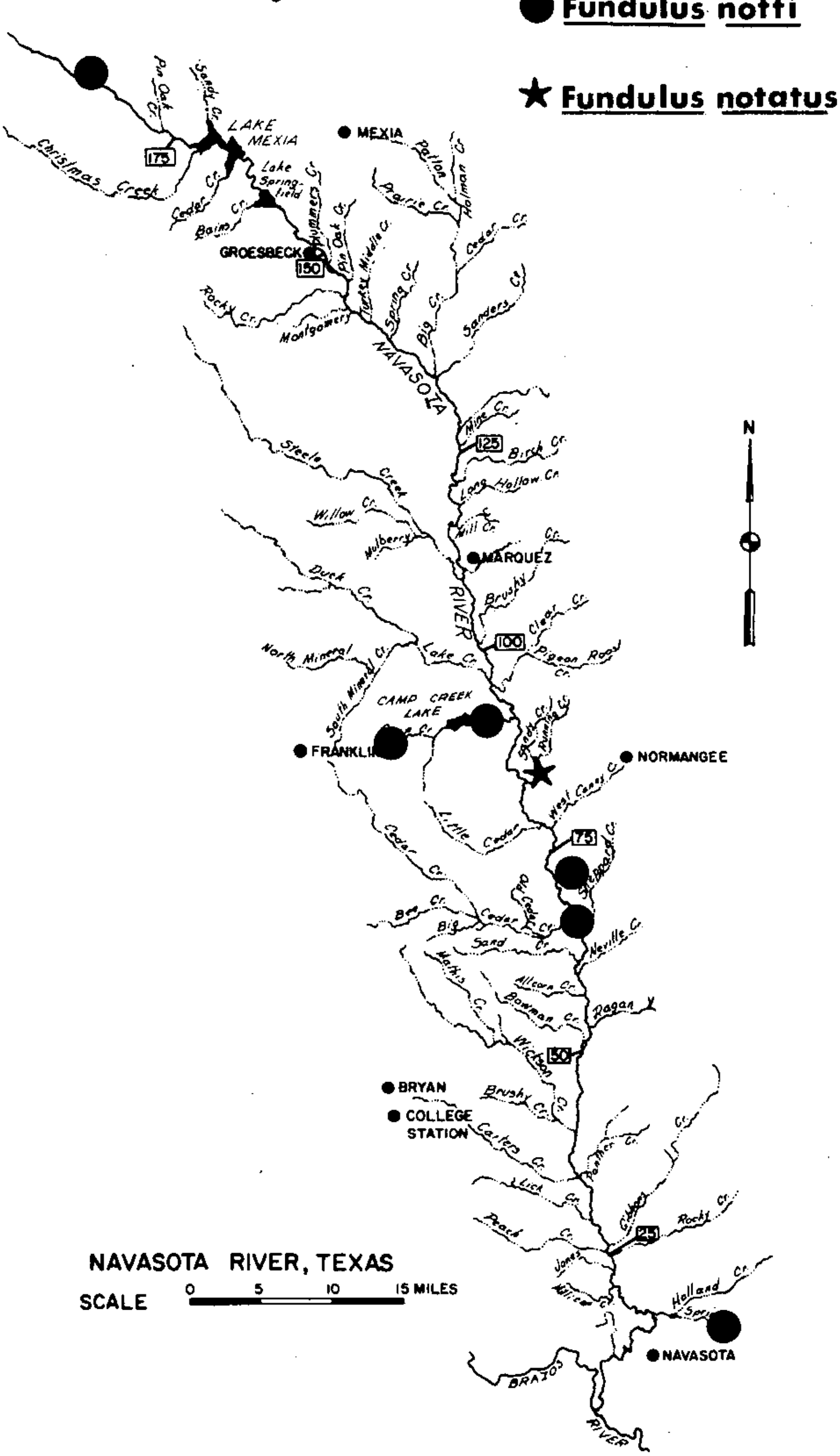

Fundulus notti
Fundulus notatus
LAKE MEXIA
MEXIA
Lake Springfield
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
Christmas Creek
Steele Creek
Duck Cr.
North Mineral Cr.
South Mineral Cr.
Lake Cr.
Little Cedar
Cedar Cr.
Big Sand Cr.
Allcorn Cr.
Bowman Cr.
Wickson Cr.
Brushy Cr.
Carters Cr.
Lick Cr.
Peach Cr.
Holland Cr.
Rocky Cr.
Sanders Cr.
Navasota River, Texas
SCALE 0 5 10 15 MILES
N

Figure 134

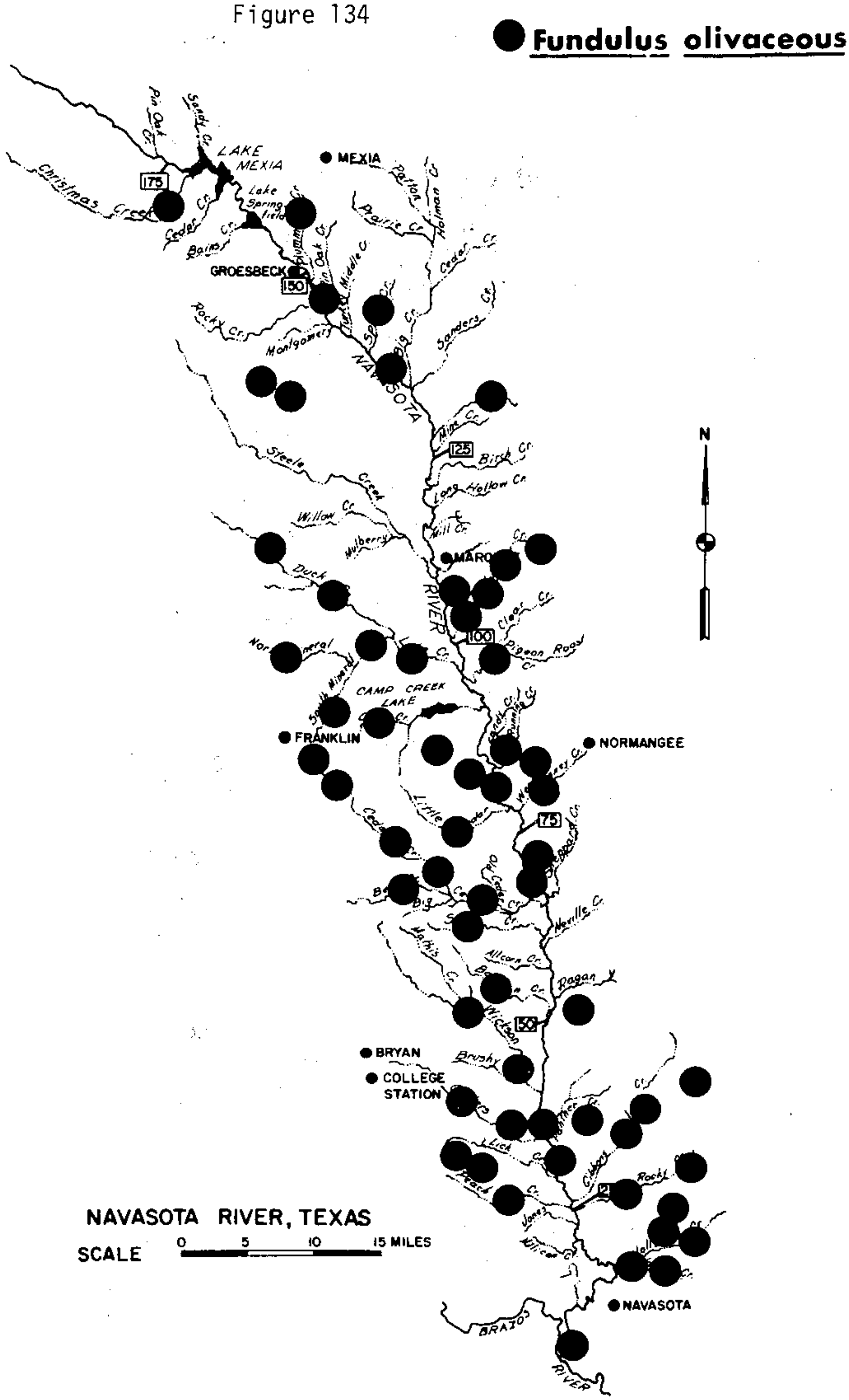

Fundulus olivaceous
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA RIVER
FRANKLIN
NORMANGEE
CAMP CREEK LAKE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 135

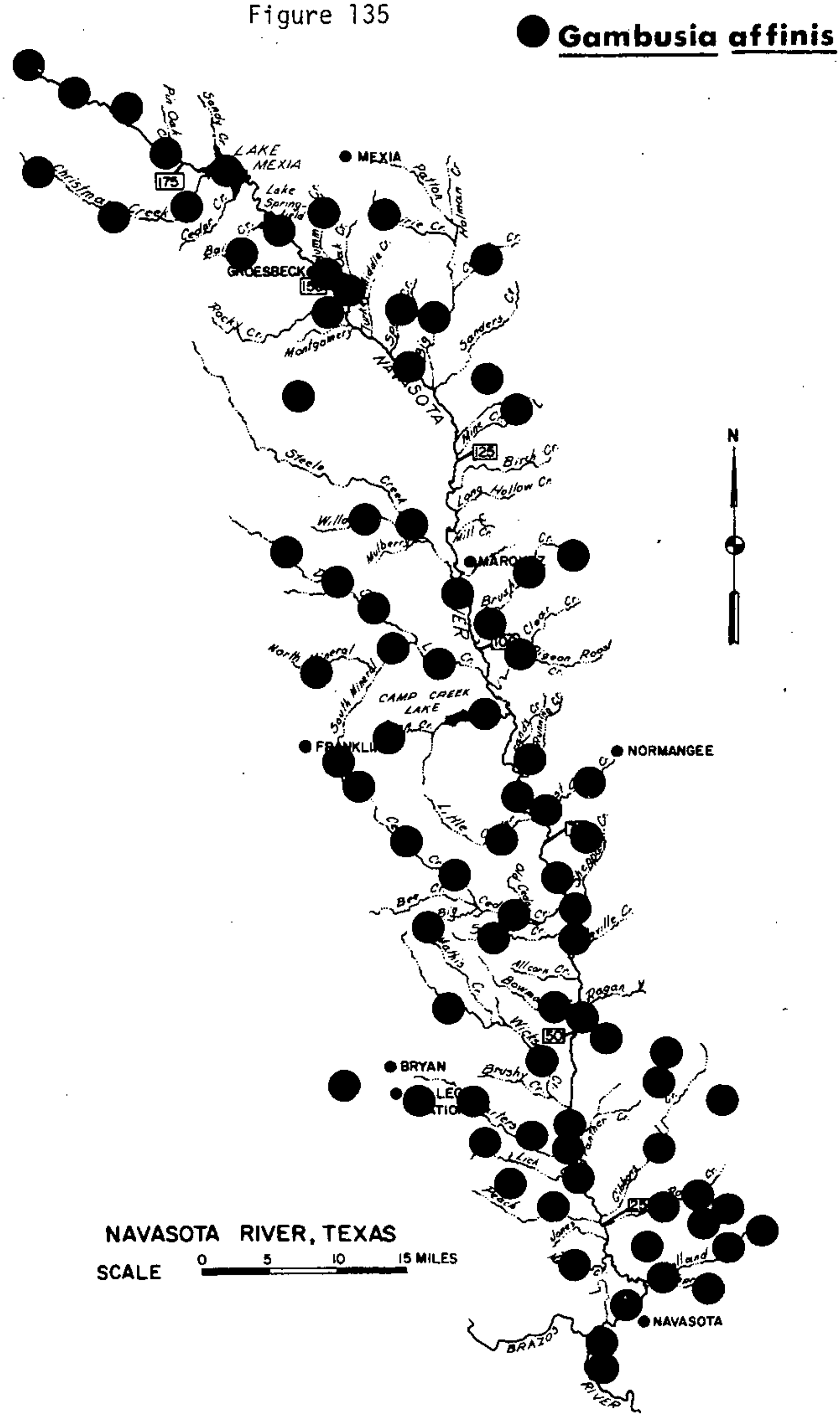

Gambusia affinis
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
NORMANGEE
CAMP CREEK LAKE
BRYAN
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 136

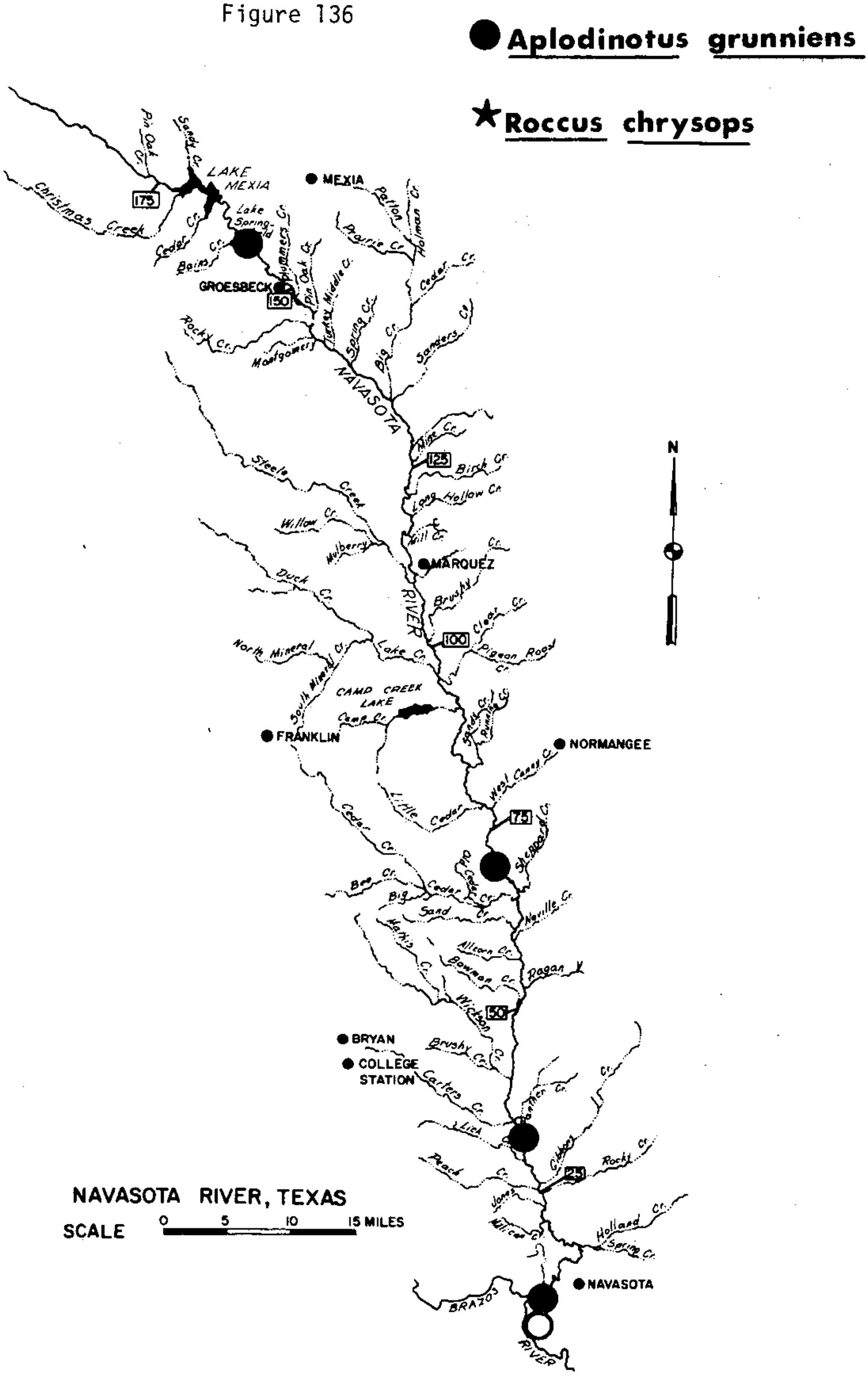

Aplodinotus grunniens
Roccus chrysops
LAKE MEXIA
MEXIA
Lake Springfield
GROESBECK
175
150
125
100
75
50
25
Pin Oak Cr.
Sandy Cr.
Christmas Creek
Cedar Cr.
Bains Cr.
Patton Cr.
Holman Cr.
Prairie Cr.
Cedar Cr.
Rocky Cr.
Montgomery Cr.
Spring Cr.
Big Cr.
Sanders Cr.
NAVASOTA
RIVER
Birch Cr.
Long Hollow Cr.
Steele Creek
Willow Cr.
Mulberry Cr.
Mill Cr.
MARQUEZ
Brushy Cr.
Duck Cr.
Clear Cr.
Pigeon Roost Cr.
North Mineral Cr.
South Mineral Cr.
Lake Cr.
CAMP CREEK LAKE
Camp Cr.
FRANKLIN
NORMANGEE
West Caney Cr.
Little Cedar Cr.
Cedar Cr.
Shepherd Cr.
Bee Cr.
Big Sand Cr.
Neville Cr.
Allcorn Cr.
Bowman Cr.
Dagan Cr.
Wickson Cr.
BRYAN
COLLEGE STATION
Brushy Cr.
Carters Cr.
Lick Cr.
Peach Cr.
Rocky Cr.
Holland Cr.
Spring Cr.
NAVASOTA
BRAZOS
RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 137

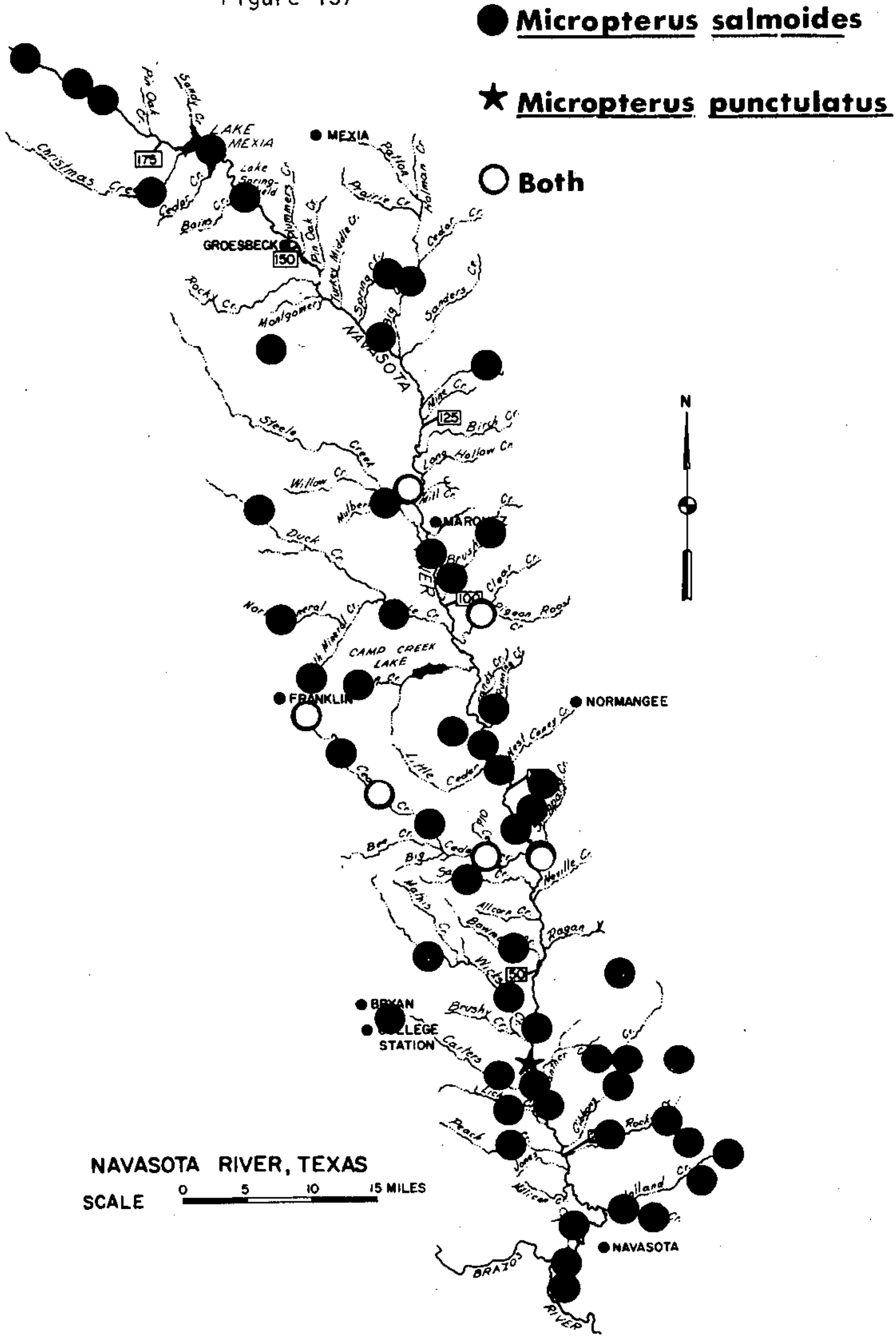

Micropterus salmoides
Micropterus punctulatus
Both
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES
N
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
NORMANGEE
FRANKLIN
CAMP CREEK LAKE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS
RIVER
Christmas Cr.
Pin Oak Cr.
Sandy Cr.
Steele Creek
Willow Cr.
Duck Cr.
Long Hollow Cr.
Birch Cr.
Clear Cr.
Pigeon Roost Cr.
Little Cedar Cr.
Neville Cr.
Allcorn Cr.
Brushy Cr.
Peach Cr.
Holland Cr.

Figure 138

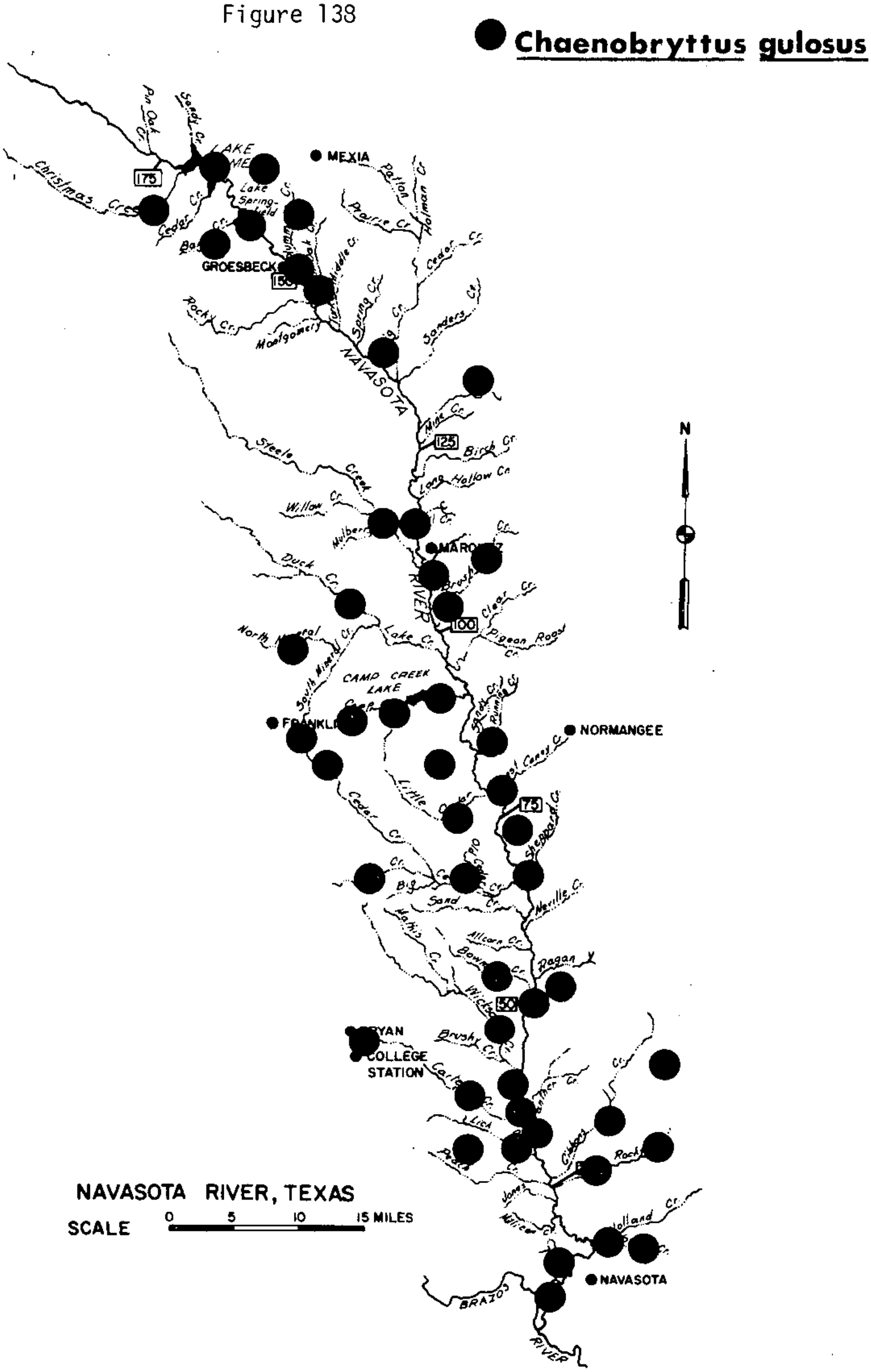

Chaenobryttus gulosus
MEXIA
GROESBECK
NAVASOTA RIVER
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
CAMP CREEK LAKE
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES
N

Figure 139

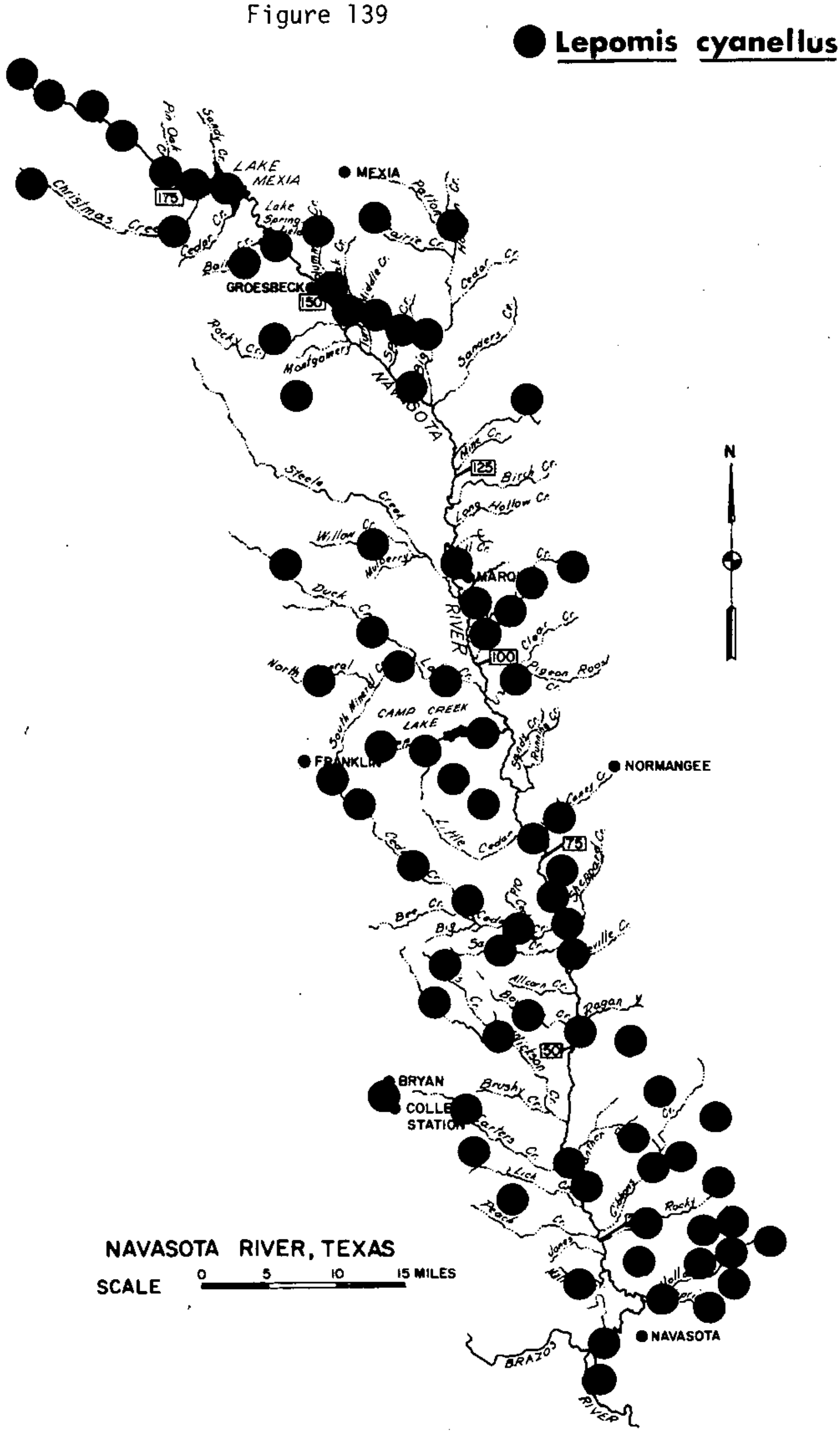
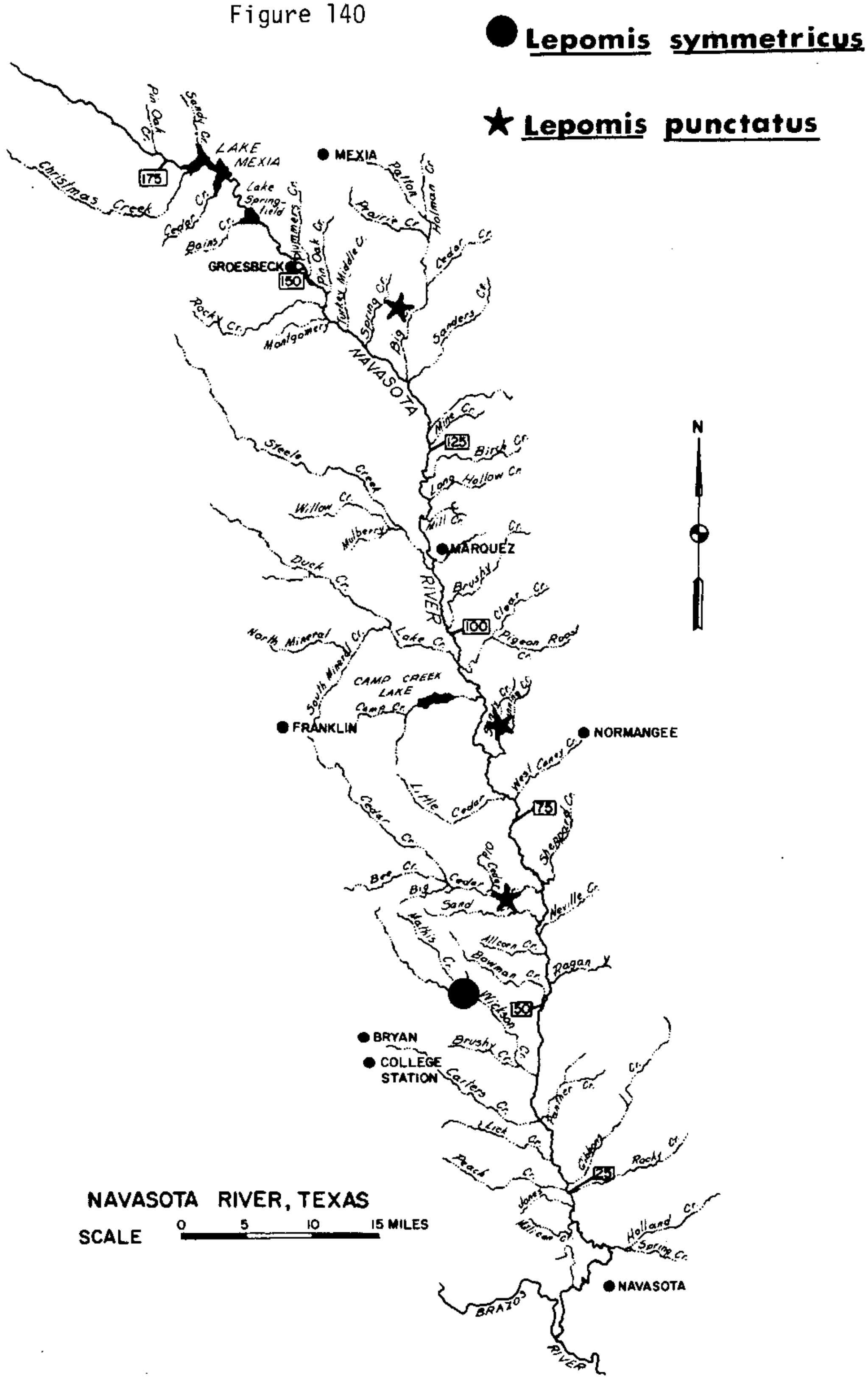
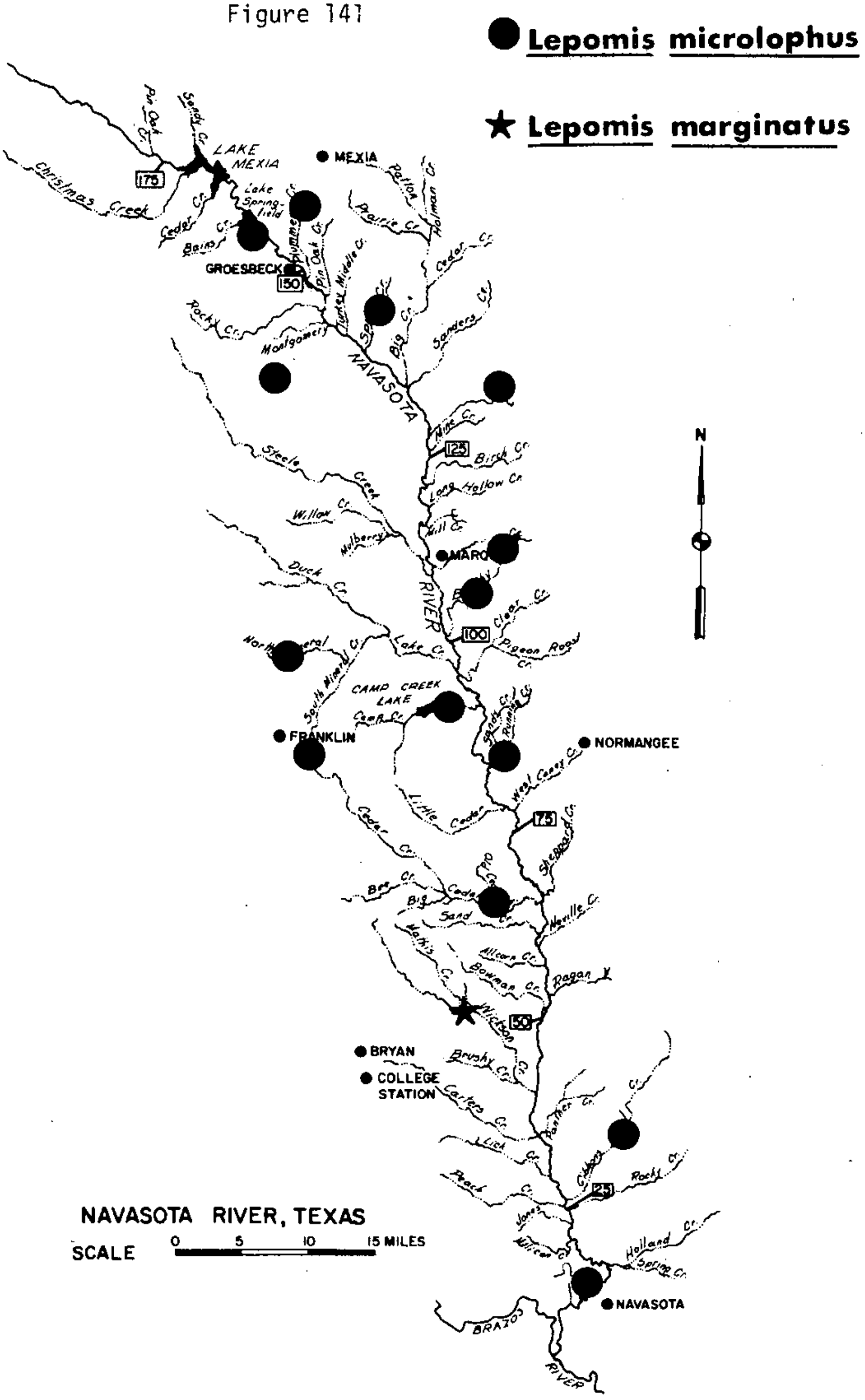

Lepomis cyanellus
LAKE MEXIA
MEXIA
GROESBECK
Christmas Creek
NAVASOTA
RIVER
CAMP CREEK LAKE
NORMANGEE
BRYAN
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 140



● Lepomis symmetricus
★ Lepomis punctatus
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 141



Lepomis microlophus
Lepomis marginatus
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES

Figure 142

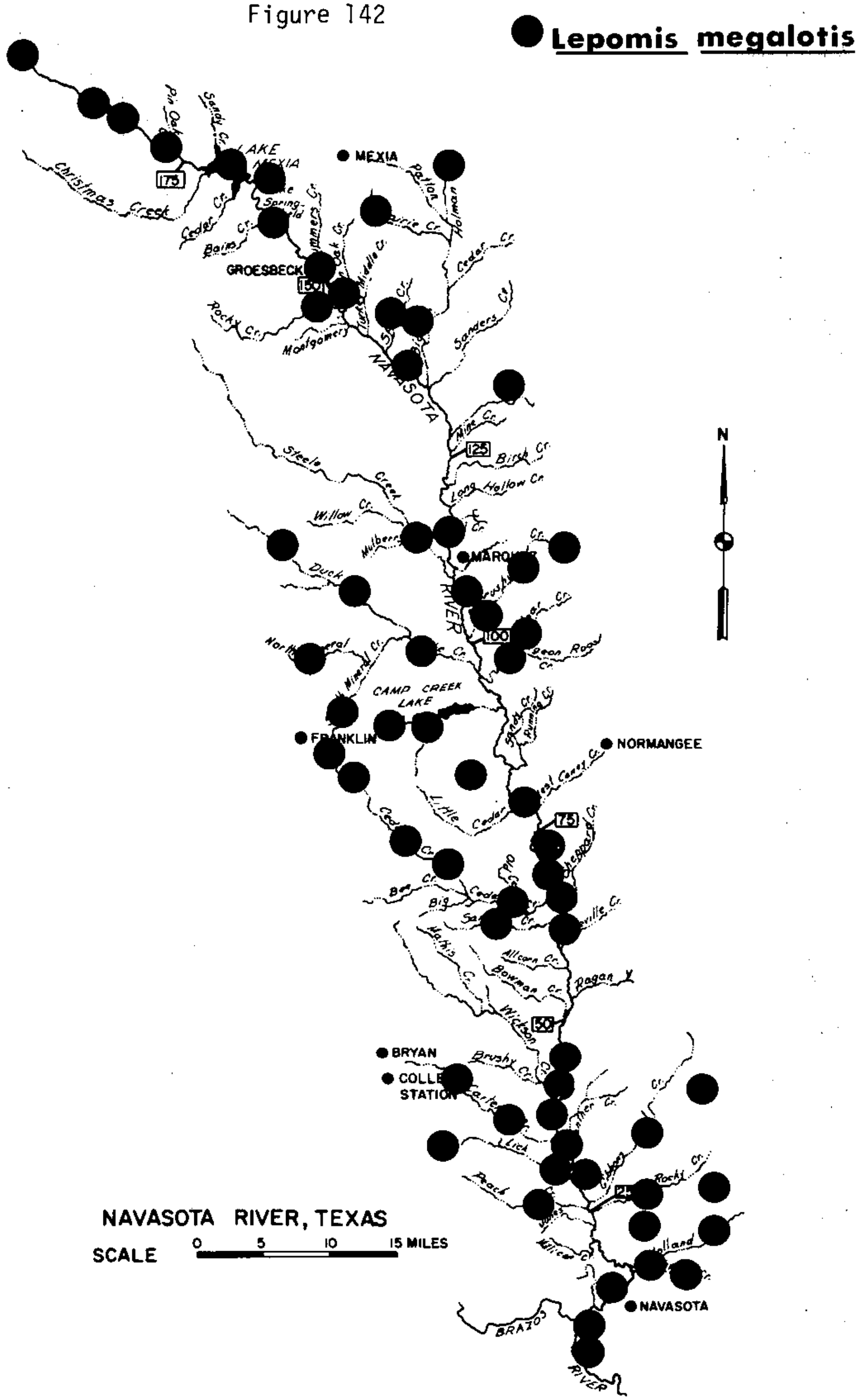

Lepomis megalotis
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES

Figure 143

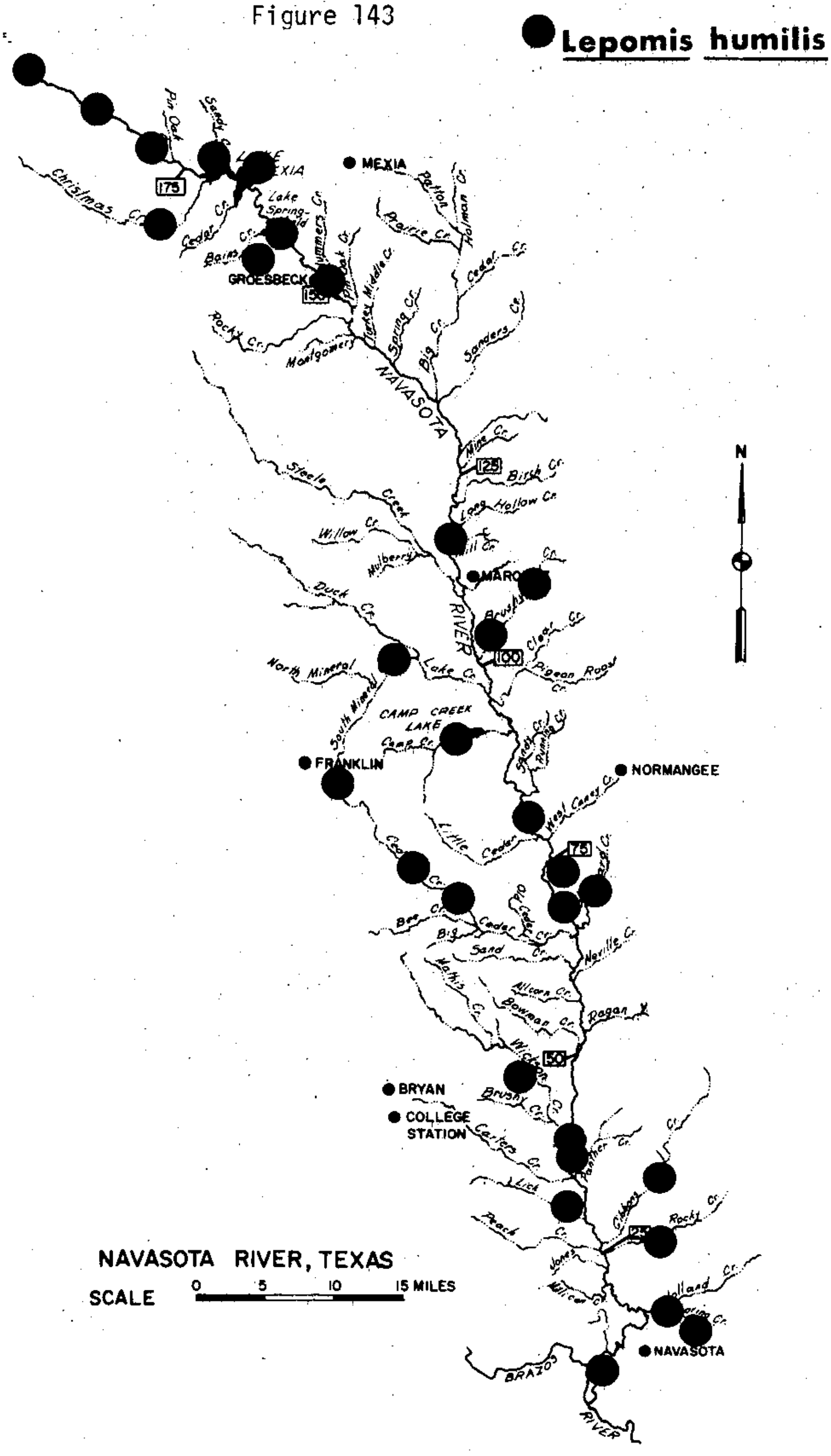

Lepomis humilis
NAVASOTA RIVER, TEXAS
SCALE 0 5 10 15 MILES
N
MEXIA
GROESBECK
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
NAVASOTA RIVER
BRAZOS RIVER
CAMP CREEK LAKE
Christmas Cr.
Steele Creek
Willow Cr.
Duck Cr.
North Mineral
South Mineral
Lake Cr.
Camp Cr.
Little Cedar
Big Cedar Cr.
Bee Cr.
Sand Cr.
Allcorn Cr.
Bowman Cr.
Neville Cr.
Wickson Cr.
Brushy Cr.
Carters Cr.
Lick
Peach
Jones
Rocky Cr.
Holland Cr.
Prairie Cr.
Holman Cr.
Patton
Cedar Cr.
Sanders Cr.
Big Cr.
Spring Cr.
Montgomery
Rocky Cr.
Nine Cr.
Birch Cr.
Long Hollow Cr.
Mulberry
Clear Cr.
Pigeon Roost Cr.
Gibbons
175
125
100
75
50
25

Figure 144

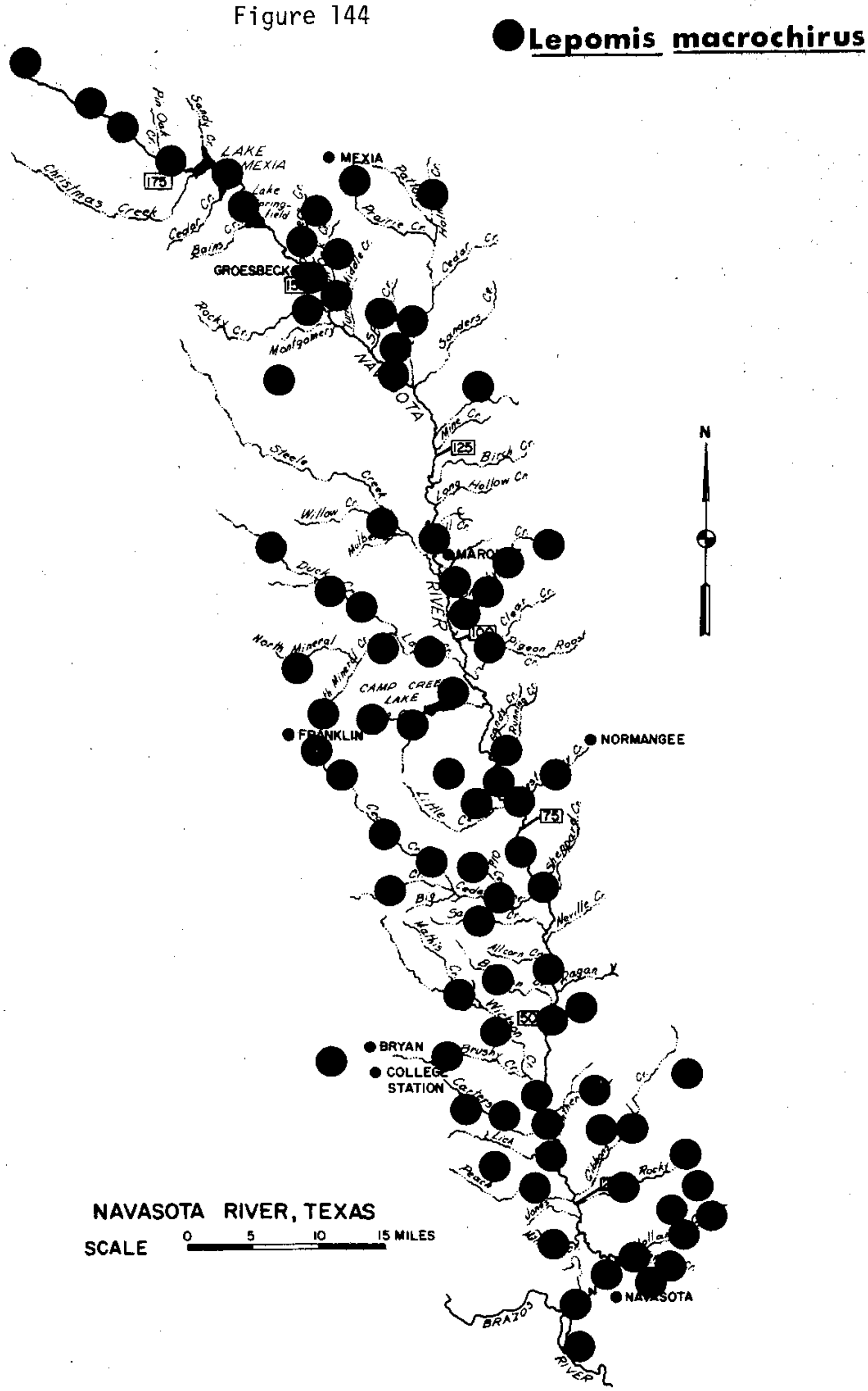
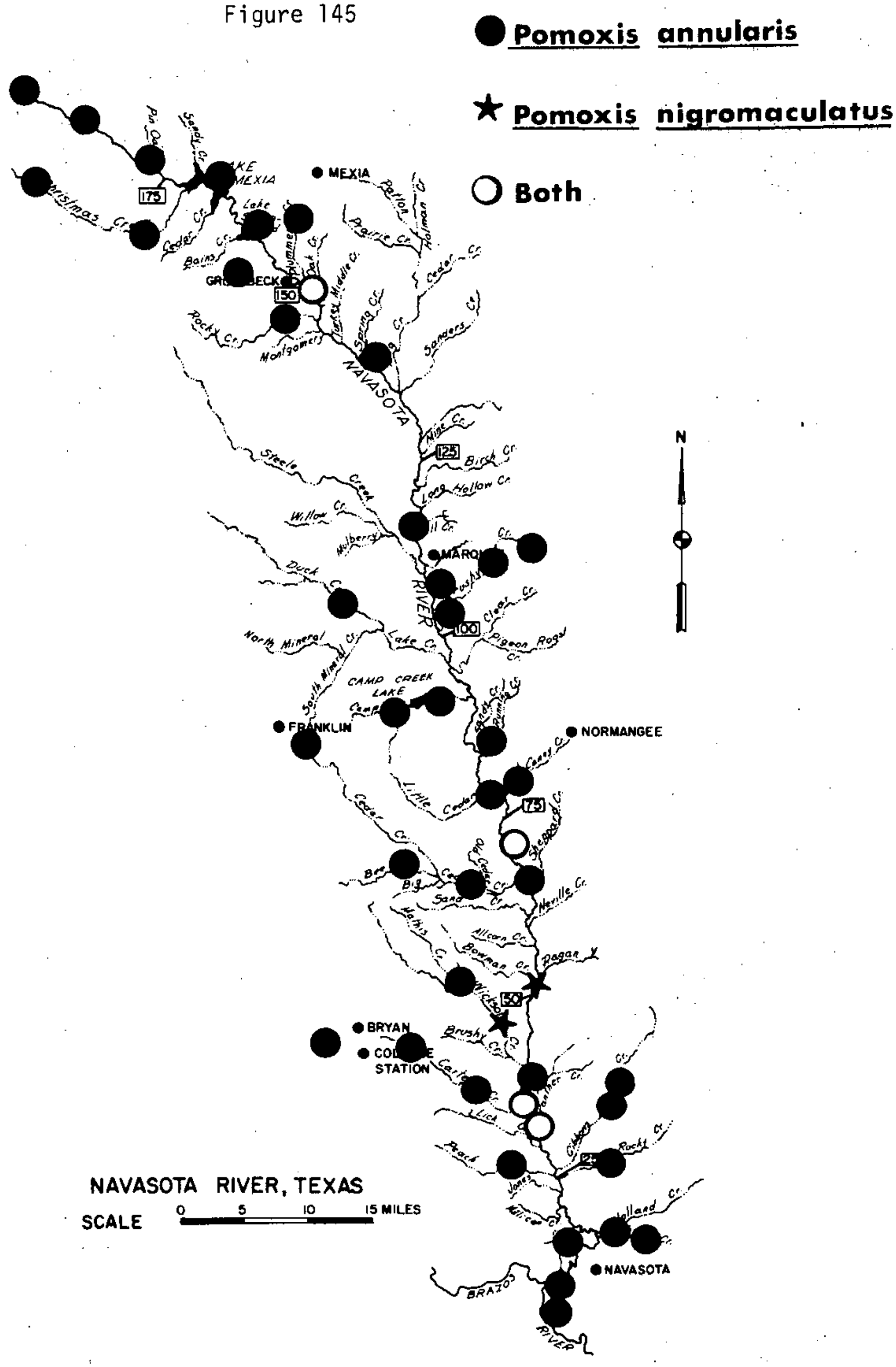

Lepomis macrochirus
LAKE MEXIA
MEXIA
Christmas Creek
Cedar Cr.
Sandy Cr.
Pin Oak Cr.
Prairie Cr.
GROESBECK
Rocky Cr.
Montgomery
Sanders Cr.
NAVASOTA
Mine Cr.
Birch Cr.
Long Hollow Cr.
Steele Creek
Willow Cr.
N
Duck
Clear Cr.
North Mineral
Pigeon Roost Cr.
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
Little
Big
Neville Cr.
Allcorn Cr.
BRYAN
Brushy Cr.
COLLEGE STATION
Lick
Peach
Rocky
NAVASOTA
BRAZOS
RIVER
NAVASOTA RIVER, TEXAS
SCALE
0
5
10
15 MILES

Figure 145



Pomoxis annularis
Pomoxis nigromaculatus
Both
MEXIA
FRANKLIN
NORMANGEE
BRYAN
STATION
NAVASOTA
NAVASOTA RIVER, TEXAS
SCALE
0 5 10 15 MILES
N

Figure 146

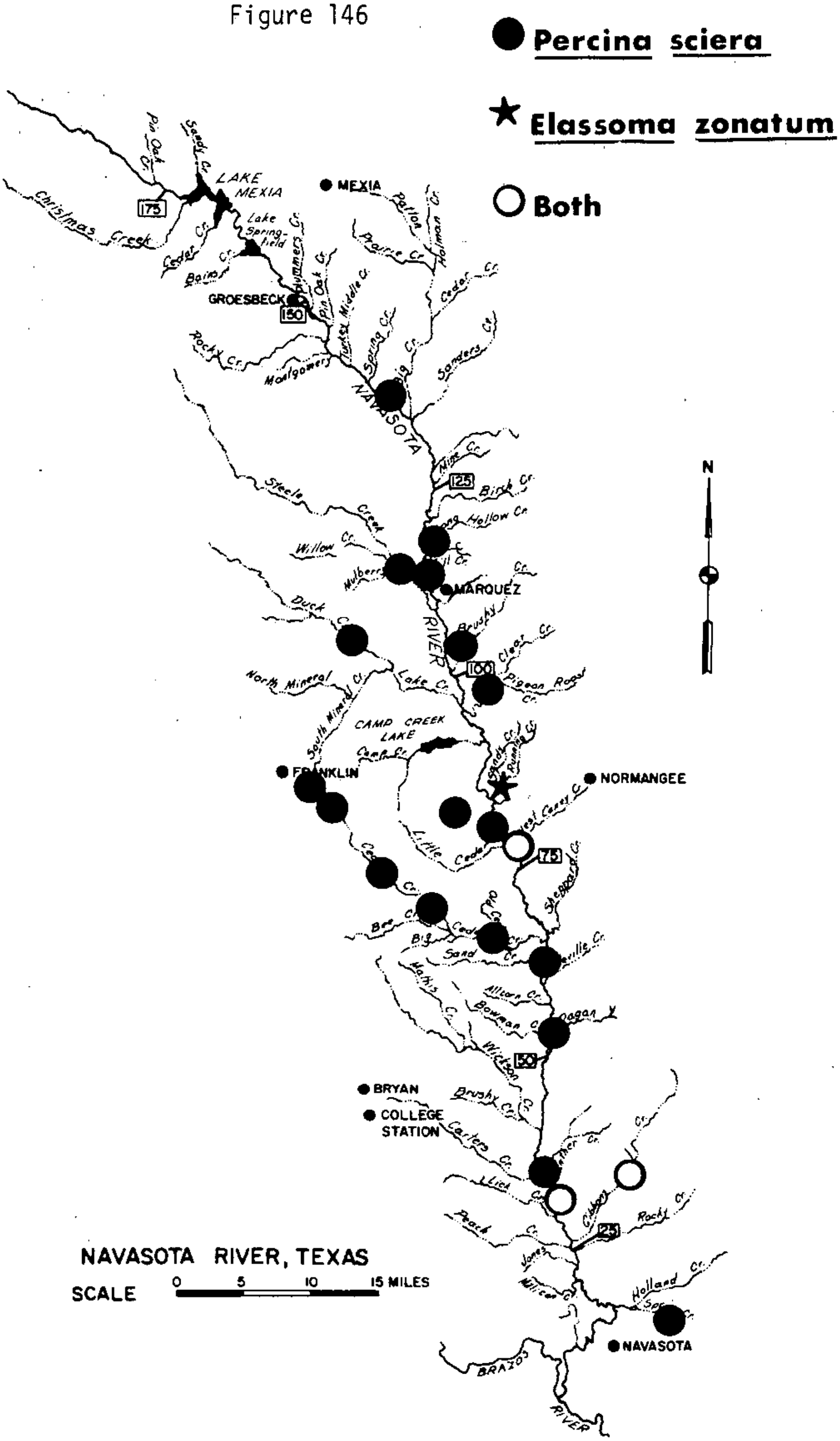
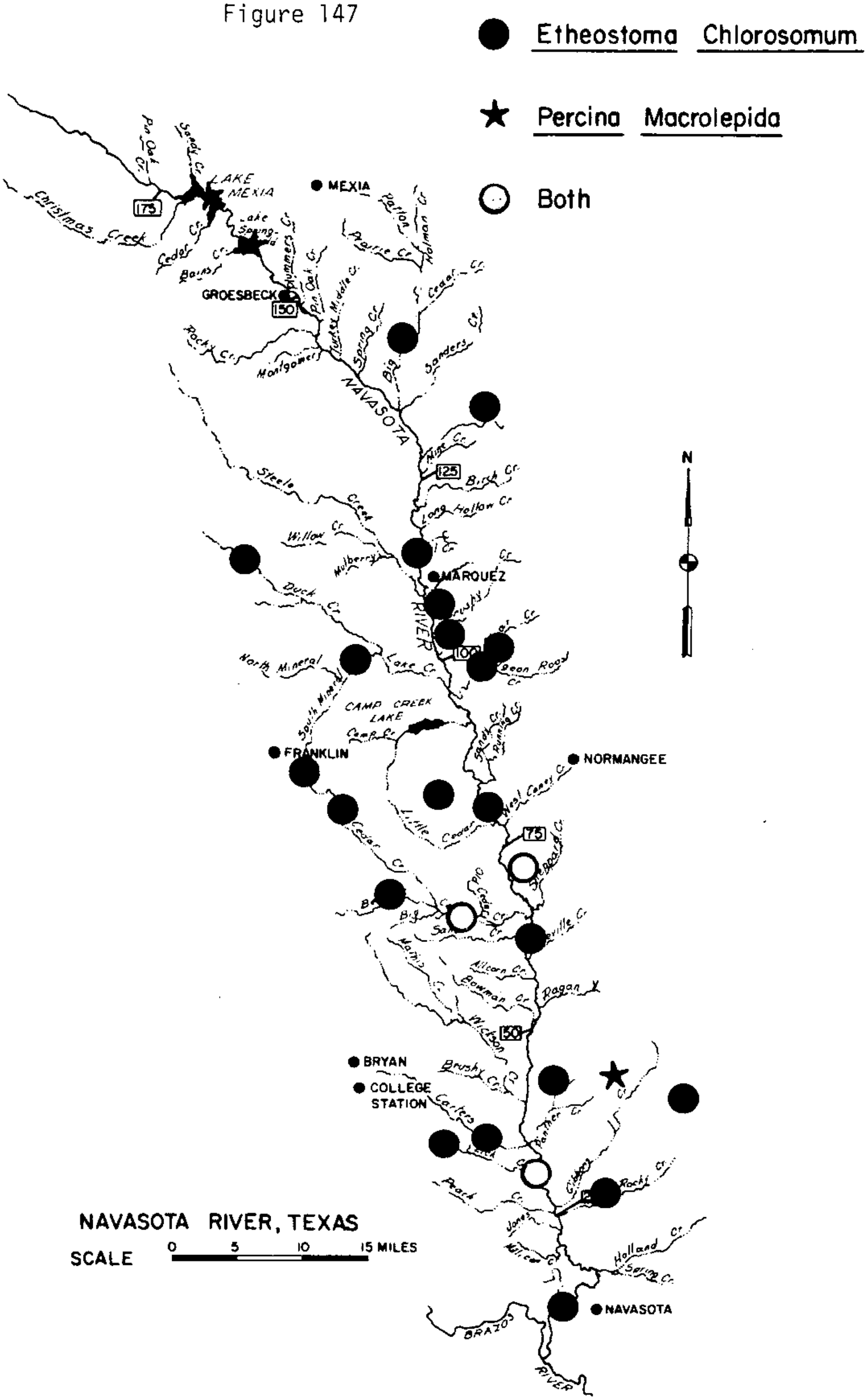

Percina sciera
Elassoma zonatum
Both
LAKE MEXIA
MEXIA
Lake Springfield
GROESBECK
Christmas Creek
Pin Oak Cr.
Sandy Cr.
Cedar Cr.
Prairie Cr.
Holman Cr.
Rocky Cr.
Montgomery
Spring Cr.
Big Cr.
Sanders Cr.
NAVASOTA
RIVER
Steele Creek
Willow Cr.
Birch Cr.
MARQUEZ
Duck Cr.
Brushy
Clear Cr.
Pigeon Roost Cr.
North Mineral Cr.
Lake Cr.
CAMP CREEK LAKE
Camp Cr.
FRANKLIN
NORMANGEE
Little Cedar
Big Sand Cr.
Allcorn Cr.
Bowman Cr.
Wickson Cr.
BRYAN
COLLEGE STATION
Brushy Cr.
Carters Cr.
Peach Cr.
Rocky Cr.
Holland Cr.
NAVASOTA
BRAZOS RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0
5
10
15 MILES

Figure 147


Etheostoma Chlorosomum
Percina Macrolepida
Both
LAKE MEXIA
MEXIA
GROESBECK
NAVASOTA
RIVER
MARQUEZ
CAMP CREEK LAKE
FRANKLIN
NORMANGEE
BRYAN
COLLEGE STATION
NAVASOTA
BRAZOS
RIVER
N
NAVASOTA RIVER, TEXAS
SCALE
0
5
10
15 MILES

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