CENTRAL HUDSON GAS & ELECTRIC CORPORATION
CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
NIAGARA MOHAWK POWER CORPORATION

50-3/247/286

ROSETON/DANSKAMMER POINT GENERATING STATIONS
AQUATIC ECOLOGY STUDIES
1971 – 1972

OCTOBER 1973

QUIRK, LAWLER AND MATUSKY ENGINEERS
ENVIRONMENTAL SCIENCE & ENGINEERING CONSULTANTS
415 ROUTE 303
TAPPAN, NEW YORK 10983

10729

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COMPUTER APPLICATIONS

October 1, 1973
File: 176-8

Mr. Charles E. Rider,
Vice President - Administration,
Central Hudson Gas & Electric Corporation,
284 South Avenue,
Poughkeepsie, New York 12602

Dear Mr. Rider,

In accordance with authorization from Central Hudson Gas & Electric Corporation, we are submitting our report on aquatic ecology studies on the Hudson River conducted during 1971 and 1972 in the vicinity of the Roseton and Danskammer Point Generating Stations. These studies consist of investigations of chemical and physical characteristics of the Hudson River and the distribution and abundance of plankton, benthos, fish and fish larvae. In addition to the report, appendices containing the detailed data resulting from these studies, are included.

The report is intended principally to summarize the data collected during 1971 and 1972. Although tentative or partial conclusions drawn from such data are cited in some instances, final conclusions based on more complete analysis will be deferred until publication of a comprehensive report in early 1974, which will include consideration of the data collected during 1973.

In addition to the investigations noted above, studies of the impingement of fish on the travelling screens at the Danskammer Point Generating Station were conducted in 1972. The results of those studies are reported in a companion volume to this report.

Dr. Robert T. Keegan served as Project Manager for these studies. Mr. Thomas Gustainis, Project Biologist, and Mr. Thomas P. Fox, Project Engineer, were responsible for the biological and engineering phases, respectively, of these studies.

For your convenience, we have preceded this report with a summary of study results.

Very truly yours,

John P. Lawler

John P. Lawler

JPL/RTK/SH

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SUMMARY OF STUDY RESULTS

SUMMARY OF STUDY RESULTS

A. GENERAL

1. The results of studies conducted in 1971 and 1972 by Quirk, Lawler and Matusky Engineers on the aquatic ecology of the Hudson River in the vicinity of the Roseton and Danskammer Point Generating Station are presented in this report.

2. These studies consist of investigations of plankton, benthos, fish, fish larvae distribution and abundance and chemical and physical studies of the Hudson River.

3. The report is intended principally to summarize the data collected during 1971 and 1972. Although tentative or partial conclusions drawn from such data are cited in some instances, final conclusions based on more complete analysis will be deferred until publication of a comprehensive report in early 1974, which will include consideration of the data collected during 1973.

4. In addition to the investigations noted above, studies of the impingement of fish on the traveling screens at the Danskammer Point Generating Station were conducted in 1972. The results of those studies are reported in a companion volume to this report.

5. As described herein the pre-operational report will define the aquatic ecology of this area of the River and relate this to the aquatic ecology of the Hudson River as a whole.

B. PLANKTON

1. Diatoms (Bacillariophyceae) were the dominant component of the phytoplankton and displayed maximum densities in the Fall. The predominant species for both years included members of the genera Coscinodiscus, Cyclotella and Melosira .

2. Blue-green algae (Cyanophyceaceae) were not observed in substantial numbers in light of the relatively high nutrient levels. Their densities dominated the community structure on few occasions, in particular a pulse of Aphanizomenon in August of 1971.

3. Concentrations of potential problem algae were observed to be below the level creating cause for concern.

4. The zooplankton community displayed seasonal abundance inversely related to the phytoplankton. Species of copepod nauplii and rotifers generally dominated the community structure.

5. Differences in the magnitude of plankton densities were observed between 1971 and 1972; the phytoplankton of 1972 was higher than that of 1971; but the zooplankton of 1971 was of higher densities than that of 1972.

6. Comparison of the population densities indicated that the plankton community was not significantly different between the sampling locations. Significant differences in plankton abundance was observed between sampling dates.

C. BENTHOS

1. The dominant benthic organisms collected in 1971-1972 in the Roseton area were oligochaetes and dipterans. Organism density was generally highest at the locations nearest the proposed discharge, which may be related to the influence of a tributary at that location.

2. Density distribution with depth was statistically significant only for the oligochaetes which had highest densities at the 20ft. depth.

3. Dipteran density was highest in the Winter and lowest in the Spring. The other organisms had highest densities during the Spring and lowest in the Fall.

4. Community structure of the sampling stations appeared more similar to each other during the Spring and more dissimilar in the Fall. Diversity indices were generally higher at the North and South Control locations.

5. The fish support potential of the area calculated on the basis of benthos biomass shows an annual average production of more than 300mg of fish flesh per 0.25ft^2 bottom area. This is lower than river areas about 30 miles north and south of Roseton. The density of fish in equal catch efforts reflects such differences between Roseton and these areas.

6. Organisms generally associated with both fresh water and estuarine waters were collected. The nature of the benthos in the Roseton vicinity may be transitional between a fresh water and estuarine character. This situation may be responsible for the low density and biomass of benthic organisms in comparison to areas farther north (more fresh water) or south (more estuarine).

D. FISH

1. Three types of fish communities in the Hudson River were found in the Roseton/Danskammer Point vicinity:

   (a) juvenile blueback herring and bay anchovy that reside in the surface waters of the channel;

   (b) white perch of a number of age groups, tomcod and occasionally hogchokers and spottail shiners, found near the river bottom; and

   (c) pumpkinseed, banded killifish, white perch, spottail shiner, and golden shiner found in the shallow cove area north of the Danskammer plant.

2. The shore community composition near the discharge of the Danskammer plant fluctuates on a seasonal basis. The maximum number of species occupied this area in the Spring and Fall. Few, if any, fish remained in this area in mid-Summer.

3. The two most prevalent species in the Hudson River near the Roseton plant were white perch and Atlantic tomcod. Adult white perch were particularly abundant during the Spring spawning season, while the young-of-the-year of both species were abundant from Summer through the Fall. Adult tomcod appeared in early December.

4. Scale analysis of white perch indicated that the age composition ranged up to age group VII,with the majority below age group V.

5. A length distribution of adult tomcod showed that the majority of the December immigrants were in age group I,with some possibly in age group II.

6. Growth of the juvenile white perch continues through October up to late November and declines for juvenile tomcod in July.

E. FISH LARVAE

1. The period of larval occurrence at Roseton in 1972 extended from the initiation of sampling in mid-May until the end of July, with peak concentrations occurring in June.

2. The larvae occurring in greatest concentrations at Roseton were the white perch and river herring (Alosa).

3. Spawning of white perch occurred primarily in the eastern part of the River at Roseton from mid-May until mid-June. Maximum concentra-

tions of perch occurred in the first half of June and inclined rapidly thereafter. White perch larvae occurred primarily in mid-depth and bottom samples.

4. River herring (Alosa) were found to occur at Roseton between May 24 and July 13. Data suggests two distinct groups of fish spawning in the area, one of the east side of the River during late May and early June and another on the west side from mid to late June. Alosa larvae were found in highest concentrations in surface samples.

5. A total of striped bass larvae (out of a total of 1073 larvae) were collected from late May to mid-June at the Roseton sampling stations. All but one striped bass larva occurred in bottom samples.

6. Striped bass occurred in very low concentrations throughout the River.

7. Larval pumps were found capable of collecting larvae in intake and discharge structures, but most larvae were found to be in either mangled or distressed conditions. It is believed that improved design will eliminate or reduce such damage.

F. CHEMICAL AND PHYSICAL STUDIES

1. The Hudson River fresh water flow increased from 1967 until the present survey period of 1971 and 1972. 1971 and 1972 were consistently high water years with the majority of the high flows occurring in the spring months with the low flow months of August,

September and October approximating average low flow conditions. This result made possible the observation of average low flow conditions in the survey area, as well as extreme high flow periods.

2. During periods of flow greater than approximately 7,000 cfs, the water quality in the Roseton/Danskammer area (MP 65) will be determined by upstream conditions. During the average low flow conditions of approximately 6,000 cfs, during the Summer and Fall months, the survey area should be considered a transition zone; the point where the water quality changes from predominantly fresh water (and constant) to estuarine (and variable). During extreme low flow conditions, this area would be subject to much greater degrees of salt water intrusion and its associated change in water quality and in the character of fish, plankton and benthic populations.

3. During average low flow conditions, the water quality in the Roseton/Danskammer area might become unacceptable for drinking purposes, but remain acceptable for the majority of uses. The Danskammer Point Generating Station uses Hudson River water as process water and during an average year, the water quality should be acceptable for process water. During lower than average Summer conditions, the water quality might become unacceptable for continuous use as process water and modifications to the process water treatment system could become necessary.

4. During the majority of an average year, the aquatic community is subject to fresh water conditions, while in portions of the Summer and Fall (August, September and October), the community is subject

to variable and unstable conditions. This result would be especially true during periods of lower than average water flow such as drought conditions. In these periods, the aquatic community would be subject to much increased saline conditions, and, in fact, may change the character of the aquatic community.

I. INTRODUCTION

I. INTRODUCTION

A. PURPOSE AND SCOPE OF 1971-1972 STUDIES

The results of aquatic ecology studies conducted for Central Hudson Gas & Electric Corporation (CHGE) in the vicinity (see Figure I-1) of the Roseton and Danskammer Point Generating Station during 1971 and 1972 by Quirk, Lawler and Matusky Engineers (QLM) are presented herein. These and other biological and engineering studies shown in Table I-1 were conducted in conjunction with CHGE's application to the New York State Department of Environmental Conservation to discharge heated waters from the Roseton plant to the Hudson River beginning in mid-1972.

This report considers those programs conducted by QLM in 1971 and 1972. A similar report to be submitted to CHGE in early 1974 will be the pre-operational report on the Hudson River aquatic ecology in the Roseton/Danskammer Point vicinity. As such that report will consider:

1. studies conducted by QLM in 1971-1973 in the Roseton/Danskammer Point vicinity;
2. studies conducted by other organizations, e.g. Oceanographic Analysts, Marist College, Dutchess Community College, in this vicinity; and
3. studies conducted on the Hudson River aquatic ecology by QLM and other organizations, e.g. Texas Instruments, New York University, Boyce Thomson Research Institute.

TABLE I-1

ENGINEERING AND ECOLOGICAL INVESTIGATIONS AT THE ROSETON AND DANSKAMMER POINT GENERATING STATIONS

Effect of Roseton Plant Cooling Water Discharge on Hudson River Temperature Distribution and Ecology, Quirk, Lawler & Matusky Engineers and Oceanographic Analysts, Inc., December 1969.

Hydrothermal Model Studies for Roseton Generating Station, Alden Research Laboratories, April 1972.

A Comparative Study of the Aquatic Life in the Hudson River at Danskammer Point and Howland, M. Pierce, 1971.

The Effect of Increased Temperature Upon the Acute Toxicity of Some Heavy Metal Ions, R. Rehwoldt, L. Menapace, B. Nerrie and D. Allessandrello, Environmental Science Program, Marist College, February 1972.

A Microfaunal and Microfloral Population Investigation of the Hudson River in the Vicinity of Roseton, A. E. Feldman, Dutchess Community College, December 1971.

Entrainment Investigations at a Fossil-Fueled, Steam-Electric Plant, R. W. Barnett and R. Tillman, Dutchess Community College, 1973.

The culmination of consideration of the entire spectrum of studies conducted on the Hudson River will permit an evaluation of the pre-operational aquatic ecology in the Roseton/Danskammer Point vicinity. The methodology and techniques to be employed in conducting this evaluation are described in a later section.

The purpose of these studies, in addition to studies conducted in 1969 (Quirk, Lawler and Matusky Engineers and Oceanographic Analysts, Inc., 1969) was to initiate programs to investigate the characteristics of the ecology of the aquatic community in the Roseton/Danskammer Point area prior to commercial operation of the Roseton Generating Station. The pre-operational studies in conjunction with similar post-operational studies, are to be utilized to assess the environmental impact of the Roseton plant.

As this report indicates, the scope of the Roseton pre-operational studies has changed considerably since 1969. Oceanographic Analysts, Inc.'s initial study in 1969 was limited in time and intensity of effort. As information became available and further questions arose, the duration and intensity of effort directed at the aquatic community were substantially increased.

The aquatic ecology programs conducted in 1971 were of a qualitative nature, i.e. the scope of the program was to establish the major components of the aquatic community in this area. In mid-1971 these programs were revised to be of a more quantitative nature to keep pace with the increased concern for environmental impact and protection.

B. SCOPE AND NATURE OF 1973 STUDIES

Further studies have been undertaken in 1973 to complement those studies conducted in 1971 and 1972. As previously indicated the Roseton plant had been originally scheduled to be in commercial operation by mid-1972. The studies reported for 1971 and 1972 would therefore have consisted of both pre- and post-operational data.

Unforeseen delays in completion of construction of the Roseton plant have resulted in commercial operation to be scheduled for late 1973 or early 1974. Pre-operational information will therefore consist of data collected in 1971, 1972 and 1973 as well as from earlier studies by Oceanographic Analysts, Inc. The intensive pre-operational information available and its ultimate use in assessing both the pre-operational ecology of the area and the post-operational plant impact is discussed in a later section of this chapter.

A summary of the aquatic ecology programs to be conducted in 1973 in the Roseton/Danskammer Point vicinity is presented in Table I-2. Sampling station locations generally encompass, as a minimum, those stations sampled in 1971 and 1972. Furthermore both field laboratory analysis techniques are similar for all sampling programs. Therefore, the 1973 studies, although of a greater intensity of effort than the 1971 and 1972 studies, are consistent and comparable.

TABLE I-2

SUMMARY OF CENTRAL HUDSON GAS & ELECTRIC CORPORATION 1973 AQUATIC ECOLOGY STUDIES IN THE ROSETON/DANSKAMMER POINT VICINITY

Study Area	Sampling Frequency	Field Gear	Comments
Fish			
1. Population sampling	Once per month, day and night throughout open-water season.	Trawl, seine, gill net, trap net.	
2. Larvae (entrainment)	Twice per month (approximately every 14 days) from April through August.	1.0 and 0.5 meter nets located in plant intakes and discharges and in River.	Survival studies conducted in the field.
3. Stomach collections	Minimum of seasonal (spring, summer, fall, winter).	Seines, trawls, trap nets.	The stomachs are collected in conjunction with collections of benthos.
4. Fecundity	During fish spawning periods (which vary with the species).	Gill nets, seines, trap nets, impingement screens, etc.	
Benthos			
1. Collection	Monthly.	Ponar grab.	Analysis will proceed on those collections that most approximate in time the 1972 collections. The remaining samples will serve as backup for data refinement if necessary.
2. Sediment mapping	At least once, or more often if possible per year.	Sediment corer.	

TABLE I-2
(continued)

Study Area	Sampling Frequency	Field Gear	Comments
Plankton			
1. Phytoplankton and microzooplankton	Twice per month with approximately 14-day separation during open-water season.	.Nanoplankton net .#20 mesh Wisconsin net .Bottles for whole water samples.	Laboratory analysis will proceed on samples that coincide with 1972 collection. The remaining samples will serve as backup for data refinement if necessary.
2. Macrozooplankton	Same frequency and location as larvae samples.		
Littoral Studies	Minimum of once per year, in August.	Tools for obtaining plants and observations of area.	The survey is designed to coincide with maximum development of the plants (usually mid-summer). Other surveys may be conducted during spawning periods primarily for observation and evaluation of embayments and tributaries.
Impingement	Approximately every 14 days on a yearly basis for 24-hour duration.	Travelling screen and River collections.	The sampling frequency will be increased during "critical" periods. Survival studies of impinged fish are to be conducted during the impingement collections.
Miscellaneous			Preliminary work will be conducted in the following areas: 1. Productivity measures 2. Bioassays 3. Periphyton

C. METHODOLOGY FOR PRE-OPERATIONAL EVALUATION

As indicated previously the pre-operational report for the Roseton Generating Station will be prepared in early 1974. That report will evaluate the pre-operational aquatic ecology in the Roseton vicinity and will consider studies conducted by QLM in 1971, 1972 and 1973, in addition similar studies conducted at other sites on the Hudson River.

The following is a description of analytical procedures and theoretical considerations which will be applied to the data available to afford an overview of the ecological communities which function in this area of the Hudson River.

The data presented in this report afford an insight into two distinct types of biotic functions of the estuary: first, to support transitory or highly motile communities, such as communities of fish eggs and larvae, or juvenile fishes or adult fishes as they occupy, for varying periods of time, the specific zone of the river under study. Second, to support permanent, relatively immobile communities which are continually present within a section of the system and which cannot, of their own, depart.

The potential impact of a power generating station on each of these groups is distinctly different. On the one hand one has seasonally abundant forms (fish eggs, larvae, juveniles and adults) which either occupy a zone for very brief periods of time, or, may actively vacate a zone, or avoid the same, if conditions are unfavorable. On the other hand, one has the benthos and the plankton, both of which are restricted to a section of the estuary; neither of which can actively relocate, should conditions become undesirable, or lethal.

Worthy of particular note is the fact that the true plankton and the benthos perform the most essential ecologic functions in a system: phytoplankton fix carbon into energy-rich organic molecules to sustain all other life forms in the system; zooplankters oonvert the phytoplankton to animal biomass which is the principle medium of energy transfer in the system; many benthic organisms provide for nutrient balance in the system by utilizing the wastes of other organisms, increasing the rate of decomposition and assisting in nutrient recycling.

In the present report, particular attention is given to analytical treatment of benthic and plankton data. Careful characterization of these communities establishes site-specific base-line data not subject to the complexities of factors which influence the presence or absence, distribution and abundances, diversity and stability of other groups. Indeed, the constancy of these communities dictates that significant environmental change shall be detected if present. While many transitory species may tolerate environmental alteration yet fail to remain in a changing zone, one can never conclude as to a cause-effect relationship. Significant changes in an immobile population, on the other hand, cannot be misinterpreted.

The pre-operational report will be based upon these studies and the pre-operational data gathered in 1973. The objective of the pre-operational report shall be to integrate, as fully as possible, all components of the biotic and abiotic environment present in the Hudson River at Roseton. In the present report, statistical procedures are applied primarily to the fixed communities; the plankton and the benthos. Sampling design employed in 1973 studies was such that similar statistical procedures may be applied to all the groups under study. Statistical and mathematical analytical techniques have been designed to interrelate all sections of the biota in integrated form. Procedures to be employed include:

Studies of population dynamics and the mechanics of biotic/chemical inter-relationships.

Community structure based upon trophic-dynamic consideration.

Community interaction based upon competition/predation/antagonism concepts of maintaining a mutual community stability.

Ecosystem matrix studies of community interactions.

Placed in the concept of a whole, i.e. the Hudson River Estuary, it is anticipated that the pre-operational report will constitute a difinitive description of the Hudson River Estuary as a unit ecosystem.

D. PREVIOUS STUDIES OF THE HUDSON RIVER AQUATIC ECOLOGY

One of the most important and necessary functions of research conducted on a large, ever-changing system such as the Hudson River Estuary is that a data base be built so that subsequent changes in the ecosystem can be discerned and evaluated. Without such a data base, statements concerning increased pollution, environmental degradation and changes in the species composition and abundance of organisms are subjective and non-comparative.

A brief summary of major biological studies conducted on the Hudson River is presented below. A similar summary of physical/chemical studies is presented in the physical/chemical section of this report. Although studies have been conducted on the Hudson River since the late 1800's only recent work is considered in this summary.

The first major work in recent times to supply baseline data of a general biological nature on the lower Hudson watershed was carried out by the New York Conservation Department in 1937 (Moore, et al, 1937). This work provided valuable background information on Hudson River fish species and their parasites, water quality, food chains and aquatic vegetation.

The next peak in biological studies on the Hudson River came during the 1950's in answer to the need for analysis of the mechanisms involved in determining shad abundance. Fecundity, or the productivity of the individual female shad measured by egg counts, was studied in an effort to determine the reproductive potential of the Hudson River shad population (Lehman, 1953). From 1954 to 1958 three papers appeared which discussed the possible factors associated with fluctuations in shad abundance, and the general consensus was that commercial overfishing was the main problem rather than pollution (Talbot, 1954; Burdick, 1954; Nichols, 1958).

During approximately the same time,attention was focused on the striped bass, another commercially important fish species found in the Hudson. Migratory and racial studies indicated that the reaches of the Hudson River north of Croton Point produced a race of striped bass morphologically different from that found in Chesapeake Bay and other, more southern areas of striped bass production. In addition, tagging studies demonstrated that the Hudson River is important in supplying the striped bass needed for the valuable sport fishery located in the western quarter of Long Island Sound (Raney and deSylva, 1953; Raney, et.al. 1954).

During 1955 the spawning grounds of the striped bass in the Hudson River were defined to include the area from Bear Mountain upriver to Cruger Island, with the most intense spawning occurring in the vicinity of West Point. The most important juvenile nursery ground for striped bass lay in the brackish water portion between Newburgh and the George Washington Bridge (Rathjen and Miller, 1957).

In 1966 the first of three Hudson River Symposias took place and, although the emphasis was on chemical and physical aspects of the Hudson, two papers were presented on fish and fish egg distribution (Perlmutter, et. al., 1966; Grim, 1966), and one paper on fish stomach analysis and invertebrate distribution in the Hudson (Hirschfield and Rachlin, 1966). These papers provide a certain amount of survey type information, although the actual stimulus for the studies arose from concern about the radioecological situation in relation to nuclear power plants.

Results of striped bass tagging study along the northeast Atlantic Coast from 1959-1963 were published in 1968, and the Hudson River was thought to be a major spawning river and source of recruitment for striped bass populations of Long Island Sound and the New York Bight (Clark, 1968).

The life histories of the migrating anadromous fish such as shad, sturgeon, and striped bass was described (Clark and Smith, 1969) and information was presented on larval fish and eggs in relation to the proposed pump storage plant at Cornwall (Carlson and McCann, 1969). Papers on fluctuations in fish populations on a diurnal and a seasonal basis were also presented, (Perlmutter, et. al. 1969; Heller and Hermo, 1969).

Research on the Hudson from 1969 through the early 1970's was mainly characterized by studies sponsored by representatives of the power generation industry. In 1969 a study on the effect of Roseton plant discharge on Hudson River ecology was published (Quirk, Lawler and Matusky Engineers and Oceanographic Analysts, Inc., 1969). Similar studies were conducted at the Lovett and Bowline Point Generating Stations (Quirk, Lawler and Matusky Engineers, 1971). The Indian Point area was also studied during this time by the Raytheon Company (Raytheon, Inc., 1972). All of these reports contain biological information on fish, benthos, plankton and their relationship to thermal discharges and other possible impacts from power plant operation.

Supplementing these comprehensive studies specific work was carried out by Marist College and Dutchess Community College under the auspices of Central Hudson Gas & Electric Corporation. The work included studies on the toxicity of heavy metal ions to benthic organisms (Rehwoldt, et. al., 1971), the effect of increased temperature on metal ion toxicity (Rehwoldt,et. al., 1972), and aquatic studies on plankton and benthos in the Roseton/Danskammer area (Feldman, 1971; Pierce, 1971).

An unusual addendum to the conventional biological surveys generally performed for aquatic studies on the Hudson was the formulation of a mathematical model to evaluate the effect of entrainment and impingement at several power facilities on the population of Hudson River striped bass (Lawler, 1972). Construction of this model utilized a great deal of the data available for the Atlantic Coast striped bass, and it represents the type of approach necessary to bring large amounts of data into focus.

In conjunction with recent hearings held by the United States Atomic Energy Commission in relation to operation of the Indian Point Nuclear Generating Plant Unit No. 2 an extensive series of documents were prepared that were directed at various phases of the aquatic environment. A tabulation of the majority of these documents is presented in Table I-3.

E. DESCRIPTION OF STUDY AREA

The studies described herein were conducted in the vicinity of Central Hudson Gas & Electric Corporation's Roseton and Danskammer Point Generating Stations. These plants are located on the shore of the Hudson River as shown in Figure I-1, some 65 miles from the Battery.

A summary of the operating characteristics of these plants is presented in Table I-4. The Roseton plant was under construction during the time the studies presented herein were conducted.

TABLE I-3

SELECTED DOCUMENTS PREPARED IN CONJUNCTION WITH INDIAN POINT UNIT 2 OPERATING LICENSE HEARINGS

Testimony of Ronald A. Alevras on The Estimation of Fish Impingement at Indian Point Units 1 and 2, February 5, 1973.

Testimony of Eric Aynsley on Alternatives to One-Through Cooling at Indian Point Unit No. 2, October 30, 1972.

Affidavit of John R. Clark, Calculations of Effects of Roseton and Bowline Plants on Hudson River Aquatic Life, dated October 16, 1972.

Testimony of John R. Clark on Cumulative Effects of Hudson River Power Plants and Other Matters, dated March 30, 1973.

Testimony of John R. Clark on Effects of Indian Point Units 1 and 2 on Hudson River Aquatic Life, October 30, 1972.

Testimony of John Clark on Certain Effects of Once-Through Cooling Systems of Indian Point Units Nos. 1 and 2 on Hudson Estuary Fishes and Their Environment, July 14, 1972.

Testimony of John R. Clark on Effects of Indian Point Units 1 and 2 on Hudson River Aquatic Life, April 5, 1972.

Testimony of John R. Clark on the Feasibility of a Fish Hatchery, April 23, 1973.

Final Environmental Statement Related to Operation of Indian Point Nuclear Generating Plant Unit No. 2, September 1972, Vol. I and II.

Testimony of Dr. C.P. Goodyear and Dr. C.C. Coutant, Direct Biological Effects on Entrained Fish Eggs and Larvae at Indian Point.

Staff Analysis of Artificial Propagation to Replace Hudson River Fishes Killed by Power Plant Operation, April 23, 1973, C. Phillip Goodyear.

Testimony of Gerald J. Lauer, James T. McFadden, Edward C. Raney on Impact of Impingement at Indian Point Units 1 and 2 on Fish Populations in the Hudson River, April 5, 1972.

TABLE I-3 CONT.

SELECTED DOCUMENTS PREPARED IN

CONJUNCTION WITH INDIAN POINT UNIT 2

OPERATING LICENSE HEARINGS

Testimony of Gerald J. Lauer on Effects of Chemical Discharges from Indian Point Units 1 and 2 on Biota and on River Chemistry, April 5, 1972.

Testimony of Gerald J. Lauer on Effects of Operations of Indian Point Units 1 and 2 on Hudson River Biota; October 30, 1972.

Testimony of Gerald J. Lauer on Effects of Elevated Temperature and Entrainment on Hudson River Biota, April 5, 1972.

Testimony of John P. Lawler on Effect of Indian Point Plant on Hudson River Dissolved Oxygen, June 19, 1972.

Testimony of John P. Lawler on Effect of Entrainment and Impingement at Indian Point on the Population of the Hudson River Striped Bass, October 30, 1972.

Testimony of John P. Lawler on Supplemental Study of Effect of Submerged Discharge of Indian Point Cooling Water on Hudson River Temperature Distribution, June 19, 1972.

Testimony of John P. Lawler on The Effect of Indian Point Units 1 and 2 Cooling Water Discharge on Hudson River Temperature Distribution, April 5, 1972.

A Response by John P. Lawler on Additional Information Requested by the Staff on the Temperature Distribution Section in our March 30, 1973 Testimony on Cumulative Effects of Bowline, Roseton and Indian Point Generating Stations on the Hudson River, April 20, 1973.

Testimony of Dr. James T. McFadden on Impact of Entrainment and Impingement at Indian Point 1 and 2 Upon Fish Populations, October 30, 1972.

Testimony of Dr. James T. McFadden, Dean, School of Natural Resources, University of Michigan on Effects on Hudson River Fish Populations of the Simultaneous Operation of Indian Point Units #1 and #2, Plus the Bowline and Roseton Power Plants, dated March 30, 1973.

Testimony of Dr. James T. McFadden and Harry G. Woodbury on Indian Point Studies to Determine the Environmental Effects of Once-Through Vs. Closed-Cycle Cooling at Indian Point Unit No. 2, February 5, 1973.

TABLE I-3 CONT.

SELECTED DOCUMENTS PREPARED IN

CONJUNCTION WITH INDIAN POINT UNIT 2

OPERATING LICENSE HEARINGS

Testimony of Edward C. Raney, Ph.D., on Striped Bass, dated February 5, 1973.

Testimony of Edward C. Raney on The Striped Bass, *Morone saxatilis*, of the Atlantic Coast of the United States With Particular Reference to the Population Found in the Hudson River, October 30, 1972.

Testimony of Dr. Robert E. Stevens, Senior Fish Biologist and Manager of Homestead and Palatka Facilities, Marine Protein Corp., on Feasibility of Stocking the Hudson River with Striped Bass, dated April 5, 1973.

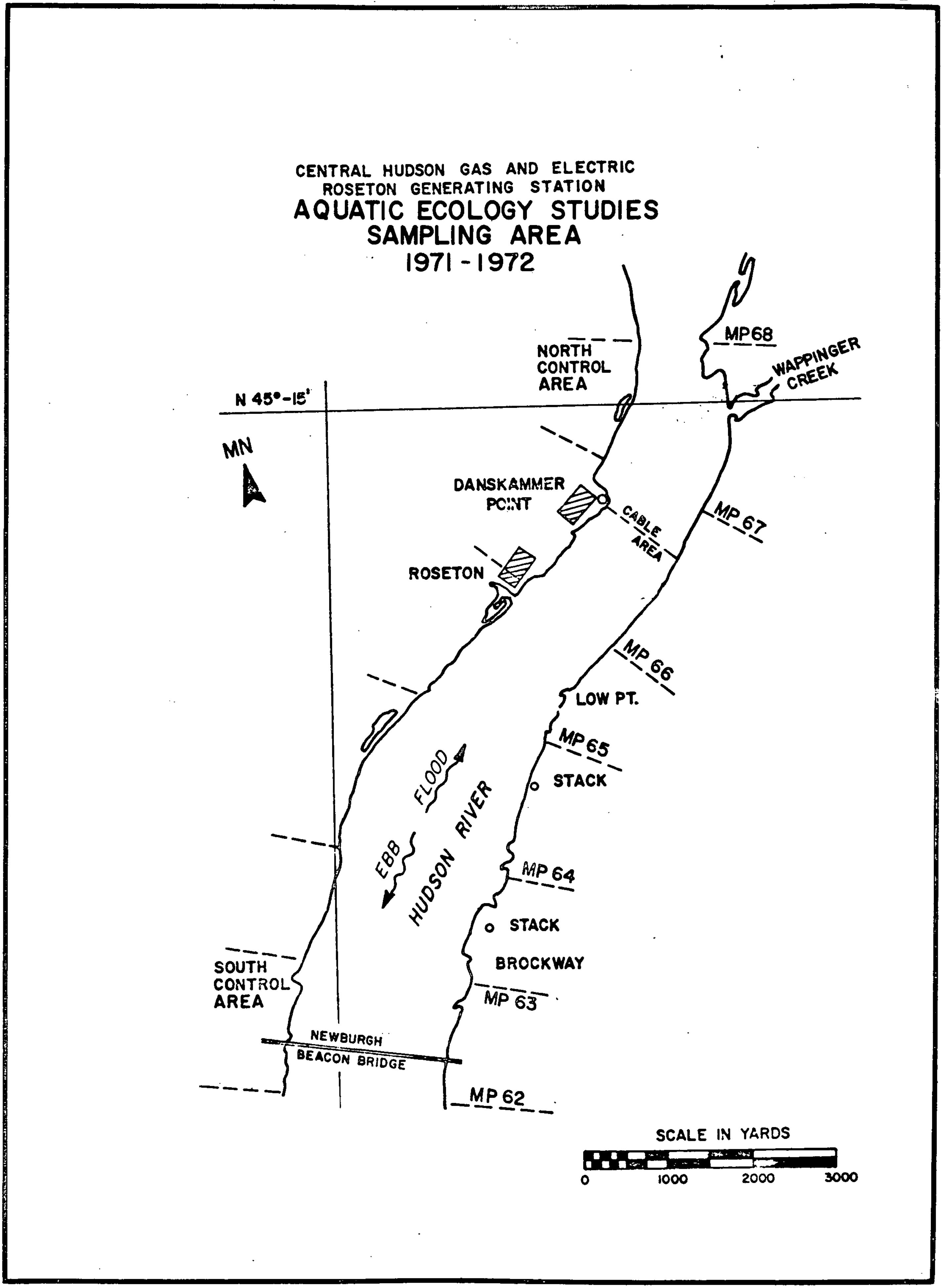
CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
AQUATIC ECOLOGY STUDIES
SAMPLING AREA
1971 - 1972
MP68
NORTH CONTROL AREA
WAPPINGER CREEK
N 45°-15'
MN
DANSKAMMER POINT
CABLE AREA
MP 67
ROSETON
MP 66
LOW PT.
MP 65
FLOOD
STACK
HUDSON RIVER
EBB
MP 64
STACK
BROCKWAY
SOUTH CONTROL AREA
MP 63
NEWBURGH BEACON BRIDGE
MP 62
SCALE IN YARDS
0
1000
2000
3000

TABLE I-4

PLANT OPERATING INFORMATION
ROSETON AND DANSKAMMER POINT GENERATING STATIONS

Description	Danskammer	Roseton
Location of Plants		
. Miles above the Battery	66.0	65.4
. East bank or west bank of the River	West bank	West bank
Size of Plants		
. Number of units	4	2
. Plant total electrical output in MW	511	1,200
. Type of generating units	Fossil	Fossil
Cooling Water System Characteristics		
. Waste heat BBTU/day	54	120
. Cooling water flow GPM	308,000	656,000
. Plant temperature rise °F	14.5	15.4
Description of the Intake Structures	Earlier design	Modern design minimizing fish impingement
Description of the Discharge Structure		
. Type of discharge	Surface discharge	Submerged diffuser
. Jet velocity (if applicable) in fps	-	16

The results of these studies are therefore of a pre-operational character, i.e. the results presented reflect conditions existing in the river prior to the operation of the Roseton plant. It is within this framework, a pre-operational aquatic ecology study, that these studies were conducted.

The ecological survey was conducted in the immediate vicinity of the Roseton and Danskammer Point plants, and as shown in Figure I-1, generally extended approximately 2-1/2 miles North and South of the Roseton plant.

In the vicinity of the two stations the Hudson River is essentially straight, the most prominent feature being Danskammer Point as shown in Figure I-1. Upstream from Danskammer the river gradually bends northward, and Wappinger's Creek runs into the Hudson just south of a contraction at New Hamburg. Downstream from Roseton, the river gradually widens and turns southward. The average river depth and width at the plants are approximately 50 and 3,000 feet, respectively. Maximum summer ambient temperatures are typically 78 to 79°F, and the winter ambient reaches a minimum of 32°F.

River hydraulics are dominated by tidal effects. At the mean yearly stage variation of 2.8 feet from low to high water, the average tidal flow is approximately 150,000 cfs and the maximum ebb or flood flow is approximately 230,000 cfs. The critical summer fresh water runoff (the runoff that would cause the salt front to be in the Roseton/Danskammer Point vicinity) is approximately 6,000 cfs, whereas the minimum 7-day fresh water runoff with a 10-year return period, is estimated to be 3,300 cfs (Quirk, Lawler and Matusky Engineers, 1969). Therefore, the summer fresh water flow typically varies from 4.0 to 2.2 percent of the average tidal flow. Further information on the physical and chemical characteristics of the Hudson in this vicinity are described in later sections of this report.

F. REPORT FORMAT AND CONTENT

The studies reported herein are presented as follows:

Chapter	Subject
II	Plankton
III	Benthos
IV	Fish
V	Fish Larvae
VI	Chemical and Physical Studies

Each chapter presents the study objectives, materials and methods, results and discussion, summary and references cited for each particular phase of investigation. Appendices to the report are as follows:

Appendix A - Roseton/Danskammer Point Plankton Data, 1971-1972

Appendix B - Roseton/Danskammer Point Benthos Data, 1971-1972

Appendix C - Statistical Analysis of Roseton Benthos Data

Appendix D - Roseton/Danskammer Point Fish Data, 1971-1972

Appendix E - Roseton/Danskammer Point Larval Fish Data, 1971-1972

Appendix F - Methods of Chemical Analyses of Water Samples

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II. PLANKTON

II. PLANKTON

A. INTRODUCTION

A study of the plankton community is an essential part of any aquatic ecological study. The organisms in this community are responsible for the input of energy into the aquatic system. The energy input is a result of the process of photosynthesis that can only be performed by plants containing chlorophyll. This energy (food) is transferred from individual to individual by energy associations referred to as food chains.

Free floating plants and animals, generally microscopic in size, are members of the plankton community referred to as phytoplankton and zooplankton. Investigations of these organisms provide biological evaluation of an area because the quality and quantity of an algal flora generally reflects the water quality of the area. However, the phytoplankton are essentially free floaters so the flora observed at a particular point in a flowing body of water are usually reflective of the water quality some distance upstream because of the time it takes the algae to respond to a change in water quality. If the water quality in a flowing body of water is uniform,the flora at any point in the river would be a reflection of the water quality for the whole river.

The Hudson River,being an estuary with substantial industrialization along the shore, is subject to changes in water quality due to salt water intrusion and to the various domestic and industrial discharges along its length.

To understand the dynamics of the phytoplankton community for a given location on the river, knowledge of what is happening farther north and south of the selected site is necessary. Environmental conditions vary from year to year and these variations may, in turn, have a profound influence on the biological communities. Successive years of data are necessary to monitor seasonal and annual fluctuations that are a result of natural environmental changes before the character of a biological community for a given area can be adequately described.

Previous studies by others in the Roseton area have utilized various techniques of analysis. The findings of these studies are valuable in establishing historic biological information for the area but are limited in application for valid comparisons because of the different techniques utilized.

The phytoplankton community in the Roseton area has been recently studied by R.L.Heffner (1972) of New York University, M. Pierce (1971) of Vassar College, A.Feldman (1971) and R. Barnett (1973), both of Dutchess Community College. These studies were primarily directed towards power generating stations, with comparisons of plankton populations both within and beyond the influence of the plants. Largely because of the dramatic effects that could result from the presence of problem algae in great numbers, there was a particular interest in potential problem algae.

B. STUDY OBJECTIVES

Being an essential part of the biological community, the plankton studies conducted in 1971-1972 were oriented towards obtaining quantitative information specific for the Roseton area and comparable to information collected in river areas approximately 30 miles North and South of this site. The program described herein was initiated in mid-1971 and expanded as continuous review of data indicated such revision was necessary. This baseline information will be expanded as the 1973 programs are completed, so that comparisons for evaluation of the plankton community can be conducted to determine if changes occur in plankton structure or abundance after the Roseton plant begins commercial operation.

The term plankton may be sub-divided into several components. In programs described herein, the plankton is divided into four and defined as follows:

1. Phytoplankton - the microscopic plants (algae) that are free floating.
2. Microzooplankton - planktonic animals that pass through a net with 500 micron mesh openings, but are retained in a net with an average mesh size of 76 microns.
3. Macrozooplankton - those animals that are retained in a net with mesh openings of 500 microns.
4. Ichthyoplankton - the larval stages of developing fish from egg to larvae.

The phytoplankton and zooplankton have inter-relationships that can result in density changes of populations and alterations in the community structure (Lindeman, 1943). This plankton study included zooplankton investigations to determine, if possible, the relationships of zooplankton cropping rates and phytoplankton abundance. This is part of the total system approach to understand the inter-effects in the plankton community.

C. METHODS AND MATERIALS

1. Procedures of Collection

Phytoplankton were sampled by pouring five gällons (18.9 liters) of surface water through a Wisconsin style plankton net thereby concentrating the algae. The net consisted of an upper cone supported by two brass rings. A straining bucket, 5.4 cm. in diameter, was attached by a bayonet-type mount to the lower end of the net. A tapered stopper, located in the bottom of the bucket, facilitated sample collections. The net and bucket were nylon mesh, with openings of 18 microns. (An exception to this procedure occurred in the first quantitative collection on August 11, 1973. On this date a vertical tow of twice the Secchi disk reading was conducted with a Wisconsin net having a #20 mesh with 76 micron openings.)

Microzooplankton were sampled by a vertical tow through the water column with a Wisconsin style net. The net was of the same design as the phytoplankton net but with No.20 nylon mesh with openings of 76 microns. The tows were conducted during slack water so that currents did not interfere with the vertical position of the net as it was towed from a known depth to the surface. The net only sampled as it was pulled to the surface. Phytoplankton and microzooplankton samples were taken at the same time and at the same station.

2. Preservation of Samples

All samples were preserved in the field with 5-10% formalin.

3. Sampling Station Locations

Four stations were established at selected distances from the Roseton plant and were referred to as Northwest, Northeast, Southwest, and Southeast as shown on Figure II-1.

Two stations were two miles north of the Roseton plant, one on the west side of the river (Northwest) and one on the east side (Northeast). Two stations were established 3-1/4 miles south of the Roseton plant, one on the west (South west) and the other on the east side ~~of~~ the river (Southeast).

4. Collection Dates

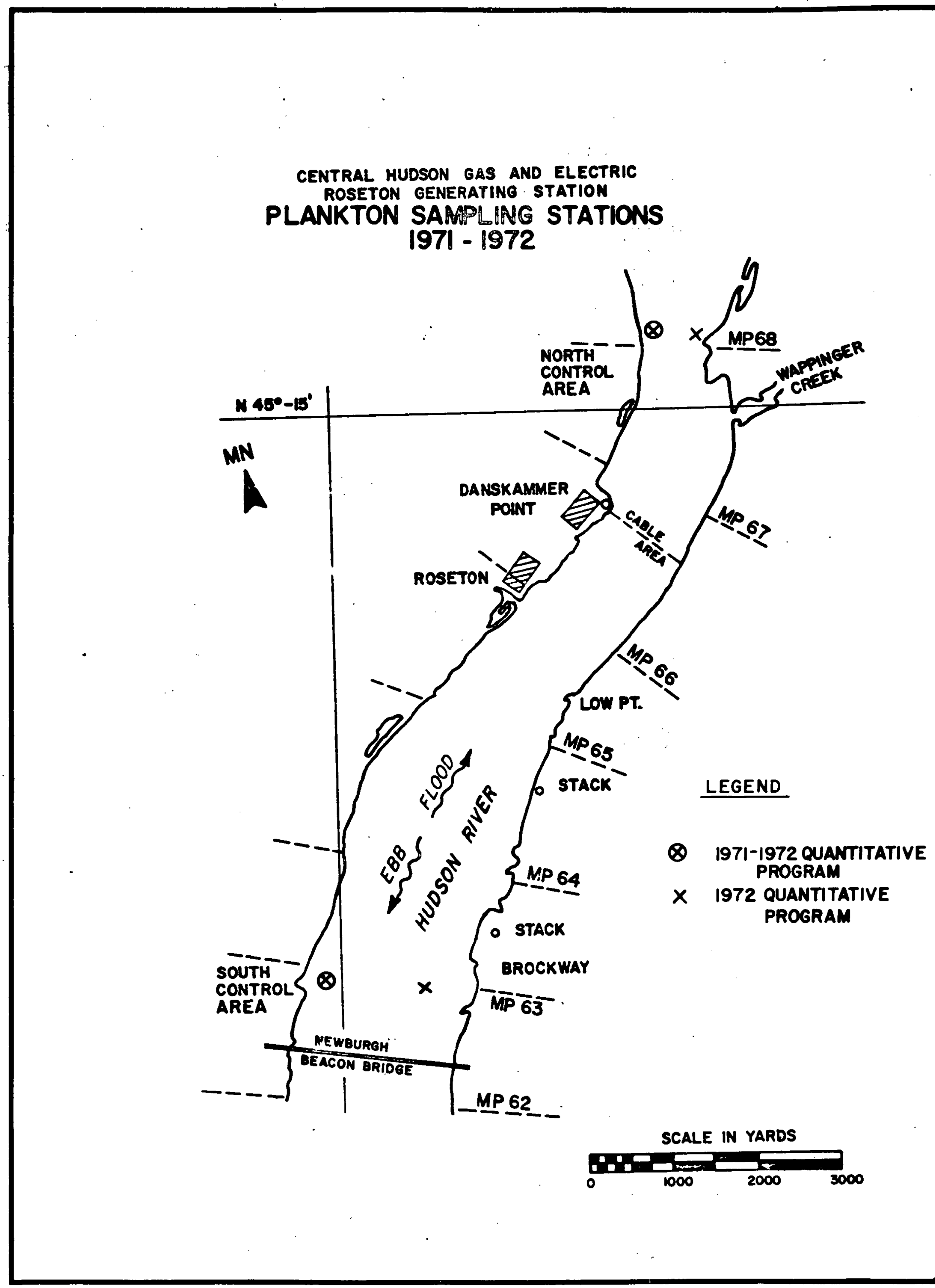
Five collections occurred in 1971 and nine collections in 1972. The sampling dates are summarized as follows:

Key: + sample collected
- sample not collected

Quantitative Plankton Program Sampling Dates 1971-1972

DATE	NORTHWEST	NORTHEAST	SOUTHWEST	SOUTHEAST
1971				
August 11	+	Station	+	Station
October 7	+	not	+	not
October 26	+	Established	+	Established
November 23	+		+	
December 8	+		+	

FIGURE II-1


CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
PLANKTON SAMPLING STATIONS
1971 - 1972
MP 68
NORTH
CONTROL
AREA
WAPPINGER
CREEK
N 45°-15'
MN
DANSKAMMER
POINT
CABLE
AREA
MP 67
ROSETON
MP 66
LOW PT.
MP 65
STACK
LEGEND
FLOOD
EBB
HUDSON RIVER
1971-1972 QUANTITATIVE
PROGRAM
1972 QUANTITATIVE
PROGRAM
MP 64
STACK
BROCKWAY
SOUTH
CONTROL
AREA
MP 63
NEWBURGH
BEACON BRIDGE
MP 62
SCALE IN YARDS
0
1000
2000
3000

DATE 1972	NORTHWEST	NORTHEAST	SOUTHWEST	SOUTHEAST
May 24	+	-	+	-
June 13	+	+	+	+
July 9	+	+	+	+
July 20	+	+	+	+
August 8	+	+	+	+
August 23	+	+	+	+
September 29	+	+	+	+
October 26	+	+	+	+
December 5	+	+	+	+

5. Laboratory Analysis

Methods used for quantification were essentially those recommended in Standard Methods (1971). A sub-sample was withdrawn from the sample and the organisms in the sub-sample were identified and enumerated. The density of cells was calculated knowing the volume of water filtered. The counting procedures were repeated two to three times and the average of the results provided the estimate of algal density.

Specific quantitative procedures were as follows:

(i) Phytoplankton

(a) The volume of the field sample concentrate was measured using a graduated cylinder.

(b) 0.05ml. of the homogeneously mixed sample was withdrawn with a pipette, placed on a glass slide and covered with a 22mm. square cover slip.

(c) three random, strip counts were made under 225X magnification. The filamentous and colonial forms were counted as both single units (clumps) and total cell number.

(d) The two steps (b) and (c) were repeated and the average of the two counts calculated.

(e) The organism density of the five gallon sample was calculated in the following manner and expressed as number per liter:

$$\text{density} = \frac{(a)\ (d)\ (200)}{18.9}$$

a - volume of the field sample concentrate in mls.

d - algae density from strip counts

200 - Conversion factor to total number in the original five gallons.

18.9 - number of liters in five gallons.

(ii) Zooplankton

(a) The volume of the field sample concentrate was measured using a graduated cylinder.

(b) 1.0 ml. of homogeneously mixed sample was placed in a Sedgewick-Rafter counting cell.

(c) The entire cell was scanned under 125X magnification with the aid of a mechanical stage and organisms present enumerated.

(d) Steps (b) and (c) were repeated and the average of the two counts calculated.

(e) Averages determined in step (d) were used to calculate densities which were expressed as organisms per cubic meter in the following manner:

$$\text{Density} = \frac{(a)\,(d)\,(1000)}{3.445 \times L}$$

a - volume of the field sample in mls.

d - zooplankton density from S-R cells.

3.445 - factor to convert to L into cubic meters.

L - length, in feet, of vertical tow.

6. Discussion of Procedures

In the preliminary quantitative program of 1972, Secchi disk readings were made and a vertical tow of twice the reading was conducted with the #20 mesh Wisconsin net. The rationale was that twice the Secchi disk reading should encompass most of the photic zone. This procedure was abandoned due to the variability of Secchi disk readings between station locations and sampling dates which resulted in different volumes of water being sampled. It was decided to collect a constant volume of water from each location to facilitate quantification. The collecting net had fine mesh (18 microns) which would retain all but the smallest algae. While the results are not representative of the very small forms, most potential problem algae were retained in the 18 micron mesh used for the collections and it was algae of this size that were the main concern of the study.

The collecting depth of 12 to 18 inches below the surface would provide an adequate representation of blue-green algae. These algae have the ability to form gas vacuoles, thereby generally floating at or near the surface. The river currents would tend to keep other algae forms either evenly distributed through upwellings or concentrated due to windrows and eddy effects.

Sampling stations were established with respect to the possible area of influence of a thermal discharge from the Roseton plant. If the proposed discharge were to have a significant impact on the plankton community the effect should be reflected in a comparison of the locations in future studies.

The algae were enumerated as both clumps and cells. Clumps refer to the natural appearance of the algal form, i.e. aggregates of cells referred to as filaments or colonies. Cell refers to the basic unit of structure for algae.

Not all algae occur as cell aggregates. Many forms are unicellular in nature, so enumeration by cell provides more absolute measures on the algae standing crop than clump counting, but does not consider the algal character that is obtained by clump counting.

D. RESULTS AND DISCUSSION

1. Phytoplankton Seasonal Abundance and Distribution

(a) Factors Affecting Phytoplankton Densities. The seasonal appearance and dominance of algae is closely associated with environmental and biological factors (Patrick, 1967). Factors known to have substantial affect on the phytoplankton community include: availability of nutrients, turbidity, various toxic compounds and elements, species interactions, grazing, temperature, and light intensity. In a study of North Carolina algal communities that included rivers similar in nature to the Hudson, Whitford and Schumacher (1963) concluded that an algal flora for a particular season was more dependent on the water quality and current speed than other factors; and that seasonal changes in the flora were chiefly related to water temperature and light.

The planktonic community of an area may differ in time of appearance and magnitude of population densities from one uear to the next. Consequently, density variations recorded between 1971 and 1972 may be an artifact of sampling frequency, which could have resulted from sampling on either side of actual peak values.

(b) <u>1971 Phytoplankton Results</u>. The findings of the plankton samples collected for quantitative analysis between August and December 1971 are presented in Appendix A.

Diatoms dominated in Spring and early Summer; green and blue-green algae, particularly *Microcystis aeruginosa*, were more common in Summer. The density of the phytoplankton population increased steadily during this period reaching the observed peak in November for 1971. Although Summer months have been usually associated with the highest phytoplankton densities for similar climatic zones (Hynes, 1970), August 1971 displayed the lowest number.

The highest concentration of blue-green, particularly the nuisance form *Aphanizomenon flos-aquae*, were observed during 1971. This species appeared infrequently in 1972 but other blue-greens, particularly species of Aphanocapsa, Coelosphaerium and Microcystis, dominated.

The high percent composition of blue-greens in August 1971 was not primarily a result of a substantial increase in the blue-greens, but was more closely related to a low density of diatoms. The high standing crop of zooplankton during this time, particularly rotifers and copepod nauplii, may have been responsible for the low diatom density because of grazing.

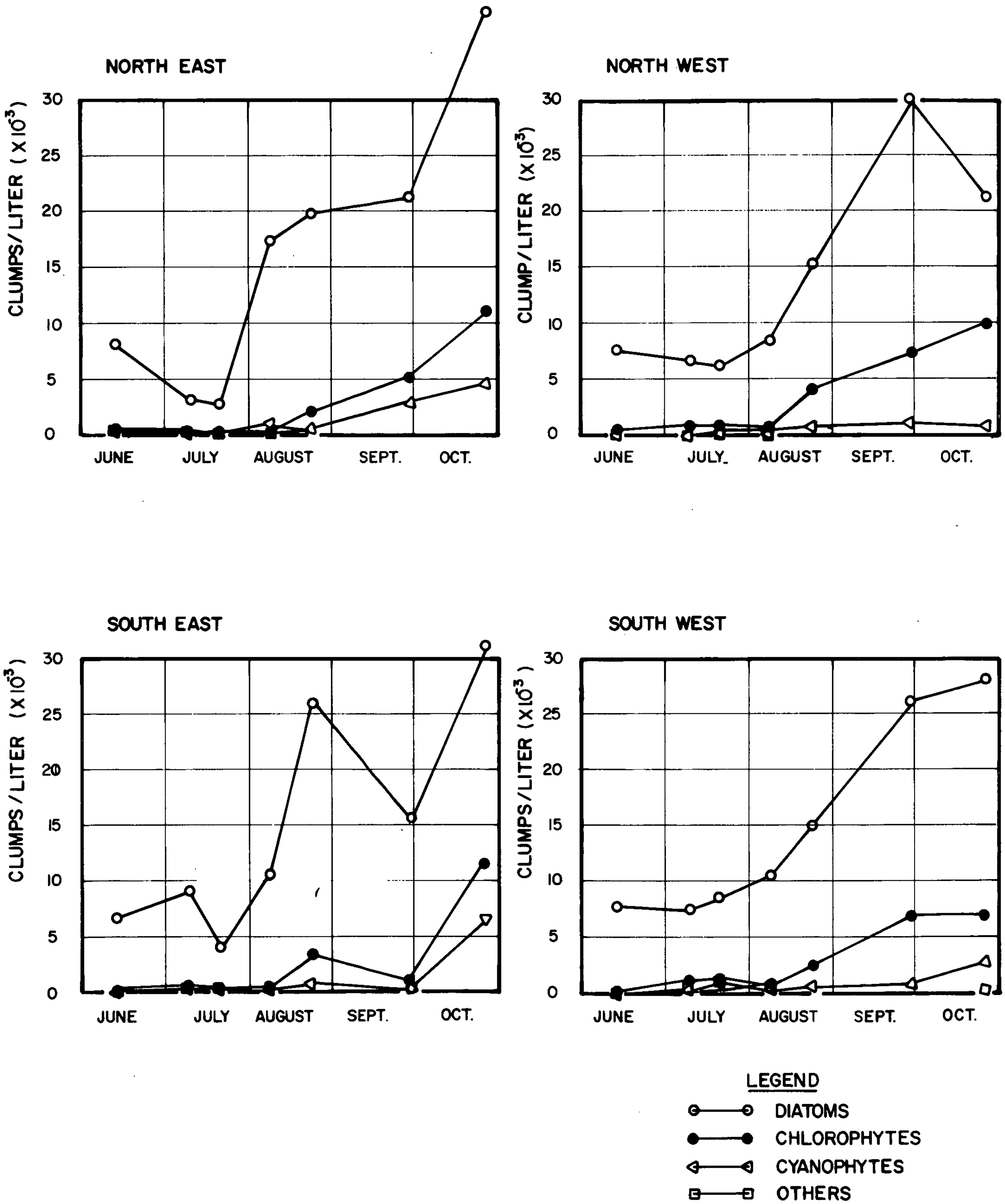
(c) 1972 Phytoplankton Results. The phytoplankton of the Roseton area were identified and enumerated with the procedures and purposes previously described. The findings expressed in terms of both clumps and cells per liter are presented in Figures II-2 through II-5. The data collected during the entire study are summarized in Appendix A.

Clumps per Liter. Figures II-2 and II-3 present the composition of the phytoplankton community in 1972. Diatoms were the dominant component of the phytoplankton community throughout the sampling period with the maximum density occurring in the Fall, primarily a result of the increase in the centric diatoms (Coscinodiscus, Cyclotella and Melosira). During August, green algae began to increase in abundance, particularly in several species, namely: Eudorina elegans, Pediastrum duplex, P. simplex and Scenedesmus quadricauda. The green algae reached maximum density in the Fall. Blue-green density increased slightly in August, September and October. The most frequently occurring planktonic blue-greens were species of Chroococcus, Aphanocapsa, and Microcystis aeruginosa.

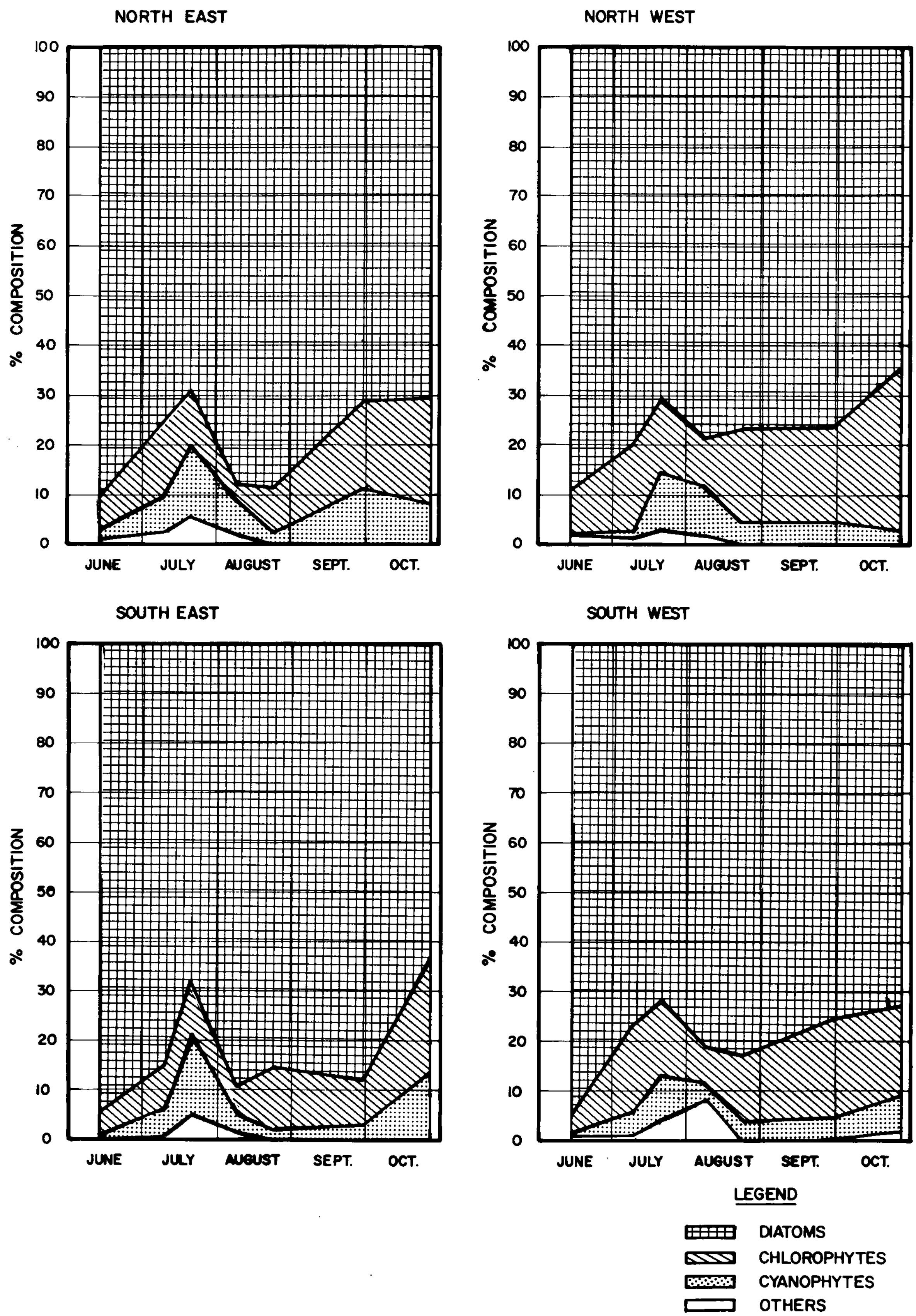
CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

ALGAL GROUP ABUNDANCE (CLUMPS/LITER)

ROSETON 1972

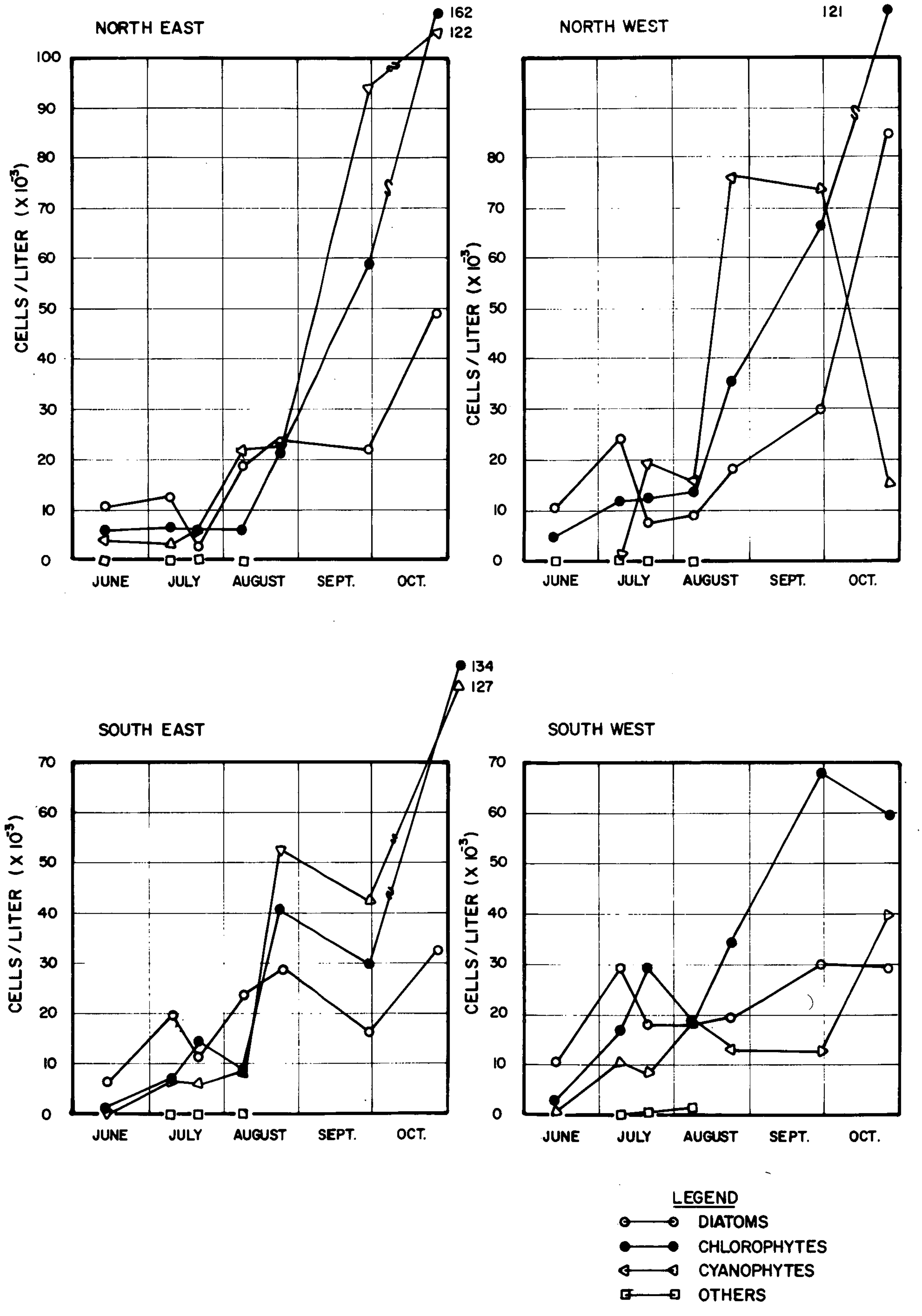


CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON
% COMPOSITION OF MAJOR ALGAL GROUPS (CLUMPS/LITER)
1972

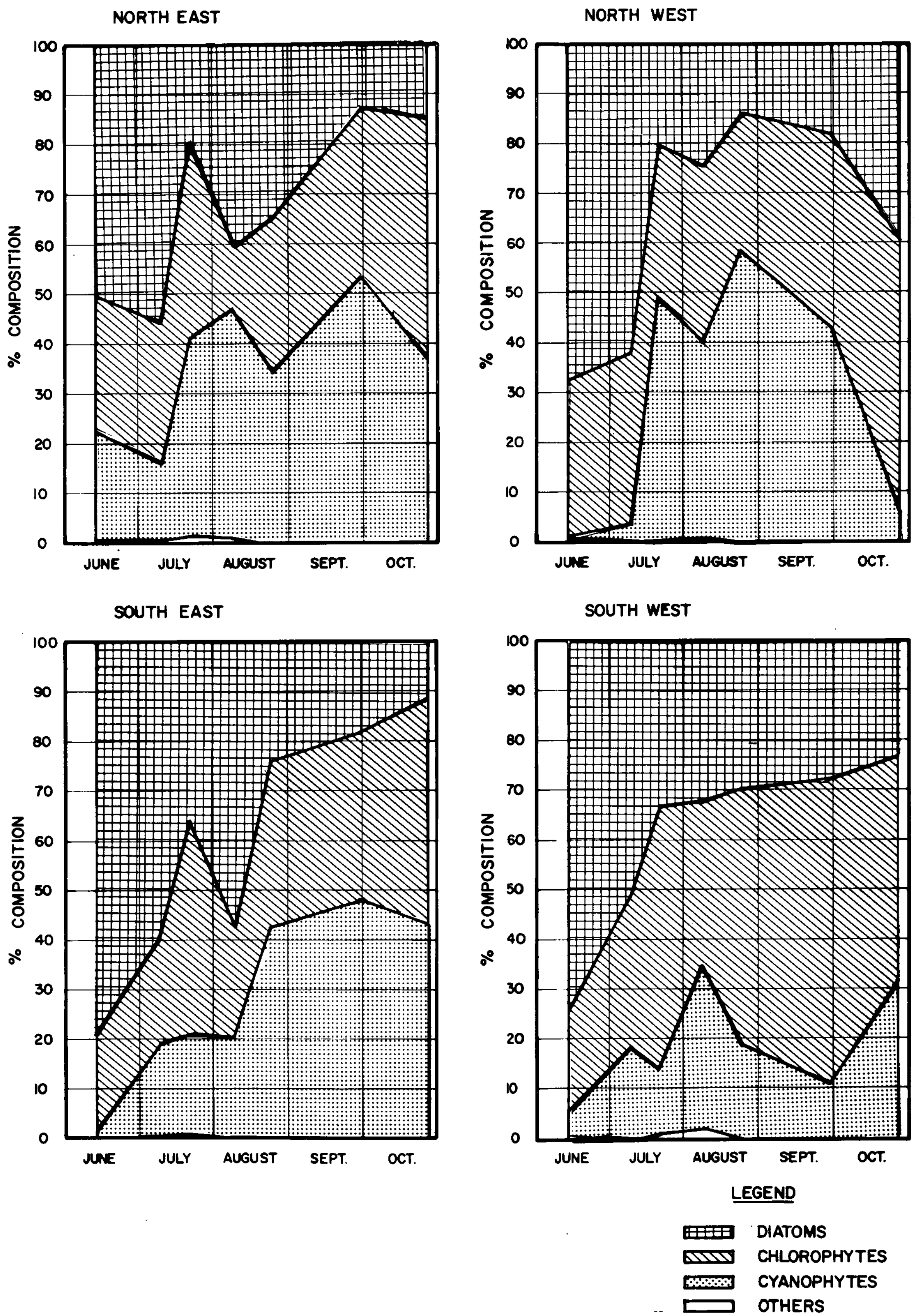


CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

ALGAL GROUP ABUNDANCE (CELLS/LITER)
ROSETON 1972



CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON
% COMPOSITION OF MAJOR ALGAL GROUPS (CELLS / LITER)
1972



The latter has often been associated with nuisance algae blooms and the creation of potential health hazards as a result of toxic substances produced by the algae when they are present in such abundance. (Gorham, 1962).

Cells per Liter. When the cells per liter were enumerated, green and blue-green algae showed substantial increases in concentration over their counts expressed in clumps per liter. This was primarily a result of the colonial nature of these forms, i.e. there were many cells within each clump or colony of these algae. As can be seen in Figures II-3 and II-4, the increase in cells per liter relative to clumps per liter suggests that the development of blue-greens was primarily through increase in the number of cells per clump as opposed to increase in the number of independent colonies (clumps) as warmer temperatures appeared.

The count of Diatom abundance remained similar when calculated in clumps or cells per liter except for occasional peaks in abundance of cells per liter observed in July and October. These peaks reflected sharp increases in colonial diatoms, *Melosira* and *Asterionella*. High peaks of either green algae, blue-green algae or both were observed in October as shown in Figure II-5.

(d) Potential Nuisance Algae. The significance of various algae in causing problems in water supplies has been studied extensively. A review of this subject was presented by Palmer (1962) and a number of specific studies were reviewed by Hutchinson (1967). In order to estimate what problems the algal population may cause, both the quality and the quantity of the algae present must be considered.

Table II-1 lists the algal genera occurring in the phytoplankton at Roseton which have been indicated by Palmer (1962) as responsible for nuisance problems. Of the twenty-six genera listed, only nine ever exceeded 10,000 cells per liter. These were the diatoms of the genera Asterionella, Cyclotella, Fragilaria and Melosira; green algae genera of: Dictyosphaeria and Pediastrum; and blue-green algae of the genera: Aphanocapsa, Gomphosphaeria, and Microcystis. The highest densities of potential nuisance algae were displayed by the blue-green M.aeruginosa during October, reaching approximately 73,500 cells per liter at the Southeast station.

Whipple (1948) established the following density criteria relevant to algae and water quality:

Number of cells per liter	Potential Problem Level
less than 500,000	no trouble
between 500,000 and 1,000,000	little trouble
between 1,000,000 and 2,000,000	noticeable trouble
between 2,000,000 and 3,000,000	decided trouble
greater than 3,000,000	serious trouble

Based on these criteria, the maximum density of this troublesome form was of "no trouble".

(e) Algae Densities in Roseton Area. The algae densities in the Roseton area are relatively low when compared to the substantial nutrient concentrations (see chemical/physical section). This observation has been previously

TABLE II-1

ALGAE GENERA FOUND IN ROSETON VICINITY ASSOCIATED WITH WATER POLLUTION PROBLEMS ACCORDING TO PALMER (1962)

Diatoms	Greens	Blue-Greens	Others
Asterionella	*Closterium*	*Anabaena*	*Glenodinium*
Cyclotella	*Dictyosphaerium*	*Aphanocapsa*	*Trachelomonas*
Diatoma	*Pandorina*	*Gomphosphaeria*	
Fragilaria	*Pediastrum*	*Microcystis*	
Melosira	*Phacus*	*Oscillatoria*	
Navicula	*Scenedesmus*	*Phormidium*	
Nitzschia	*Staurastrum*		
Stepanodiscus			
Surirella			
Synedra			
Tabellaria			

noted by Prescott (1966). Heffner (1972) also noted substantial concentration of nutrients in the area, but could not make correlations of algal densities with nutrient levels. This may be in part due to the transient nature of much of the phytoplankton, as Prescott (1966) observed.

If the algae present in a given area represent the end result of some upstream conditions, then a time lag of a given density could be expected from one location to the next. Heffner noted approximately a one month time lag in characteristics of the phytoplankton between the Newburgh and Indian Point areas (Heffner, 1972).

The net downstream movement of a particle of water in the Hudson River is dependent on the volume of freshwater flow. Using an assumption of average net movement of 0.8 mile per day (equivalent to an average summer month's flow of 7500 cfs) the time lag Heffner noted is about the same time period for a particle of water to travel that distance (approximately 30 miles).

(f) 1971/1972 Comparisons. In both 1971 and 1972, phytoplankton abundance increased from August through October. Heffner's (1972) data showed a similar trend at this time in the Newburgh area in 1969 and 1970.

When the species composition of phytoplankton in 1971 and 1972 are compared, clear similarities are noted. The dominant phytoplankton forms in both years were diatoms, particularly species of *Cyclotella*, *Coscinodiscus* and *Melosira*. These forms were also reported as the dominant genera during 1960 and 1961 in a study conducted at Poughkeepsie by Williams (1963).

In terms of abundance, expressed as clumps-per-liter, 1972 had higher standing crops of phytoplankton than 1971 on comparable dates and temperatures. Higher zooplankton concentrations were observed in 1971 than in 1972 and may have contributed to the higher phytoplankton densities observed in 1972.

2. Zooplankton Seasonal Abundance and Distribution

(a) Factors Affecting Zooplankton. Hutchinson (1967) and Carlin (1943) have identified two factors which appear to be important in regulating the abundance and composition of the rotifer population; temperature and the nature and quantity of the phytoplankton. Riley (1967) discussed some of the factors that affect the zooplankton of estuaries, noted the influence of temperature, salinity and biological competition on the composition structure of the zooplankton. Pennak (1953) mentions effects of water quality and light on various members of the zooplankton community.

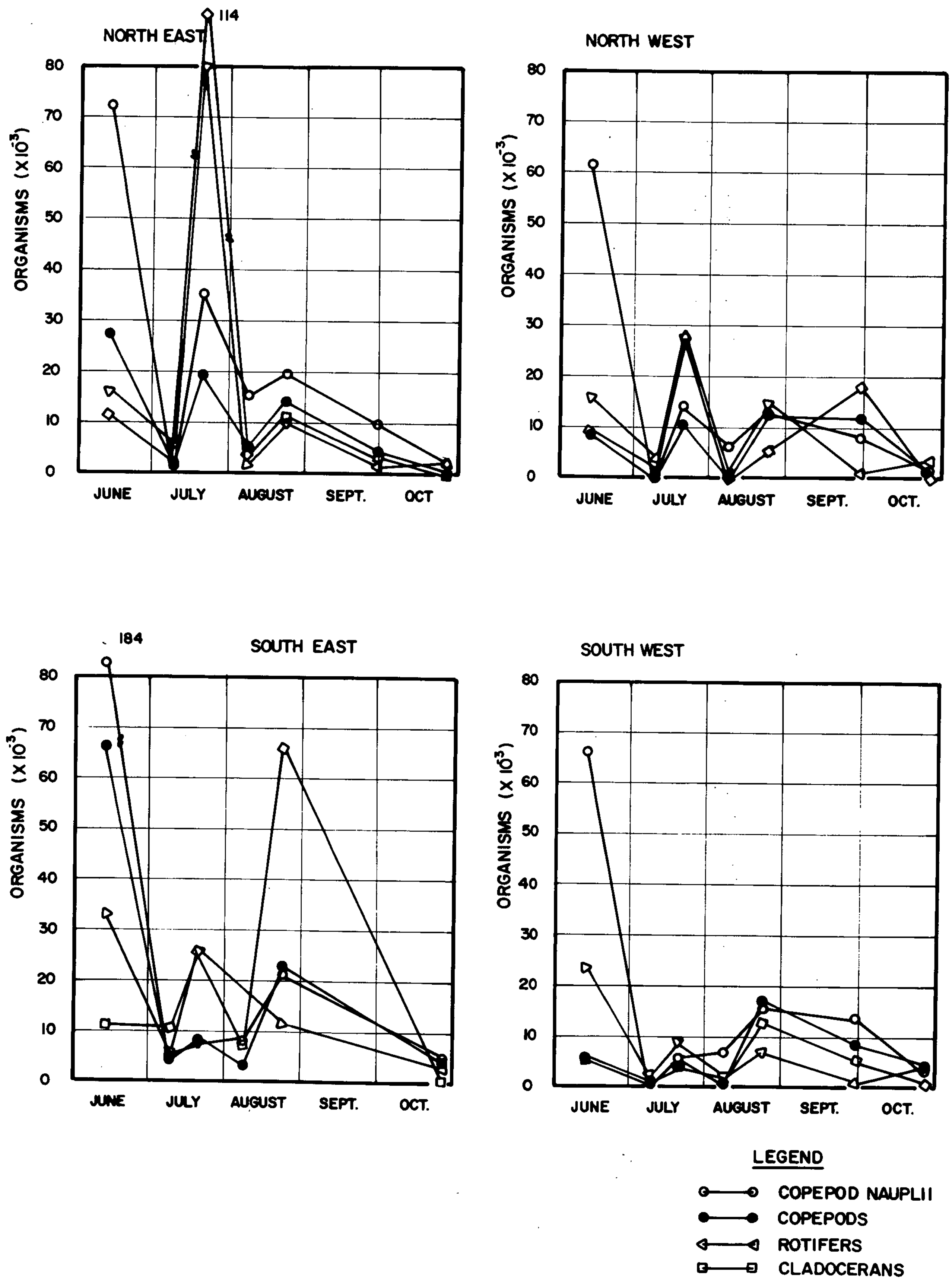
(b) 1971 Zooplankton Results. A tabulation of results of the 1971 zooplankton sampling efforts is presented in Appendix A. The quantitative sampling program initiated in August 1971 indicated high densities of microzooplankton, particularly copepod nauplii and rotifers.

(c) 1972 Zooplankton Results. Results of the 1972 zooplankton sampling efforts are presented in Appendix A and in Figures II-6 and II-7 in terms of organisms/m^3 and % composition respectively. As indicated in Figures II-6 and II-7 the magnitude of pulses of zooplankton was different at the four stations whereas the timing of fluctuations and peaks was

FIGURE II - 6

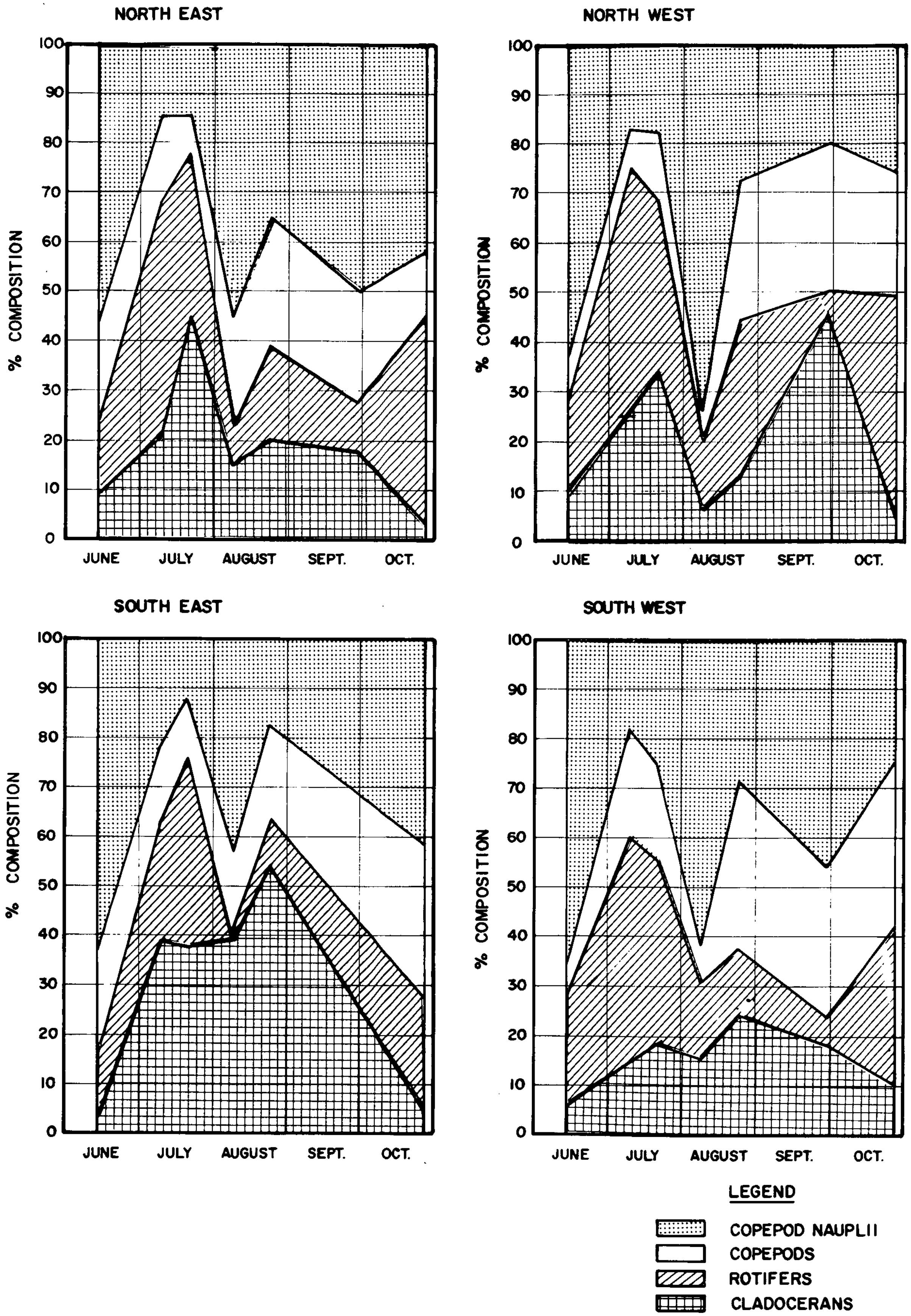
CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

GROUP ABUNDANCE ORGANISMS / m^3
1972 ROSETON ZOOPLANKTON



CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

ROSETON ZOOPLANKTON
% COMPOSITION 1972



similar at all four. As shown in Figure II-6, Copepod nauplii were the dominant zooplankters in June, averaging over 96,000 organisms per cubic meter.

A sharp decrease in zooplankton abundance in early July was observed and was followed by a pulse of variable magnitude at all stations in late July. On July 20, the Cladoceran, Bosmina and the Rotifers, Keratella Ploesoma and Brachionus were the dominant zooplankters.

Juvenile stages of the Cladoceran, Bosmina, were observed throughout the sampling period in June through September but were not observed in October. The development of Cladoceran populations during the warm Summer months was substantiated: in other studies, however investigations on Bosmina show maxima and minima that were not closely correlated with the seasonal cycle of temperature (Hutchinson, 1967). The findings of the present study conform to observations of Carlin (1943), who studied the seasonal succession of rotifers.

Species of Notholca were observed in late Spring and early Summer; Keratella Brachionus and Ploesoma increased in abundance during the Summer; Trichocerca formed a substantial part of the rotifer population in late Summer and early Autumn. Trichocerca has often been associated with productive (eutrophic) waters. Carlin felt that the appearance of Trichocerca during late Summer and early Autumn in less productive waters was due to the appearance of increased densities of blue-green algae, e.g. Oscillatoria.

Oscillatoria was present in the Roseton area at this time but in low concentration. Although this does not substantiate Carlin's observation, it is possible that sampling frequency may have missed the peak density of Oscillatoria.

(d) Zooplankton Relation to Fish. Zooplankton are an important link in the transfer of energy from the microscopic primary producers to the higher trophic levels. Hutchinson (1971), Kutkuhn (1957) and Massmann (1963) have discussed the direct grazing of phytoplankton and zooplankton organisms by particular species of fish in the herring family (Clupeidae). A number of these species and their larvae were found to be present in the Roseton area at various times of the year. Fish stomach analysis, indicated that at particular times of the year, microzooplankton, particularly copepods, were numerically a dominant component in the diet of young-of-the-year and juvenile white perch. As grazing zooplankton affects phytoplankton densities, varying grazing pressures by fish could substantially alter concentrations of both zooplankton and phytoplankton.

(e) 1971/1972 Comparisons. The high densities of microzooplankton, particularly copepod nauplii and rotifers, observed in August 1971 averaged about 125,000 organisms/m^3 and are comparable to the densities of the pulse observed in July 1972 which averaged 105,130 organisms/m^3. Although these peaks differ in the synchronization by about three weeks, increased temperature and low density of phytoplankton were present during both pulses. Therefore, it appears that during the summer months one would expect to find high densities of these organisms and a low phytoplankton abundance. The species composition was similar for both years, Bosmina being the dominant Cladoceran with Keratella and Brachionus the dominant rotifers.

E. STATISTICAL ANALYSIS

Analysis of variance (Anova) is a statistical test to determine whether two or more sample means could have been obtained from populations with the same parametric mean with respect to a given variable; if the means differ from each other to a degree greater than the parametric means it can be assumed that they were sampled from different populations (Sokal and Rohlf, 1969).

A two-way Anova design without replication was used to test the hypothesis that no differences existed in plankton populations between stations and between dates. For phytoplankton, tests were conducted on twelve genera or species of diatoms, ten genera of cyanophytes, total diatoms, total chlorophytes, total cyanophytes and total algae. For zooplankton, tests were conducted on copepod nauplii, adult copepods, rotifers, cladocerans and total zooplankters. Results of these tests are presented in Table II-2.

Although there were significant differences between dates for particular phytoplankters and zooplankters there were no significant differences between the four sampling stations. On the basis of this analysis, the factors regulating the standing crop of plankton can be considered to have been homogenous at all stations during the sampling period.

Further examination of the plankton was directed towards investigation of density of predominant forms on specific dates in relation to location and zooplankton. The algae selected, (Cyclotella, Pediastrum, Microcystis, Scenedesmus, Asterionella and Melosira) did not show any consistent trends or differences between station locations. Differences between east-west and north-south locations on a particular date were not consistently observed over

TABLE II-2

ROSETON PLANKTON
ANALYSIS OF VARIANCE

Problem	Source of Variation	Degrees of Freedom	Mean Square	F-Ratio
Asterionella	Date	6	0.01664	2.94*
	Location	3	0.00500	0.88
	Residual	18	0.00565	
	Total	27		
Coscinodiscus	Date	6	0.59613	51.21*
	Location	3	0.03372	2.89
	Residual	18	0.01164	
	Total	27		
Cyclotella	Date	6	0.26371	9.70*
	Location	3	0.02421	0.89
	Residual	18	0.02718	
	Total	27		
Diatoma	Date	6	0.03271	2.58
	Location	3	0.00822	0.64
	Residual	18	0.01266	
	Total	27		

*Significant difference at 0.05 confidence level.

TABLE II-2
(continued)

Problem	Source of Variation	Degrees of Freedom	Mean Square	F-Ratio
Fragilaria	Date	6	0.00764	0.75
	Location	3	0.01038	1.02
	Residual	18	0.01009	
	Total	27		
Melosira	Date	6	0.07839	7.38*
	Location	3	0.01673	1.57
	Residual	18	0.01061	
	Total	27		
Surirella	Date	6	0.03474	3.60
	Location	3	0.00746	0.77
	Residual	18	0.00965	
	Total	27		
Synedra	Date	6	0.04068	2.36
	Location	3	0.01699	0.98
	Residual	18	0.01720	
	Total	27		
Micractinium	Date	6	0.00248	0.74
	Location	3	0.00260	0.78
	Residual	18	0.00332	
	Total	27		

*Significant difference at 0.05 confidence level.

TABLE II-2
(continued)

Problem	Source of Variation	Degrees of Freedom	Square	F-Ratio
Pediastrum simplex	Date	6	0.03075	3.44*
	Location	3	0.00390	0.43
	Residual	18	0.00892	
	Total	27		
Pediastrum tetras	Date	6	0.00917	2.34
	Location	3	0.00406	1.03
	Residual	18	0.00391	
	Total	27		
Scenedesmus quadricauda	Date	6	0.12906	16.31*
	Location	3	0.01921	2.42
	Residual	18	0.00791	
	Total	27		
Chroococcus	Date	6	0.02014	1.07
	Location	3	0.01707	0.91
	Residual	18	0.01867	
	Total	27		
Microcystis	Date	6	0.03870	5.36*
	Location	3	0.00447	0.61
	Residual	18	0.00722	
	Total	27		

*Significant difference at 0.05 confidence level.

TABLE II-2
(continued)

Problem	Source of Variation	Degrees of Freedom	Mean Square	F-Ratio
Oscillatoria	Date	6	0.00681	1.33
	Location	3	0.00766	1.49
	Residual	18	0.00511	
	Total	27		
Total Diatoms	Date	6	0.28417	17.66*
	Location	3	0.00330	0.20
	Residual	18		
	Total	27		
Total Greens	Date	6	0.39713	28.38*
	Location	3	0.02445	1.74
	Residual	18	0.01399	
	Total	27		
Total Blue-Greens	Date	6	0.19072	10.23*
	Location	3	0.01427	0.76
	Residual	18		
	Total	27		
Total Others	Date	6	0.01710	2.14
	Location	3	0.01449	1.81
	Residual	18		
	Total	27		

*Significant difference at 0.05 confidence level.

TABLE II-2
(continued)

Problem	Source of Variation	Degrees of Freedom	Mean Square	F-Ratio
Total Algae	Date	6	0.32455	20.18*
	Location	3	0.00306	0.19
	Residual	18	0.01608	
	Total	27		
Copepods	Date	6	0.51697	9.15*
	Location	3	0.15290	2.70
	Residual	18	0.05646	
	Total	27		
Copepod Nauplii	Date	6	0.90771	27.92*
	Location	3	0.09079	2.79
	Residual	18	0.03250	
	Total	27		
Rotifers	Date	6	0.77039	20.60*
	Location	3	0.04118	1.10
	Residual	18	0.03739	
	Total	27		
Cladocerans	Date	6	0.70904	7.52*
	Location	3	0.25381	2.69
	Residual	18	0.09418	
	Total	27		

*Significant difference at 0.05 confidence level.

TABLE II-2
(continued)

Problem	Source of Variation	Degrees of Freedom	Mean Square	F-Ratio
Total Zooplankton	Date	6	0.714	13.95*
	Location	3	0.19371	3.78*
	Residual	18	0.05118	
	Total	27		

*Significant difference at 0.05 confidence level.

the sampling period.

Correlation between specific algal forms and particular zooplankton taxa could not be established. Thus selective grazing by zooplankters was not evident. This is not surprising because of the relative insensitivity of the design of the sampling program for detection of this type of relationship. Although no consistent relationship could be determined between particular members of the zooplankton and the phytoplankton communities, the synergistic effects of the total zooplankton on the total phytoplankton appeared to be substantial as has been noted.

F. SUMMARY OF RESULTS

1. Diatoms (Bacillariophyceae) were the predominant component of the phytoplankton and displayed maximum densities in the fall. The predominant species for both years included members of the genera *Coscinodiscus*, *Cyclotella* and *Melosira*.

2. Green algae (Chlorophyceae) were next in abundance with species of the genera *Pediastrum* and *Scenedesmus* the dominant forms.

3. Blue-green algae (Cyanophyceaceae) were not observed in substantial numbers in light of the relatively high nutrient levels. Their densities dominated the community structure on few occasions, in particular the pulse of *Aphanizomenon* in August of 1971.

4. Concentrations of potential problem algae were observed to be well below the level.

creating cause for concern.

5. The zooplankton community displayed seasonal abundance inversely related to the phytoplankton. Species of copepod nauplii and rotifers generally dominated the community structure.

6. Differences in the magnitude of plankton densities were observed between 1971 and 1972; the phytoplankton of 1972 was higher than that of 1971; but the zooplankton of 1971 was of higher densities than that of 1972.

7. Comparison of the population densities indicated that the plankton community was not significantly different between the sampling locations. Significant differences in plankton abundance was observed between sampling dates.

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III. BENTHOS

III. BENTHOS

A. INTRODUCTION

Benthos are organisms that live on or in the bottom sediments of a body of water. While benthos can be divided into categories based on size, mode of feeding or relation to substrate, this study concentrated on macrobenthos, the large size benthos usually consumed by the larger organisms like fish.

Studies performed by Oceanographic Analysts Inc. (1969), Rehwoldt (1972), Pierce (1971), Feldman (1971) and Barnett (1973) have provided information on the aquatic biology in the vicinity of the Danskammer Plant. The study by Oceanographic Analysts, Inc. (1969) compared findings of sampling efforts immediately south of the proposed Roseton plant, to those collected immediately south of, and within the probable area influenced by the Danskammer plant thermal discharge. The results of that study indicated that the benthos in the influence of the heated effluent was more abundant than in the Roseton sampling area.

Pierce (1971) conducted a qualitative survey of benthic grabs, aquatic weeds and plankton found 700 feet south of the Danskammer Plant and at a control area two miles north of the plant. Pierce concluded that the same species were present in both the heated effluent area and the control area. No quantitative measures were performed but general comparison of abundance indicated that fewer aquatic weeds were living in the effluent area than in the control area. In addition, organisms associated with the weeds were less abundant in the effluent area influence than at the control.

Feldman (1971) conducted studies on the micrroflora and microfauna at four locations: The Roseton area, Danskammer influent and effluent areas and at a control 2.5 miles north of Danskammer Point. He observed "substantial benthic fauna" at all locations in comparison to the effluent channel station which had a marked absence of benthos.

B. STUDY OBJECTIVES

In light of the apparent contradictions in the finding of such previous studies, e.g. Feldman and Oceanographic Analysts, Inc., the study presented herein was initiated to obtain qualitative and quantitative information on the macrobenthos in the area of the Roseton plant. Such information will serve as baseline data for future comparisons during plant operation.

The benthic program was conducted in two phases. The first phase consisted of collections in the intake and discharge areas, and at a location north of the Roseton plant. This was a preliminary investigation into the nature and distribution of benthic organisms in the Roseton area. Findings of the preliminary program determined the scope of the expanded second phase.

The second phase consisted of sampling at specific locations during each season to obtain quantitative data about the benthos population at different depths at specific locations in the vicinity of the proposed discharge. In addition to this enumeration of organisms, biomass was measured to gain further information concerning the standing crop (Carriker, 1968). Biomass represents a measure of productivity in terms of standing crop, which can be translated into a calculated measure of potential consumer biomass.

C. METHODS AND MATERIALS

1. Procedures of Collection

a. Preliminary Program - 1971

Station Location

The three locations for sampling the benthos were the intake and discharge areas for the Roseton plant and an area 2.5 miles to the north. These sampling areas are noted in Figure III-1.

Sampling Procedure

An Ekman grab sampler with 6" x 6" jaw openings was used for sample collection. The device was operated from a boat anchored in the desired area. The dredge was lowered in a controlled but rapid descent and the spring loaded jaws were released by means of a messenger that slid down the line attached to the sampler. The sampler was raised to the surface and its contents washed into a plastic lined bucket and preserved in 5-10% formalin. The plastic liner was sealed, forming a bag for transport of contents.

Sampling Frequency

The sampling dates and depths of samples collected are summarized in Table III-1.

b. Quantitative Program - 1971-1972

Station Location

Benthic stations were established at defined distances from the proposed discharge and are noted in Figure III-1. The rationale in selecting these stations was to sample areas estimated to be within and beyond the influence of the proposed thermal discharge from the Roseton plant.

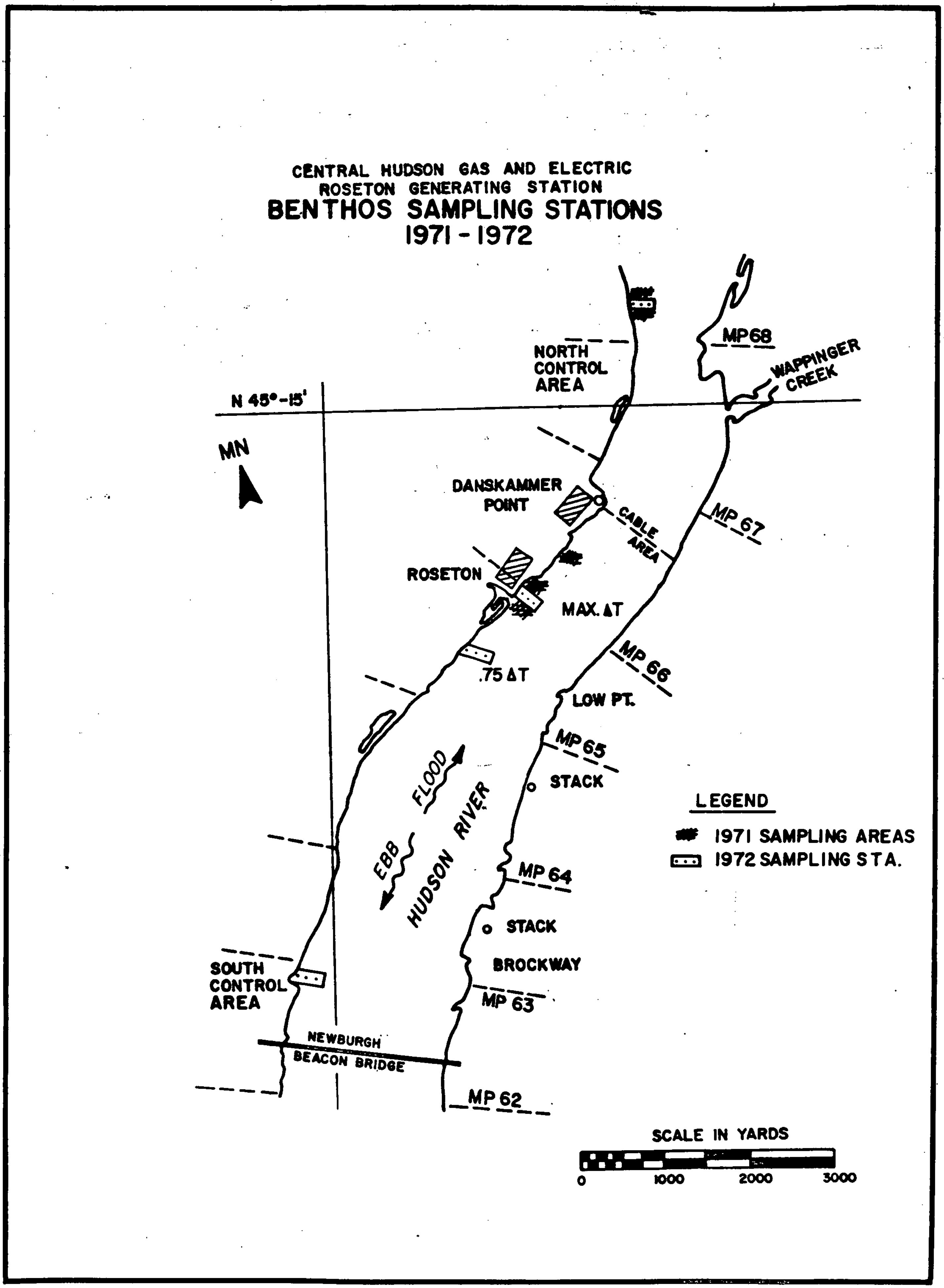

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
BENTHOS SAMPLING STATIONS
1971 - 1972
NORTH CONTROL AREA
MP 68
WAPPINGER CREEK
N 45°-15'
MN
DANSKAMMER POINT
CABLE AREA
MP 67
ROSETON
MAX. ΔT
.75 ΔT
MP 66
LOW PT.
MP 65
STACK
FLOOD
EBB
HUDSON RIVER
LEGEND
1971 SAMPLING AREAS
1972 SAMPLING STA.
MP 64
STACK
BROCKWAY
SOUTH CONTROL AREA
MP 63
NEWBURGH BEACON BRIDGE
MP 62
SCALE IN YARDS
0
1000
2000
3000

TABLE III-1

ROSETON PRELIMINARY BENTHOS PROGRAM - 1971
SAMPLING DATES

Location	May				June			July	Total Samples
	7	12	19	26	2	8	22	13	
Intake	-	8'	33'	26'	18'	22'	23'	18'	7
Discharge	ND	-	23'	30'	25'	22'	18'	ND	7
Control	-	-	-	45'	18'	-	-	24'	3
Total	1	1	2	3	3	2	2	3	17

Key: - No sample collected
ND Sample collected but depth not recorded.

The four locations (transects) were:

1. an area about 150 yards from the discharge expected to receive maximum discharge influence;
2. 600 yards downstream from the discharge; but within the expected influence of the discharge;
3. 2.5 miles north of the discharge, and
4. 3 miles south of the discharge, beyond the anticipated influence.

The respective transect coding was maximum temperature influence (max ΔT); 75% temperature influence ($.75\Delta T$); and north and south control (NC and SC).

At each transect, three stations were established at depths of 10, 20 and 30 feet at mean low water. These transects were marked with anchored floats, enabling accurate and rapid location and relocation of the sampling stations.

Sampling Procedure

The collections were made using a Ponar grab sampler having 500 micron mesh covering and jaw openings of 6" x 6". Sampling efforts were conducted during slack water periods. The sampler was lowered in a controlled but rapid descent from a boat fastened to the station marker. The sample was brought to the surface and washed into a plastic lined bucket. The sample was labeled and preserved with 5-10% formalin. The plastic liner was sealed, forming a bag for transport of contents. This procedure was repeated at each station to obtain a replicate sample.

Sampling Frequency

Sampling was conducted during each of the four seasons. The dates of sampling were as follows:

1971:	October 7th	December 7th
1972:	June 20th	October 18th
	August 17th	December 12th

2. Laboratory Procedures

(a) Preliminary Program - 1971. The preserved samples were washed through a No. 40 mesh (420 micron openings) U.S. standard sieve screen. The residue retained on the screen after washing was preserved in 5% formalin.

Sample analysis consisted of enumerating benthic organisms as they were removed from the sample debris with forceps and with the aid of a dissecting scope. Identification was generally to the level of order with speciation proceeding on selected types.

(b) Quantitative Program - 1971-1972. Initially the preserved samples were washed through a U.S. standard sieve screen having mesh openings of 420 microns. Beginning with the August 1972 sampling, a large cone with 500 micron mesh was used to facilitate washing. Visual description of the sediment character was noted prior to and after sediment washing. The material retained on the screen after washing was preserved in 70% ethyl alcohol with the stain phloxine-B added. Phloxine-B is a red dye which stains organisms, establishing contrast so that their distinction from other material is obvious (Mason, 1967). The organisms were removed from the samples by use of forceps with the aid of a dissecting microscope.

The organisms were sorted according to order. Each category was blotted to remove excess liquid then weighed on an analytical balance to determine wet-weight biomass of that order to the nearest tenth of a milligram.

3. Discussion of Procedures

(a) Sampling Stations. Benthic organisms tend to concentrate in favorable micro-habitats and are also known to be associated with depth (Thut, 1969). Therefore, results from benthic analyses can be quite variable and may an artifact of either the sampling procedure or program rather than a true reflection of the natural structure of a biological community. Future sampling program designs will utilize the results of the 1971-1972 studies to minimize the possibility of such occurrences.

Although samples are collected in a specific area the morphology of the river may permit the matter of several or more yards difference in river location to result in substantial differences in depth or sediment character. Thus widely fluctuating densities of organisms can be recorded for different dates for the same sampling station merely by sampling some small distance or depth away from the desired location. In order to eliminate such variables the preliminary 1971 program was modified to include the marking of defined stations and the selection of a more reliable sampling device, both of which provided the framework for the expanded or quantitative benthic investigation.

(b) Sampling Gear. The selection of the Ponar over the Ekman grab was made because of:

1. Ease of use (Smith and MacIntyre (1954), Holme (1964)).
2. Decreased influence of currents on dredge descent.
3. Automatic release mechanism.
4. The jaw size was identical with the Ekman sampler enabling comparability to Ekman results.
5. Favorable comments by other investigators (Flannagan (1970), Kajak (1971)).

(c) Sample Washing. The mesh size of screens used for the collection of benthic organisms is dependent on the purpose of the study and is selective for organisms of a particular size range. Mesh openings of 420-500 microns were used for concentrating the benthic organism from the sediments. This size approximates that recommended for study of the macrobenthos. (Hynes, 1971; Holme and McIntyre, 1971).

(d) Measuring Biomass. The biomass was determined for each order and the biomass per individual was calculated to determine conditions and trends of the benthos and also provide a basis for comparison of areas by support potential for consumers. One area may display a higher density of organisms but continually possess the lowest biomass indicating that organisms, although numerous, are very small and may not be as readily available to consumers.

4. Data Analysis

The 1971-1972 quantitative data were reduced to numerical values expressing the amount of information represented in the structure of the benthic community referred to as the information theory index. The information theory index is an expression of how the organisms are arranged in a sample, i.e. the more even the distribution the more information contained in that sample. In comparative samples, the elimination of particular organisms or a disproportionate increase in the abundance of a particular organism will result in a reduction of information content, thus producing a decrease in index value or loss of information.

The Shannon-Weaver general diversity index (Odum, 1971) was used in this study and is defined as follows:

$$\bar{H} = -\sum \frac{n_i}{N} \log \frac{n_i}{N}$$

where $\bar{H}$ = general diversity index.

n_i = importance value for each order.

N = total of importance values.

This index is reasonably independent of sample size and is valuable for making comparisons without regard to diversity components (Odum, 1971).

The diversity components of a sample were compared between locations by use of an affinity index (Sanders, 1960). This index is a numerical value that expresses the degree of similarity in the arrangement of the diversity components between two samples. Affinity values were calculated by summing the values of identical organism taxa between two stations, i.e. oligochaetes are common between two stations and comprise a certain percentage of the total fauna for each.

Assuming the total fauna of Station A is 50% oligochaetes and for Station B is 30%, the value (%) common between those two stations is the lower of the two or 30. This summing of common values is then repeated for each taxa represented at those stations to obtain the affinity or similarity index.

For example,

STATION A % Composition	Common Taxa	STATION B % Composition	Common Value
50	Oligochaetes	30	30
20	Dipterans	40	20
30	Gastropods	30	30
100	TOTAL	100	80

The affinity index for this comparison equals 80.

The more similar the structure between two locations the higher the affinity values. The level at which locations are considered to be quite similar is subject to individual definition. In this report an affinity index value of greater than 76 is used to indicate close similarity.

The affinity indices may be arranged in a Trellis diagram (MacFadyen, 1963) to display the affinity values and graphically represent areas or comparisons illustrating the degree or ranges of similarity. These diagrams thus provide pictorial comparisons as well as specific values for detailed information.

A three-factor analysis of variance (Anova) design in which all factors are random was utilized in analyzing benthos data. The purpose of this analysis is to determine how much of the variation among observations is due to variation in each factor influencing the character being studied. (Simpson, et. al., 1960). In the present study the relative effects of three random factors:

A. Depth

B. Date

C. Transect

were examined with respect to the density (character) of oligochaetes, dipteran larvae, mollusks (gastropods and pelecypods) and the total benthic fauna.

A brief summary of the procedure for testing the results of Anova utilizing random factors is presented below:

(a) 2nd order interaction is tested:

$$\frac{MS\ (ABC)}{MS\ Error}$$

MS = mean square
A = Depth Factor
B = Date Factor
C = Transect Factor

(b) 1st order interaction is tested:

$$\frac{MS(AC)}{MS(ABC)},\ \frac{MS(AB)}{MS(ABC)},\ \frac{MS(BC)}{MS(ABC)}$$

(c) if all interaction effects turn out to be non-significant then the main effects, i.e. A, B and C can be tested as follows:

$$\frac{MS(A)}{MS\ Error},\quad \frac{MS(B)}{MS\ Error},\quad \frac{MS(C)}{MS\ Error}$$

(d) if one or more interaction effects are found to be significant then the following procedure is utilized:

(1) all non-significant interaction effects are considered to be equal to zero thereby eliminating them from consideration;

(2) main effects will be tested as follows:

$$\frac{MS(\text{Main Effect})}{MS\ \text{of 1st order interactions containing main effect} - MS(ABC)}$$

The denominator of this ratio calls for subtracting a mean square. This could lead to the possibility of obtaining a negative denominator. According to the population model, it is not possible to have a negative denominator in terms of parameters. However, in terms of the estimates of these parameters it is possible to have a negative denominator (Winer, 1962).

Since the benthos displays patchy distribution, log transformation was applied to normalize the data (this is one of the basic assumptions of Anova). The transformation used was $\log_{10}$ (X+1) (where X = density in real numbers of any particular benthic group).

When a main effect was found to be significant by the Anova the next question to be answered was "Where do the differences occur?" In order to determine which levels differ from each other with respect to a given factor Student-Neuman-Keuls test were conducted on the significant effects.

D. RESULTS AND DISCUSSION

1. Preliminary Program 1971.

The preliminary program was conducted to assess the relative density of the benthic organisms at the intake, and discharge areas of the Roseton plant, and at the north control.

The results of these efforts are presented in Table III-2 and indicate that the Roseton area had a relatively sparse benthic community. Diversity was low with oligochaetes being the dominant organism. Of the three locations, the greatest numbers of oligochaetes and dipterans occurred in the intake area, Other organisms (including dipterans) were sparsely represented at all locations.

The intake region contained the greatest number of organisms and also had the greatest range in population density. The north control contained a more consistent population in terms of density fluctuations, and had the least variety of benthic organisms.

An amphipod pulse appeared in July at the north control. This reading may not be significant since some amphipods are mobile and are often present in the waters above the bottom. This is evident by their presence in surface water plankton samples collected for fish larvae.

2. Quantitative Program - 1971-1972

All 1971-1972 data were reduced to demonstrate seasonal fluctuations in density, biomass and percent composition of community. The 1971-1972 raw data is presented in Appendix B .

TABLE III-2

ROSETON PRELIMINARY BENTHOS PROGRAM - 1971
ORGANISMS PER 0.25 FT^2 BOTTOM AREA

Collection Area	May 7	May 12	May 19	May 26	June 2	June 8	June 22	July 13	Organism
Intake									Crustacea
								5	.Amphipoda
									Insecta
					4	21	1	1	.Dipteran larvae
						1			Gastropoda
		26	31	19	23	193	51	53	Oligochaeta
					1			1	Pelecypoda
									Polychaeta
Discharge									Crustacea
								4	.Amphipoda
									Insecta
				1		3	2	1	.Dipteran larvae
									Gastropoda
	5		13	39	2	28	8		Oligochaete
						4			Pelecypoda
			1			1	2	8	Polychaeta
North Control									Crustacea
								111	.Amphipoda
									Insecta
				2	1			2	.Dipteran larvae
					1				Gastropoda
				111	17			16	Oligochaeta
									Pelecypoda
									Polychaeta

The results of the benthic sampling programs for 1971 and 1972 will be discussed as follows:

a. Density Distribution

b. Seasonal Patterns in Biomass Per Individual

c. Community Structure

d. Fish Support Potential

e. Salinity Influence

a. Density Distribution

Results from both the qualitative and quantitative benthos programs indicated that oligchaetes and dipterans were dominant organisms in this area of the river. Similar findings have been observed 30 river miles north (Kingston), but the abundance of organisms at this location was higher with more of a variety of organisms represented, while an area 30 miles south (Haverstraw Bay)had a different benthic community structure than Roseton or Kingston.

These two areas, Kingston and Haverstraw Bay, offer different environmental conditions, i.e. fresh water and saline water environments respectively, thus one would expect these differences to be reflected in the benthic organisms. In addition the highest seasonal densities of organisms between these three river areas were not concurrent, i.e. highest densities were observed in Kingston summer collection, Haverstraw Bay was highest in the Fall and Roseton highest densities were observed in Spring.

Seasonal sampling as conducted in 1971 and 1972 could miss peak density occurrences with this relatively long time period between collections. The 1973 data will be useful because monthly collections are conducted with laboratory analysis proceeding on selected stations which will provide a basis for seasonal sampling evaluation.

Density distribution in the Roseton/Danskammer Point area was based on the sampling locations that had been primarily established to monitor benthos structure and abundance on a pre-operational basis. Density differences were statistically analyzed and the results are presented in Appendix C.

Significant density differences in the benthos were observed between years for the same seasons (Fall and Winter of 1971 vs. Fall and Winter 1972). This may reflect environmental change from an unnatural source or a shift in abundance peaks by several months as a result of natural fluctuations.

Subsequent years of sampling should provide information on the magnitude of abundance or community changes that occur before operation of the Roseton Generating Station. This baseline information is necessary in order to evaluate whether future biological changes would be within expected natural ranges or due to some other source.

Figures III-2 through III-4 present abundance data for the sampling stations to illustrate the trends and conditions observed. Except for the 1971 Winter collection,benthos (total fauna) at the Max ΔT transect was significantly higher than other transects. Any one of the other three transects at a particular season may have displayed higher benthos abundance than the other two but the differences were not significant.

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION

BENTHOS TOTAL NUMBER
FALL & WINTER - 1971

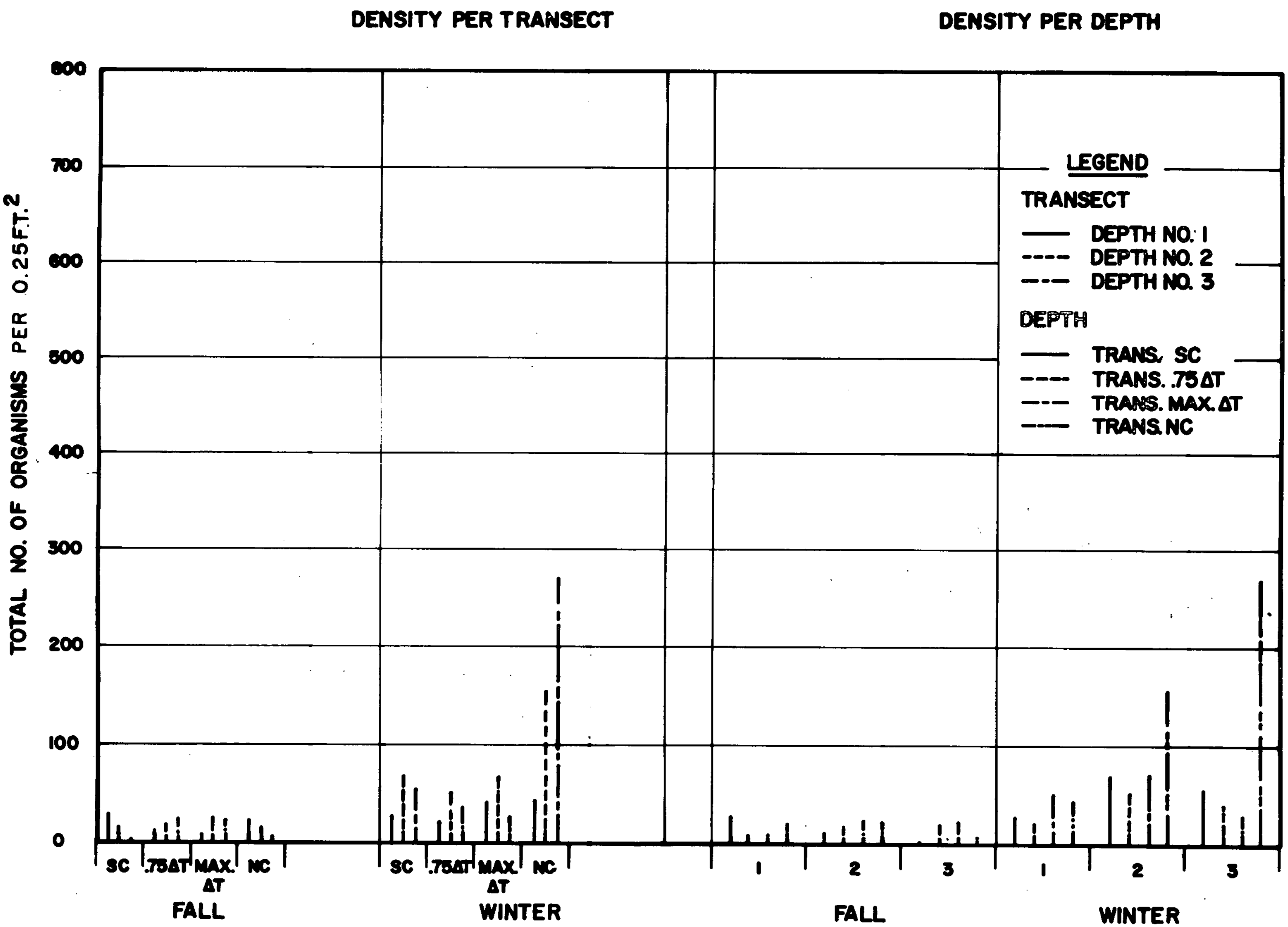


FIGURE III-2

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION

BENTHOS TOTAL NUMBER
PER TRANSECT, SEASONAL
1972

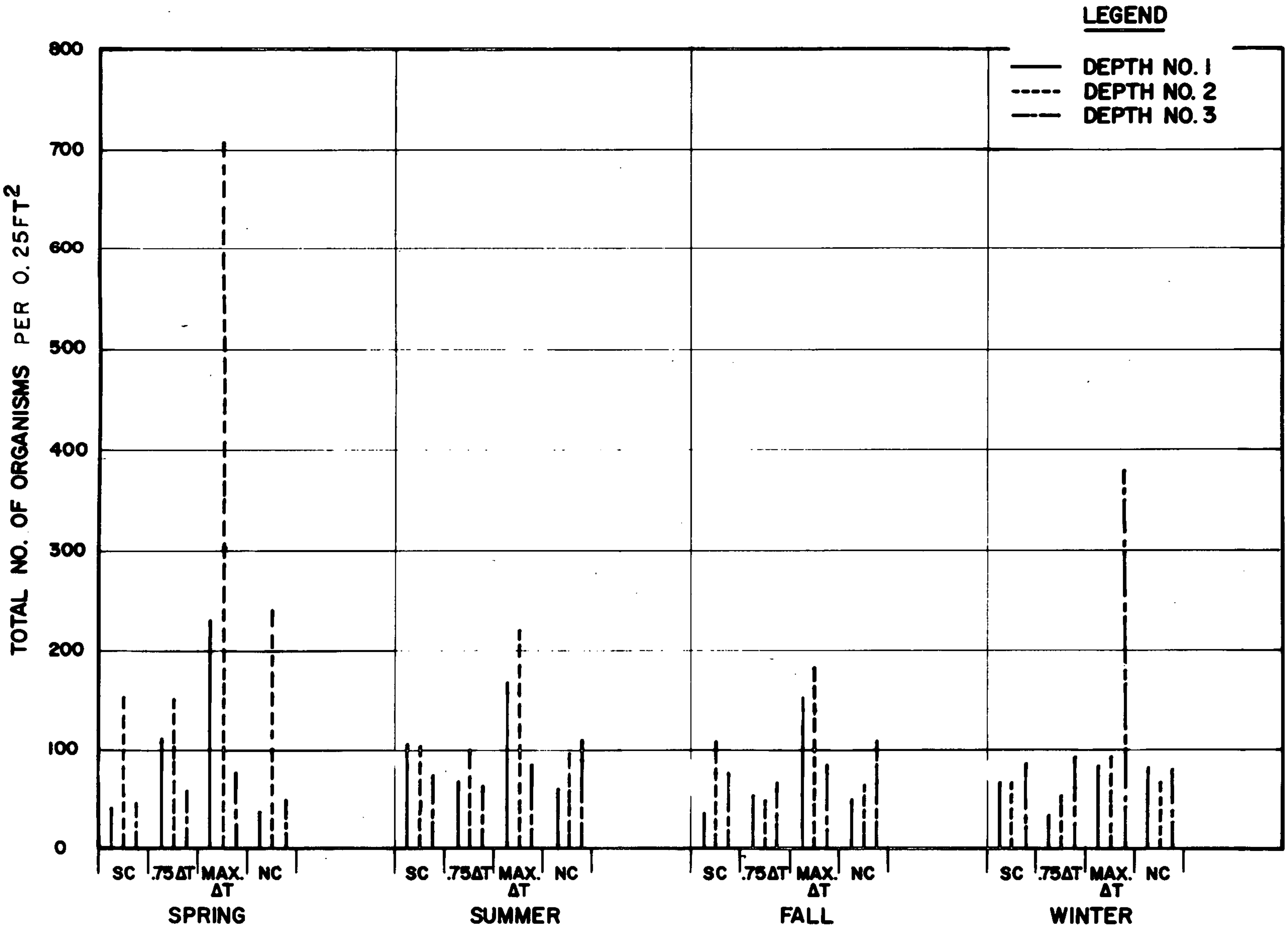


FIGURE III-3

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
BENTHOS TOTAL NUMBER
PER DEPTH, SEASONAL
1972

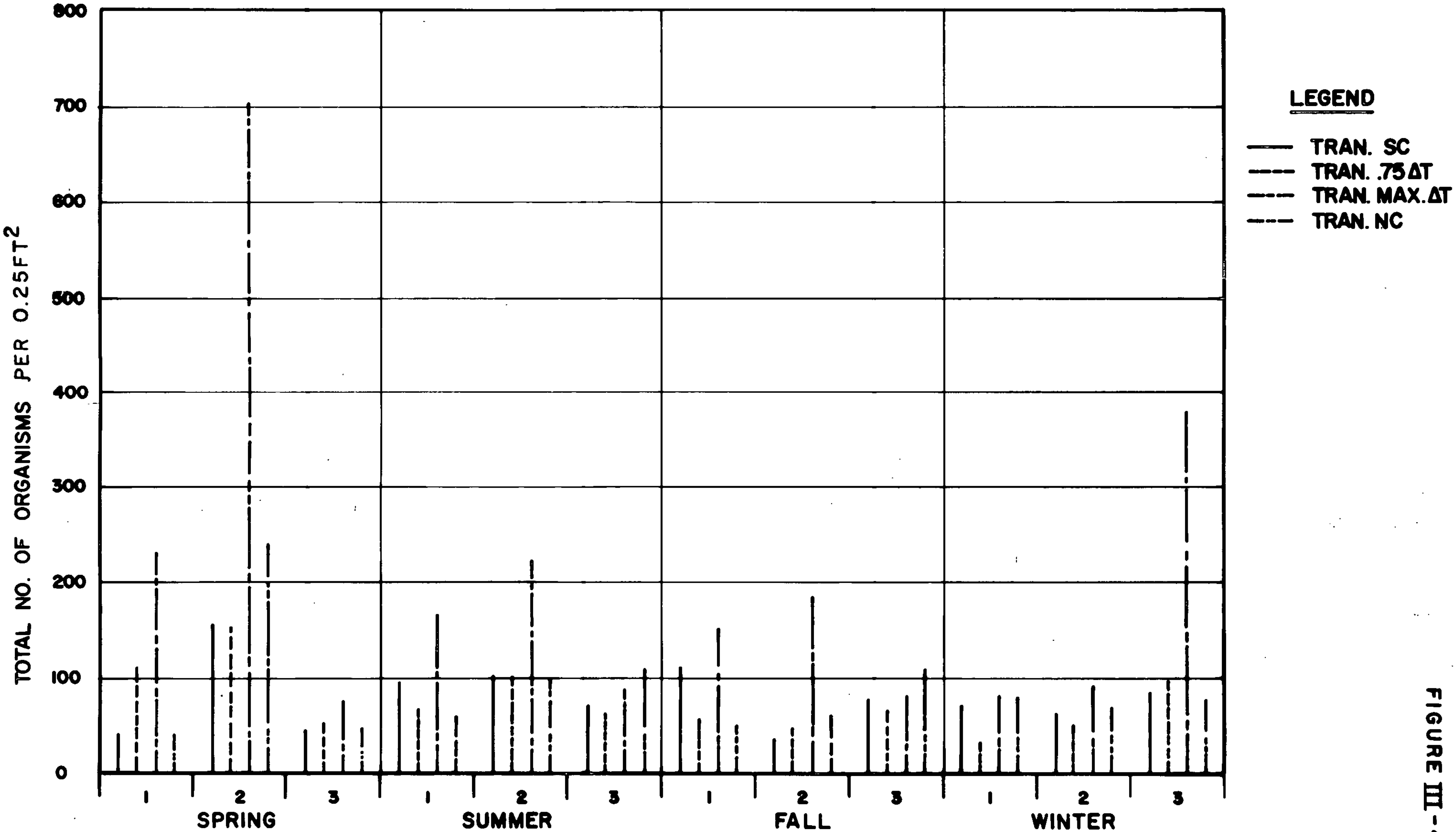


FIGURE III-4

The abundance of organisms displayed significant seasonal changes. The total benthos abundance was highest in Spring with Fall displaying lowest abundance values.

The abundance values of the more common organisms composing the benthic community were examined for significant differences with season, depth and transect. The oligochaetes, the most common organism in this area, increased in abundance between Fall and Winter 1971 and between Winter of 1971 and Spring 1972. After this densities decreased and were significantly less in Fall 1972 than in the Spring 1972.

The 20ft. sampling depth had higher oligochaete densities than either the 10ft. or 30ft. sampling depth. Oligochaete abundance was higher at North Control and Max ΔT transect than either .75ΔT or South Control.

The abundance of dipteran larvae was highest in the Winter months and lowest during the Spring. Other comparisons did not show any consistent or trends or patterns.

The gastropods (snails) and pelecypods (clams) were in sparse abundance and patchily distributed. These organisms were lumped together (as Mollusks) and statistically analyzed. Abundance (when present) was higher at the North Control and Max ΔT transects. Organisms that were present at various stations and in low numbers were: Hirudenia (leeches), isopods, polychaetes, Acari (watermites) and turbellarians (flatworms). These organisms did not appear to show consistent trends or patterns in their density distribution.

Figures III-5 through III-7 present the biomass distribution of the benthic organisms. Trends were generally similar to those observed for abundance (density) distribution. Differences from the density trends were a result of the patchy distribution of a few large organisms, particularly the clams Elliptio sp. and Lampsillis sp.

b. Seasonal Patterns in Biomass Per Individual

The standing crop of benthos can be increased through reproduction and recruitment or decreased by natural death, predation, and or emergence of adult stages of aquatic insects. To determine what factors may be influencing population densities, the average weight of the common organisms was calculated by dividing the biomass of a particular group by the number of individuals in that group. Table III-3 summarizes these results and also indicates the mean for total number of organisms from the sampling effort so that density numbers can be considered.

There are advantages and limitations of using average biomass per individual as an aid in interpreting data. These will vary from group to group. The advantages include:

1. Allowing differentiation between increases in group biomass due to reproduction of individuals and those caused by growth of individuals.

2. Identifying the seasonal succession of species of different size ranges.

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
BENTHOS BIOMASS
FALL & WINTER - 1971

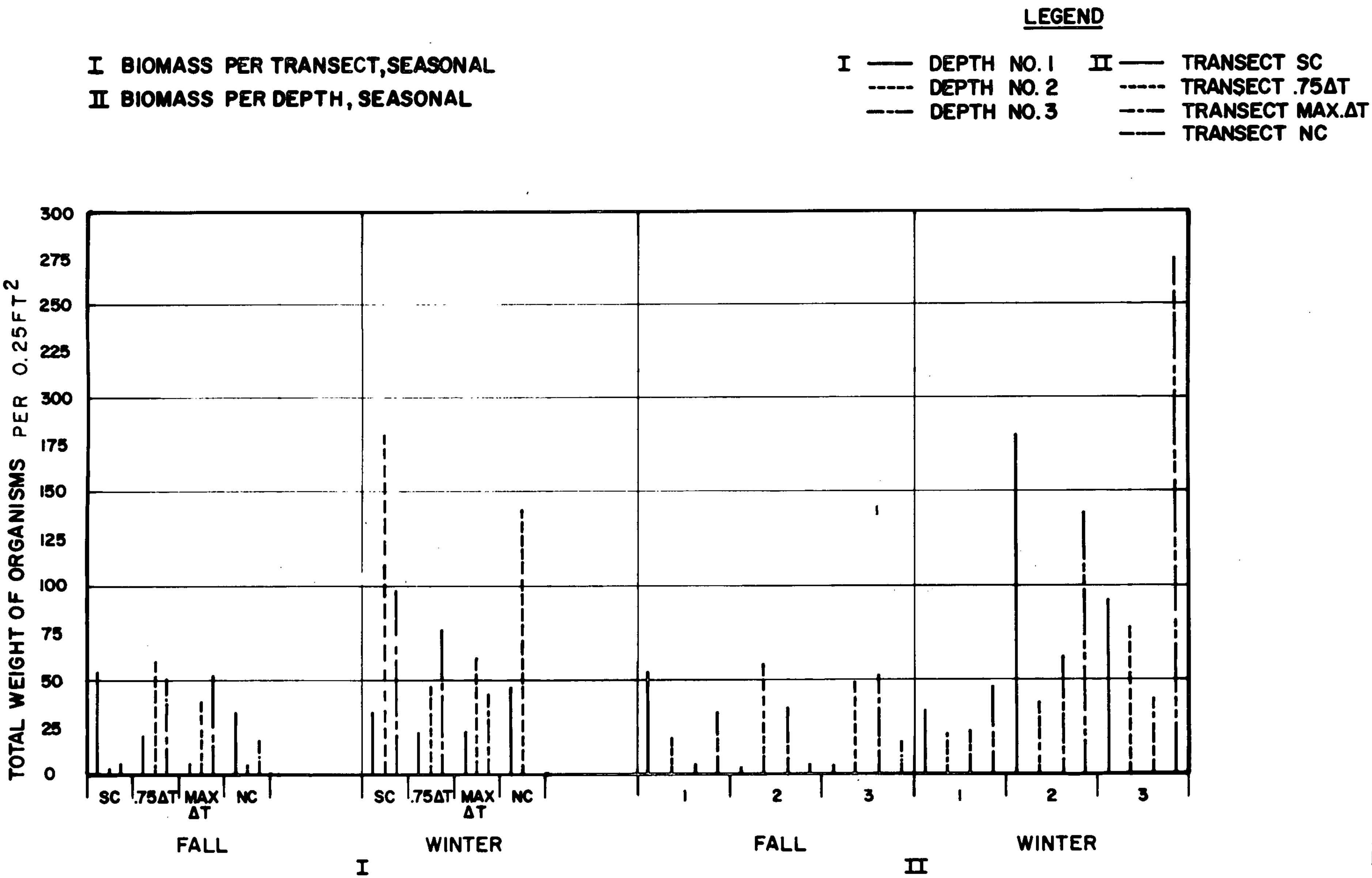


FIGURE III-5

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION

BENTHOS BIOMASS PER TRANSECT, SEASONAL 1972

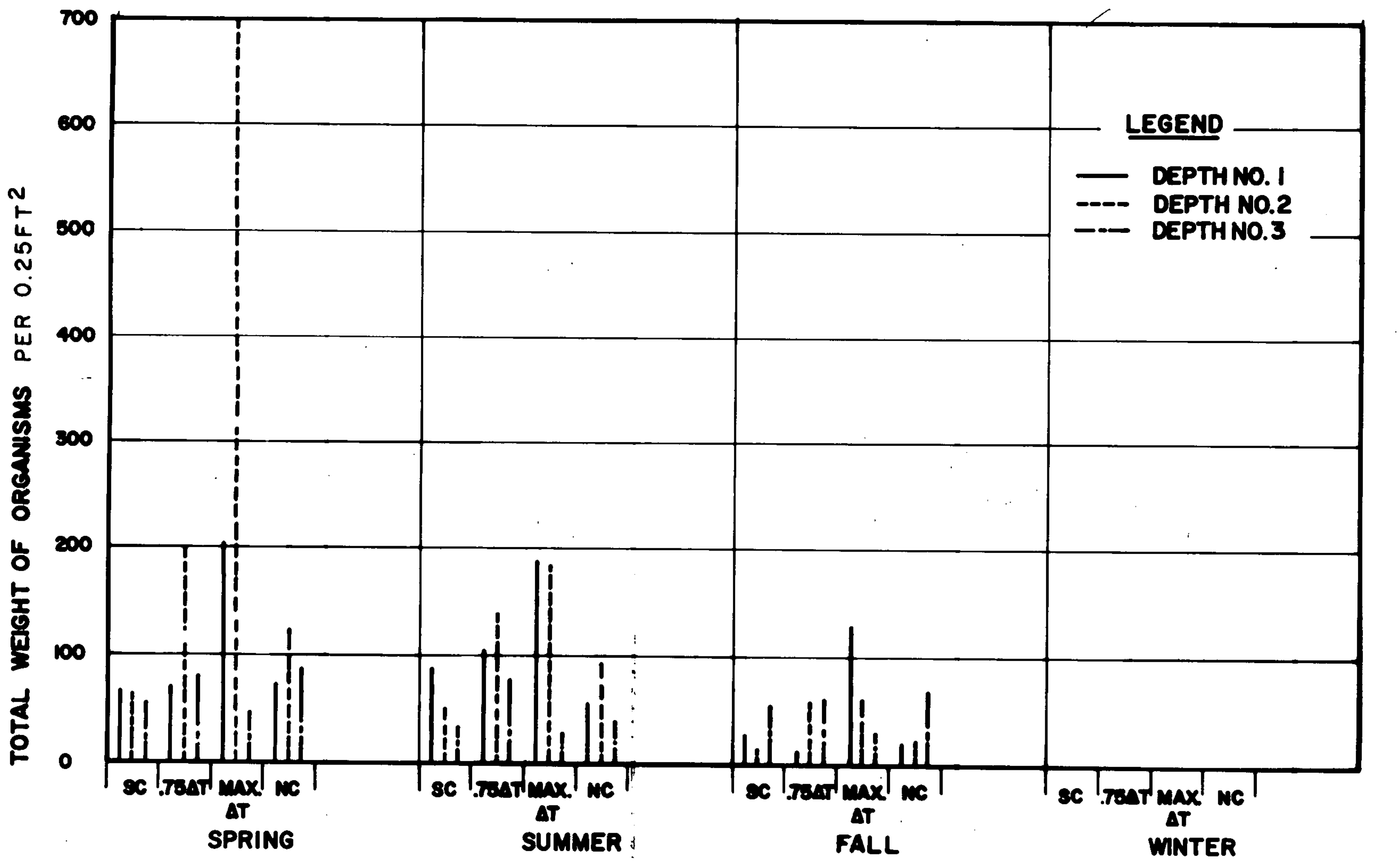


FIGURE III - 6

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
BENTHOS BIOMASS
PER DEPTH, SEASONAL
1972

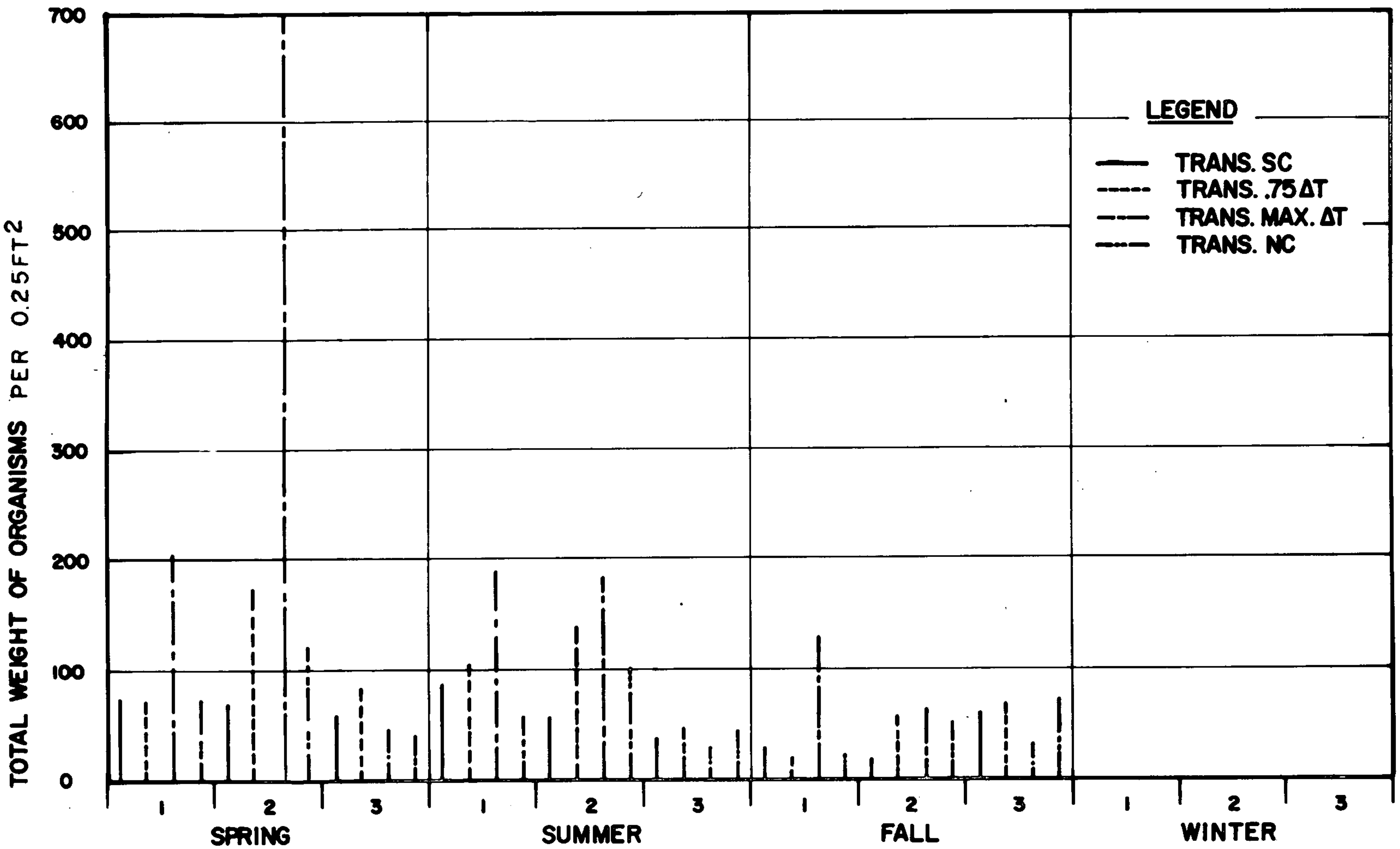


FIGURE III-7

TABLE III-3

ROSETON BENTHOS QUANTITATIVE PROGRAM
AVERAGE BIOMASS PER ORGANISM
1971-1972

[Milligrams per Individual (Wet Weight)]

	1971		1972			
	Fall 10/26	Winter 12/17	Spring 6/20	Summer 8/17	Fall 10/18	Winter 12/12
Oligochaetes						
. Average biomass	2.25	0.83	0.87	1.08	0.66	not biomassed
. Average total number	(9)	(36)	(142)	(68)	(48)	(66)
Dipteran Larvae						
. Average biomass	0.67	0.66	1.12	0.43	3.86	not biomassed
. Average total number	(5)	(23)	(6)	(11)	(48)	(18)
Amphipods						
. Average biomass	0.05	3.77	1.04	0.39	0.23	1.07
. Average total number	(<1)	(3)	(7)	(16)	(9)	(2)
Isopod *(Cyathura polita)*						
. Average biomass	2.32	6.80	2.88	2.92	3.15	2.84
. Average total number	(<1)	(1)	(1)	(2)	(3)	(2)

Key: ( ) Mean for total number of organisms per 0.25 ft^2 surface area.

Oligochaetes were the most abundant group throughout the sampling period. During the Fall of 1971 average density was low, with average individual biomass high, which may indicate a period of growth per individual, high grazing pressure by various predators or mortality in the population. From Fall to Winter 1971, oligochaete density increased with the average individual biomass decreasing indicating a period of reproduction or recruitment.

The maximum density of oligochaetes was observed in June 1972 with the average individual biomass remaining relatively low. Oceanographic Analysts, Inc. (Quirk, Lawler and Matusky Engineers and Oceanographic Analysts, 1969) also observed peak oligochaete densities during the month of June, which appears to be a period of high reproduction. Many oligochaetes reproduce during early summer (Edmonson and Winberg, 1971) and the spring collection may represent an early contingent.

The oligochaete density decreased from spring to summer but average individual biomass increased, indicating individual growth with decrease in population size due to mortality or predation. Oligochaete density continued to decrease into Fall with average individual biomass decreasing and reaching the observed low. The average biomass per unit area also decreased during this period indicating limited recruitment and or size selective grazing by consumers. A sharp decrease of oligochaete density occurred at most stations during Summer and Fall.

Determining seasonal trends in dipteran larvae using values of average weight per individual has certain limitations. These difficulties are primarily due to substantial size differences between species and the aspect of emergence. Without species level analysis and regard to instar stages, data interpretation by biomass per individual is limited.

Substantially higher values of biomass per dipteran occurred in the Spring and Fall of 1972 than at other dates. This could be related to major emergence cycles, i.e. at these times of the year the larvae are larger and are nearing pupation.

The amphipods, identified as Gammarus fasciatus, had the highest observed biomass per organism during the Winter and Spring. Their highest densities were observed during the summer, with a low biomass per individual which indicates a reproduction period. Gammarus has been reported to rise in numbers during the summer as the amphipod produces brood after brood (Hynes, 1955).

The average biomass per individual for the isopod Cyathura polita appeared fairly uniform except for the Winter of 1971 when the average individual biomass was highest at 6.80 mg per individual. However, this organism displayed no clear seasonal trends in terms of biomass per individual.

c. Community Structure

It is generally accepted that a diverse community is indicative of a balanced environment and is characterized by a variety of interspecific relationships (Tenor, 1972). A community consisting of many organisms but only a few species is generally considered to be representative of unbalanced environmental conditions (Goodnight, 1973). This is a result of the wide range of tolerance of some species as opposed to the narrow range of tolerance of others (Patrick, 1971).

In a fluctuating environment, or one that has undergone a shift in conditions, i.e., as in a polluted body of water, species with a narrow range of tolerance cannot exist. This results in a decrease of interspecific interaction and often an increase in the densities of species having a wide tolerance range.

Community structure was analyzed in terms of per cent composition of both numbers of organisms and total biomass of organisms and is presented in Figures III-8 through III-11. Table III-4 summarizes the locations which showed domination (defined as greater than or equal to 50% of the total number) by a particular group of organisms.

Of the 72 samples taken during 1971-1972, 54 were dominated by a particular group of organisms. The oligochaetes were the most frequent of the dominating groups, followed by the dipterans, with only occasional domination by the total group termed others, (including amphipods, isopods and leeches). The amphipods were the largest component in this latter group.

When the community structure is converted into a numerical expression, station values can be compared and trends may become more obvious. The community affinity index (index of similarity) for sampling station comparisons are displayed in trellis diagrams as shown in Figures III-12 through 17. Community structure dominance by one or a few types of organisms at most of the sampling stations would result in high affinity associations. The highest mean affinity values for 1972 were observed

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
PERCENT COMPOSITION BENTHOS
PERCENT OF TOTAL NO. AT EACH TRANSECT
FALL & WINTER - 1971

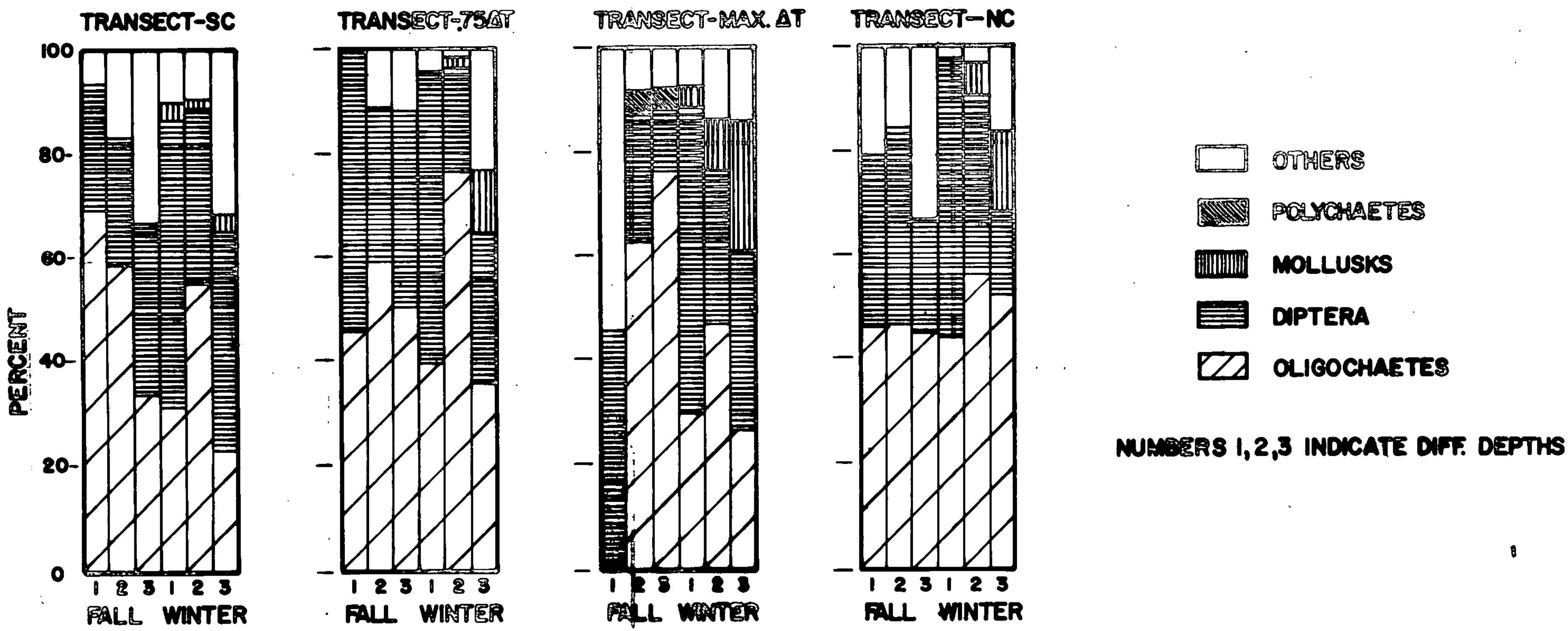
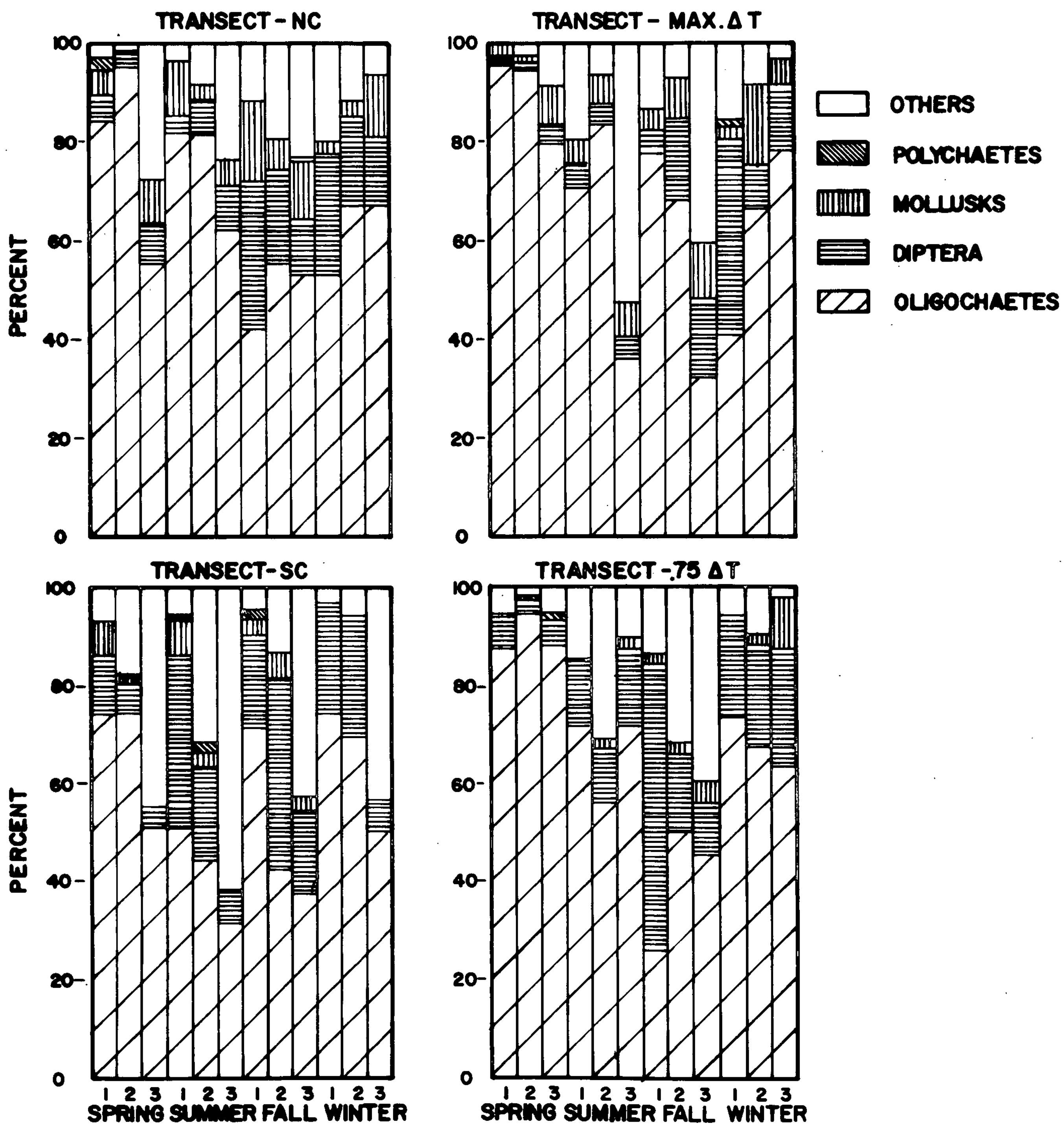


FIGURE III-8

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION

PERCENT COMPOSITION BENTHOS
PERCENT OF TOTAL NO. AT EACH TRANSECT EACH SEASON - 1972



CENTRAL HUDSON GAS & ELECTRIC

PERCENT COMPOSITION — BENTHOS
ROSETON
PERCENT OF TOTAL BIOMASS AT EACH TRANSECT
FALL & WINTER 1971

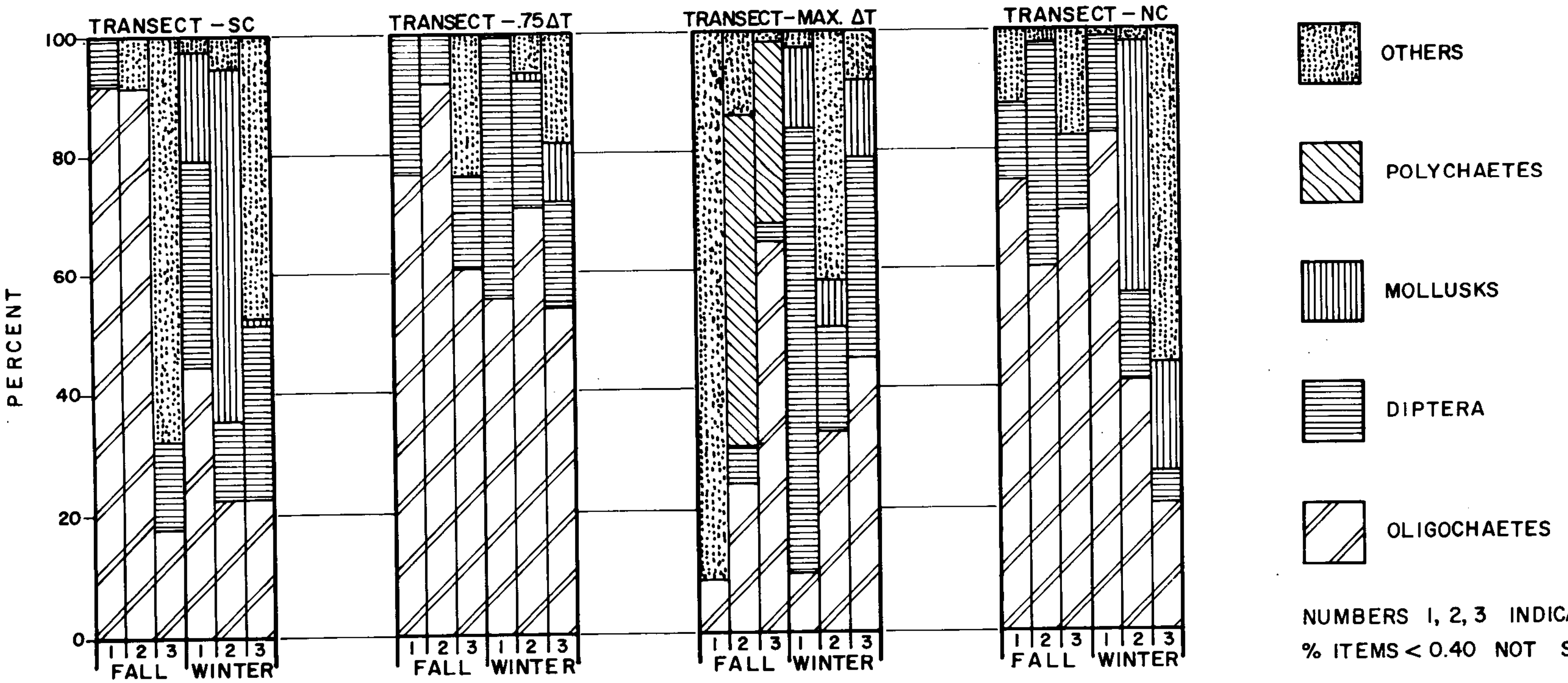


FIGURE III-10

CENTRAL HUDSON GAS & ELECTRIC

PERCENT COMPOSITION — BENTHOS
ROSETON
PERCENT OF TOTAL BIOMASS AT EACH TRANSECT EACH SEASON — 1972

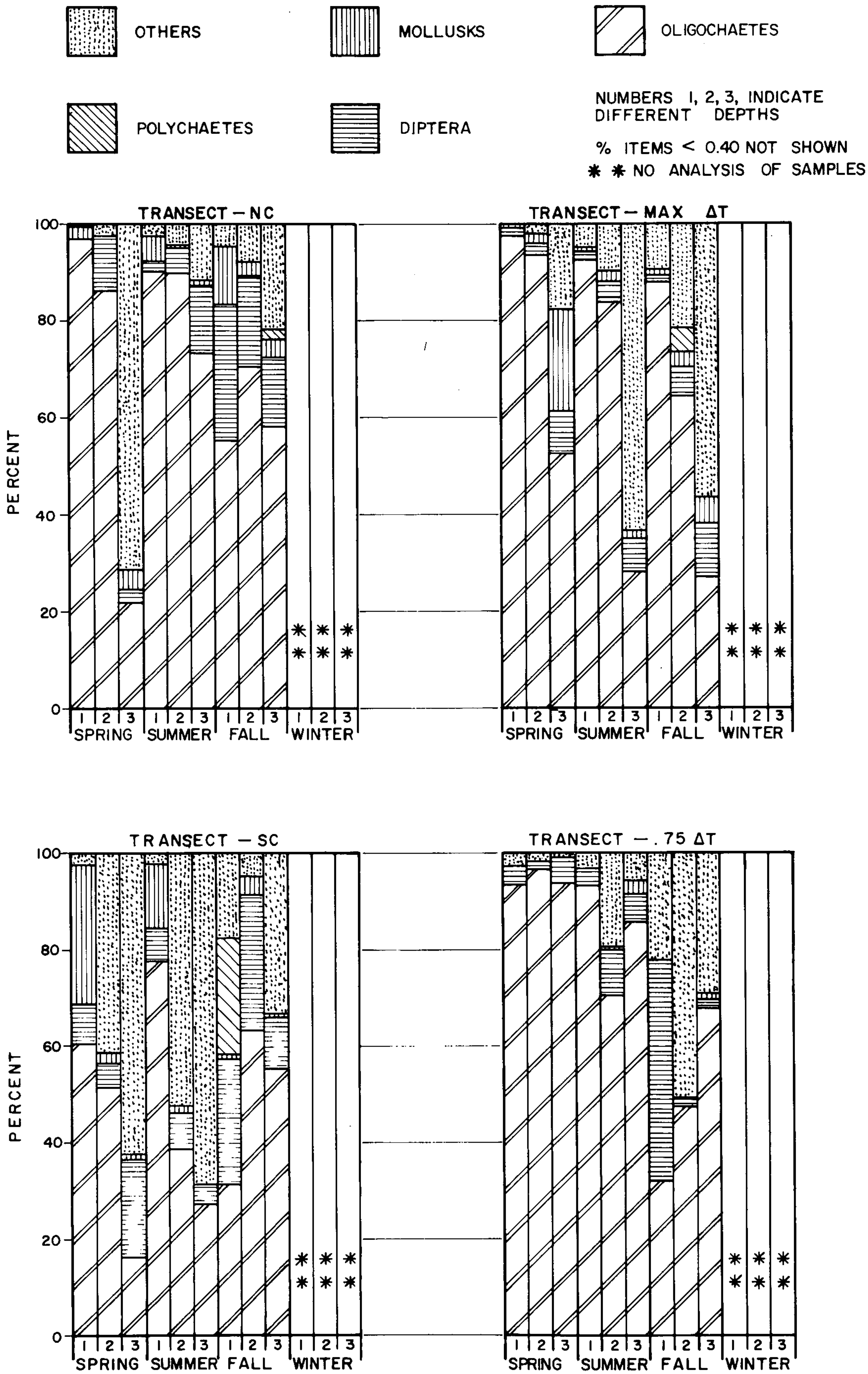


TABLE III-4

ROSETON BENTHOS

SAMPLE LOCATIONS HAVING POPULATION DENSITY STRUCTURE ≥50% DUE TO ONE GROUP OF ORGANISMS

	1971						1972													Total Depth		
	Fall			Winter			Spring			Summer			Fall			Winter						
Transect	10'	20'	30'	10'	20'	30'	10'	20'	30'	10'	20'	30'	10'	20'	30'	10'	20'	30'	Totals	10'	20'	30'
Oligochaetes																						
.North Control						+	+	+	+	+	+	+		+	+	+	+	+	12			
.Maximum ΔT*		+	+				+	+	+	+	+		+	+			+	+	11			
.0.75 ΔT**		+	+		+		+	+	+	+	+	+				+	+	+	12			
.South Control	+	+			+		+	+	+	+			+			+	+		10	14	18	13
Dipterans																						
.North Control				+															1			
.Maximum ΔT*				+															1			
.0.75 ΔT**	+			+									+						3			
.South Control				+															1	6	0	0
Others																						
.North Control																			0			
.Maximum ΔT*	+											+							2			
.0.75 ΔT**																			0			
.South Control												+							1	1	0	2
Total	3	3	2	4	2	1	4	4	4	4	3	4	3	2	1	3	4	3				
	8			7			12			11			6			10						

*Immediate vicinity of proposed discharge.
**600 yards south of discharge.
Key: + ≥ 50% of community structure.

FIGURE III-12

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

BENTHOS AFFINITY INDEX
FALL 10/6/71

KEY

- 0 - 25%
- 26 - 50%
- 51 - 75%
- 76 - 100%

STATION

STATION	NC 1	NC 2	NC 3	MAX 1	MAX 2	MAX 3	.751	.752	.753	SC 1	SC 2	SC 3
NC 1												
NC 2	80											
NC 3	69	84										
MAX 1	39	33	25									
MAX 2	71	64	53	57								
MAX 3	61	80	80	17	57							
.751	80	73	62	50	86	58						
.752	83	92	81	36	72	77	81					
.753	82	83	82	40	71	72	80	85				
SC 1	73	92	84	25	61	88	70	89	80			
SC 2	73	84	84	41	68	76	70	84	90	84		
SC 3	54	55	42	60	57	42	50	50	55	50	58	

KEY

0-25%

26-50%

51-75%

76-100%

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

BENTHOS AFFINITY INDEX
WINTER 12/7/71

STATION

STATION	NC 1	NC 2	NC 3	MAX 1	MAX 2	MAX 3	.751	.752	.753	SC 1	SC 2	SC 3
NC 1												
NC 2	74											
NC 3	60	80										
MAX 1	83	66	55									
MAX 2	73	87	87	68								
MAX 3	62	65	67	70	72							
.751	94	73	62	89	75	66						
.752	64	78	70	53	70	44	62					
.753	66	76	75	71	84	77	70	56				
SC 1	83	63	58	91	71	69	89	51	73			
SC 2	79	89	75	70	85	66	80	78	74	71		
SC 3	65	58	61	73	70	78	69	46	73	75	65	

FIGURE III-14

CENTRAL HUDSON GAS AND ELECTRIC AT ROSETON
BENTHOS AFFINITY INDEX
SPRING 6/20/72

KEY

- 0 - 25%
- 26 - 50%
- 51 - 75%
- 76 - 100%

STATION	NC 1	NC2	NC3	MAX 1	MAX 2	MAX3	.751	.752	.753	SC 1	SC 2	SC 3
NC 1												
NC 2	88											
NC 3	68	59										
MAX 1	88	97	59									
MAX 2	88	98	60	96								
MAX 3	91	83	74	83	83							
.751	92	90	67	88	90	87						
.752	88	98	60	96	96	83	92					
.753	92	91	63	89	91	94	95	92				
SC 1	87	78	75	78	79	88	85	78	82			
SC 2	83	78	81	76	79	87	85	79	82	87		
SC 3	58	54	83	52	54	64	61	56	60	60	73	

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

BENTHOS AFFINITY INDEX
SUMMER 8/17/72

KEY
- 0-25%
- 26-50%
- 51-75%
- 76-100%

STATION

STATION	NC 1	NC 2	NC 3	MAX 1	MAX 2	MAX 3	.751	.752	.753	SC 1	SC 2	SC 3
NC 1	X											
NC 2	90	X										
NC 3	72	79	X									
MAX 1	78	85	79	X								
MAX 2	94	92	75	82	X							
MAX 3	50	51	68	51	52	X						
.751	78	85	79	88	81	51	X					
.752	63	72	89	71	66	74	75	X				
.753	78	86	81	87	82	51	95	76	X			
SC1	61	62	67	66	64	51	71	66	73	X		
SC2	55	62	79	64	58	74	72	84	72	74	X	
SC3	38	45	61	46	81	88	49	69	48	43	69	X

FIGURE III-16

KEY

- 0-25%
- 26-50%
- 51-75%
- 76-100%

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

BENTHOS AFFINITY INDEX
FALL 10/18/72

STATION

STATION	NC 1	NC2	NC 3	MAX1	MAX 2	MAX 3	.751	.752	.753	SC 1	SC 2	SC 3
NC 1												
NC 2	70											
NC 3	73	85										
MAX 1	56	69	70									
MAX 2	71	84	79	80								
MAX 3	64	65	69	47	62							
.751	65	52	48	41	52	52						
.752	65	81	81	65	74	78	51					
.753	60	72	75	60	67	79	46	86				
SC 1	65	79	71	80	89	53	52	70	62			
SC 2	85	68	66	57	68	58	76	66	62	65		
SC 3	64	68	69	55	63	86	55	82	82	60	68	

KEY

0-25%

26-50%

51-75%

76-100%

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

BENTHOS AFFINITY INDEX
WINTER 12/12/72

STATION	NC1	NC2	NC3	MAX1	MAX2	MAX3	.751	.752	.753	SC1	SC2	SC3
NC1	X											
NC2	76	X										
NC3	72	89	X									
MAX1	81	61	58	X								
MAX2	70	81	91	56	X							
MAX3	72	86	86	59	84	X						
.751	74	89	84	62	77	88	X					
.752	82	89	85	70	81	87	92	X				
.753	82	85	88	68	84	79	83	84	X			
SC1	76	86	81	64	76	88	97	90	85	X		
SC2	84	90	85	73	83	87	89	95	88	91	X	
SC3	75	66	61	63	64	62	61	65	58	58	63	X

in the Spring collections. This was primarily due to high abundance of oligochaetes which were dominant (more than 50% of the community structure) at every sampling station. The lowest mean affinity values were observed in the Fall when the abundances of the community components were more evenly distributed.

No consistent pattern was observed in affinity values for depth or transect comparisons. Affinity associations from transect or depth comparisons varied seasonally. For any given season a transect or depth may have displayed low affinity values for the particular comparisons but in another season this was not the situation.

The Shannon index of general diversity is a numerical expression of community structure, which is a representation of how much information, or diversity, is contained in a given community. The results of this analysis are presented in Table III-5. As shown in Figures III-18 and 19 mean diversity values appear to be inversely related to mean affinity values.

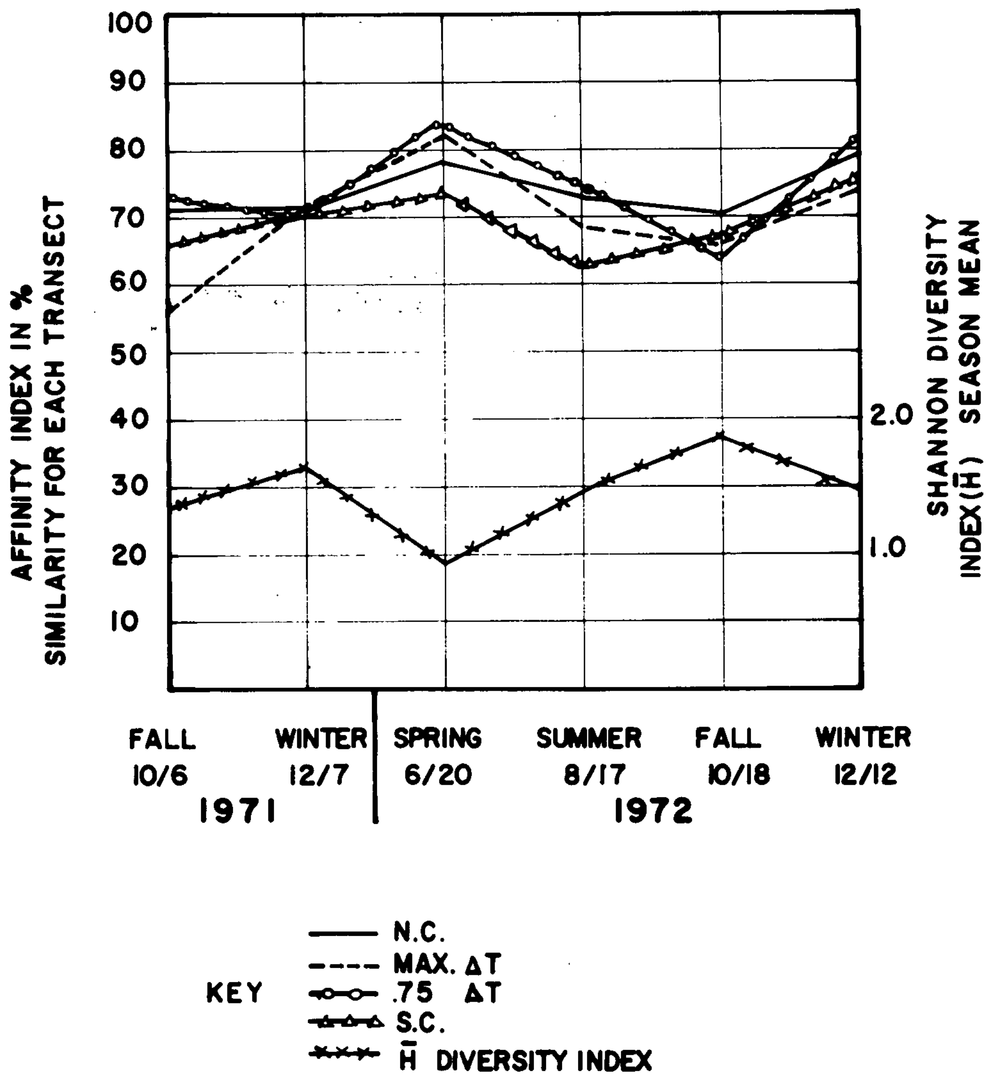
The Spring collections, being dominated by oligochaetes, have a low diversity index. Fall collections, having abundance values more evenly dispersed among the community components, had a higher diversity index. Higher diversity values were generally observed at the deeper depths, indicating somewhat more balanced community conditions than those observed in shallower waters.

TABLE III-5

ROSETON BENTHOS
SHANNON DIVERSITY INDEX

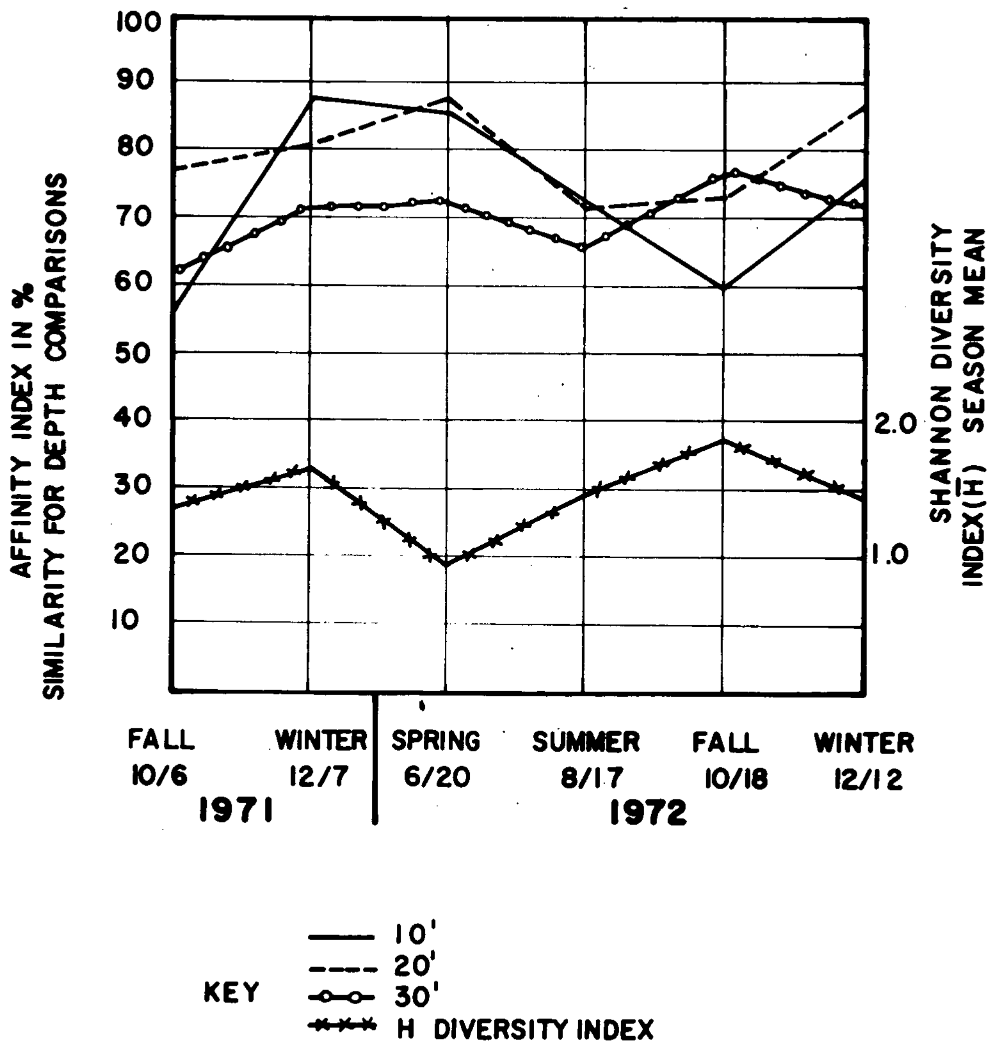
Transect	Depth	1971 Fall	1971 Winter	1972 Spring	1972 Summer	1972 Fall	1972 Winter
North Control	10'	1.7386	1.2030	0.9321	0.9497	2.1070	1.7093
	20'	1.1350	1.6028	0.3627	1.0117	1.8698	1.5323
	30'	1.4183	2.1043	1.7677	1.6265	2.2285	1.5082
Maximum ΔT	10'	1.6855	1.3277	0.2992	1.4377	1.3366	1.7485
	20'	1.5744	2.0100	0.4163	0.9900	1.4853	1.5567
	30'	1.0239	2.0526	1.0939	1.8875	2.3179	1.1512
0.75 ΔT	10'	0.9940	1.1964	0.7338	1.3682	1.7000	1.0949
	20'	0.9403	0.9824	0.3876	1.5191	2.0459	1.2493
	30'	1.6438	2.1412	0.7537	1.3685	2.0529	1.4084
South Control	10'	0.8113	1.5034	1.3423	1.6963	1.3166	1.1209
	20'	1.5511	1.5840	1.1672	2.0239	1.7877	1.3283
	30'	2.0000	2.2483	1.8374	1.8497	2.3845	2.1229

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON
BENTHOS 1971-72
AFFINITY INDEX
& SHANNON DIVERSITY INDEX
ACCORDING TO TRANSECT



CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

BENTHOS 1971-72
AFFINITY INDEX
& SHANNON DIVERSITY INDEX
ACCORDING TO DEPTH



Comparison of Fall and Winter 1971 to Fall and Winter 1972 showed a general increase in diversity values in 1972, except for the Max ΔT transect which slightly decreased. This reflects more balanced distribution of the community components at most stations. The Max ΔT transect, which displayed oligochaete domination had a somewhat unbalanced condition which increased from one year to the next. The Max ΔT transect was located near a backwater tributary which may have served as a seed source for benthic organisms or provided a source of nutrients favorable for oligochaetes. Sediment analysis conducted in 1973 should provide information for evaluation of this and other possibilities.

In other comparisons from 1971 to 1972, the South Control transect generally displayed higher diversity values than those observed at the other transects. Diversity comparisons on a seasonal basis showed that in 1972 the North and South Control transects generally had higher diversity values than Max ΔT and $.75\Delta T$ transects. This reflects the oligochaete domination of Max ΔT; and relative low organism abundance and diversity at the $.75\Delta T$ transect.

d. <u>Fish Support Potential</u>

Benthic organisms such as dipteran larvae, gastropods, pelecypods, isopods, amphipods, crayfish and worms are important members of the diets of various fish during all or at certain stages of their life (Brinkhurst, 1969; Hynes, 1970). Preliminary stomach analysis has shown that these organisms are important constituents in the diets of white perch and young striped bass in the Roseton vicinity.

Hayne and Ball (1956) and Allen (1951) studied the effect of fish predation on benthic productivity. They observed that 180 pounds of fish were produced in association with 810 pounds of fish food (benthos) and that the average annual production of benthic biomass was approximately 17 times the standing crop. This value (Hynes, 1970) was first suggested by Allen (Allen, 1951) and came to be known as the "Allen Paradox". Although this figure of benthis is many times the standing crop of benthos (Hynes, 1970).

Assuming similar relationships the theoretical production of fish flesh, based on benthos biomass, was calculated and is summarized in Table III-6.

The mean fish flesh production calculated from the benthos biomass at Roseton was 307 mg per 0.25 ft^2. Compared with other river areas this figure is low, i.e. at Kingston (MP 95) it was 1664 per 0.25 ft^2 and at Haverstraw Bay (MP 35) it was 765 mg per 0.25 ft^2. This illustrates substantial regional differences in the river benthos as food sources for fish and this was also reflected in the fish catches. Reflecting this variation in potential fish food, Kingston and Bowline had higher densities of fish caught per equal unit of effort than did Roseton.

e. Salinity Influence

The benthos of the Roseton area displayed characteristics in composition and abundance that were different than those observed at Kingston or Haverstraw Bay (approximately 30 river miles north and south, respectively).

TABLE III-6

ROSETON BENTHOS
FISH SUPPORT POTENTIAL

(Calculated Fish Flesh Production in mg Fish per 0.25 ft^2 Bottom Area)*

Location	1971 Fall	1971 Winter	1972 Spring	1972 Summer	1972 Fall	Mean
North Control	76.48	584.70	301.48	254.91	178.95	279.30
Maximum ΔT	126.91	164.64	1,196.74	508.86	286.64	456.76
0.75 ΔT	165.51	180.73	445.23	414.78	174.12	276.07
South Control	81.96	388.54	251.55	224.96	133.78	216.16
Mean	112.72	329.65	548.75	350.88	193.37	307.07
Depth						
10'	110.10	122.83	401.16	420.91	185.68	248.14
20'	103.87	404.03	1,030.25	453.24	181.30	434.54
30'	124.15	462.12	214.84	178.46	213.14	238.54
Mean	112.71	329.66	548.75	350.87	193.37	307.07

*Based on Hayne and Ball, 1956, and Allen, 1951.
**No biomass measured.

Biological observations suggest that the Roseton area is in a transitional zone between fresh and brackish water communities. Evidence for this suggestion comes from the decreasing abundance of an estuarine polychaete that was tentatively identified as belonging to the genus Scolecolepides and the appearance of a polychaete generally associated with fresh waters, identified as Manayunkia sp.

Polychaete abundance reported in 1969 (Quirk, Lawler and Matusky Engineers and Oceanographic Analysts, 1969) initially appear to be equivalent to densities found in the present study. However, although sample sizes were equal in both studies, the polychaete abundance in 1969 was actually based on a sub-sample count whereas the present studies are based on whole sample analysis. It appears therefore that polychaete abundance was higher in 1969 than in 1972.

Although the data from chemical sampling did not indicate salinity values associated with brackish waters, it is possible that because of the nature of the sampling frequency its presence could have been undetected. Salinity gradients in estuaries are known to result in decreased community diversity as the salinity changes (Reid, 1961).

The polychaete trend plus the comparative low abundance values of organisms and relative lack of variety in benthic community components suggest that the benthos in the Roseton area had been affected by the salt front. Whether the seasonal trends observed from one year to the next suggest a gradual response to the presence of fresh water due to the high flows from the past several years that pushes the salt front to the lower portion of estuary is not known. Nor is it known at this time if the observed decrease in organism abundance and diversity values during the Fall is associated with salt front intrusion. Increased sampling frequency and intensity during 1973 should provide information for evaluation of these possibilities.

E. SUMMARY OF RESULTS

1. The dominant benthic organisms collected in 1971-1972 in the Roseton area were oligochaetes and dipterans. Organism density was generally highest at the locations nearest the proposed discharge, which may be related to the influence of a tributary at that location.

2. Density distribution with depth was statistically significant only for the oligochaetes which had highest densities at the 20ft. depth.

3. Dipteran density was highest in the Winter and lowest in the Spring. The other organisms had highest densities during the Spring and lowest in the Fall.

4. Community structure of the sampling stations appeared more similar to each other during the Spring and more dissimilar in the Fall. Diversity indices were generally higher at the North and South Control locations.

5. The fish support potential of the area calculated on the basis of benthos biomass shows an annual average production of more than 300mg of fish flesh

per $0.25ft^2$ bottom area. This is lower than river areas about 30 miles north and south of Roseton. The density of fish in equal catch efforts reflects such differences between Roseton and these areas.

5. Organisms generally associated with both fresh water and estuarine waters were collected. The nature of the benthos in the Roseton vicinity may be transitional between a fresh water and estuarine character. This situation may be responsible for the low density and biomass of benthic organisms in comparison to areas farther north (more fresh water) or south (more estuarine).

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IV. FISH

IV FISH

A. INTRODUCTION

Fishes function at more levels of nutrient exchange and energy cycling than any other group of estuarine organisms. While other groups, such as the molluscs, or the crustaceans or the phytoplankton perform essential ecological functions, such as production of energy-rich organic molecules, or detritus feeding or consumption of plant matter, they are limited to a particular function or narrow range of functions in the system. The fishes are unique in applying all strategies to their function in an estuarine system. Various species or life history stages of species function as primary consumers, secondary consumers top-carnivores and detritus feeders. Fishes occupy all habitats in the estuary, and employ all methods of feeding; filtration, passive predation, active predation and detritus feeding.

The presence and persistence of fishes in an estaury is essential to functioning of the system and may dictate the stability of the system, in that the diversity of fishes and their roles provide for plasticity in response to environmental change and a variety of means whereby the two essential functions of the system, nutrient cycling and energy flow, may be maintained without interruption.

B. STUDY OBJECTIVES

In 1971 and 1972 extensive field studies were performed in the vicinity of the Danskammer Point and Roseton Generating Stations. The design of the studies was such that a variety of habitats in this area of the Hudson River would be sampled for fishes in a quantitative manner. The results of the studies would be used to assess baseline characteristics of the fish populations and communities prior to the operation of the Roseton Generating Station.

C. MATERIALS AND METHODS

1. Sampling Frequency

Fishes were sampled once each month from May to December in 1971, and from April to December in 1972. From May to August 1972, samples were collected biweekly to better determine characteristics of fish distribution and abundance during the period of most intense biological activity.

2. Collection Techniques

Several types of sampling gear, each suited to sampling specialized habitats, were employed in the present study. In 1971 samples were collected primarily by otter trawl and experimental gill nets. In 1972 sampling techniques were expanded to include drift gill nets, shore seines and fyke nets.

Trawls were made by a 30 foot otter trawl with 2 inch mesh in the body of the net and a 1/4 inch square mesh cod end liner. Surface and bottom trawls were made with the same trawl. For surface trawls buoys were attached to the doors to maintain the net at the surface.

The experimental gill nets consisted of five panels; 1/2, 1, 1 1/2, 2 and 2 1/2 inch square mesh. Each composite net measured 125 feet long by six feet deep. The drift gill nets were of 3 inch and 5 inch stretched mesh. Each net was 300 feet long. The 3 inch mesh net was 8 feet deep, the 5 inch mesh net was 10 feet deep.

Shore seine collections were made with a 50 foot long by 5 feet deep seine having a 1/4 inch square mesh.

The fyke net had a 2 1/2 foot hoop diameter, with a 1/4 inch square mesh. The net was set perpendicular to shore with a 50 foot lead between the net and shore.

3. Station Locations

The sampling stations for 1971 and 1972 are shown in Figures IV-1 and IV-2 respectively. The Roseton intake-discharge transect extended from south of the Danskammer Point Generating Station to the Hess fuel dock and was conducted in 30-40 feet of water. Trawls were conducted south of the Roseton station after July 1972 because they had frequently been caught on a mud hump on previous dates. The experimental gill nets were set in 30 feet of water at the designated stations.

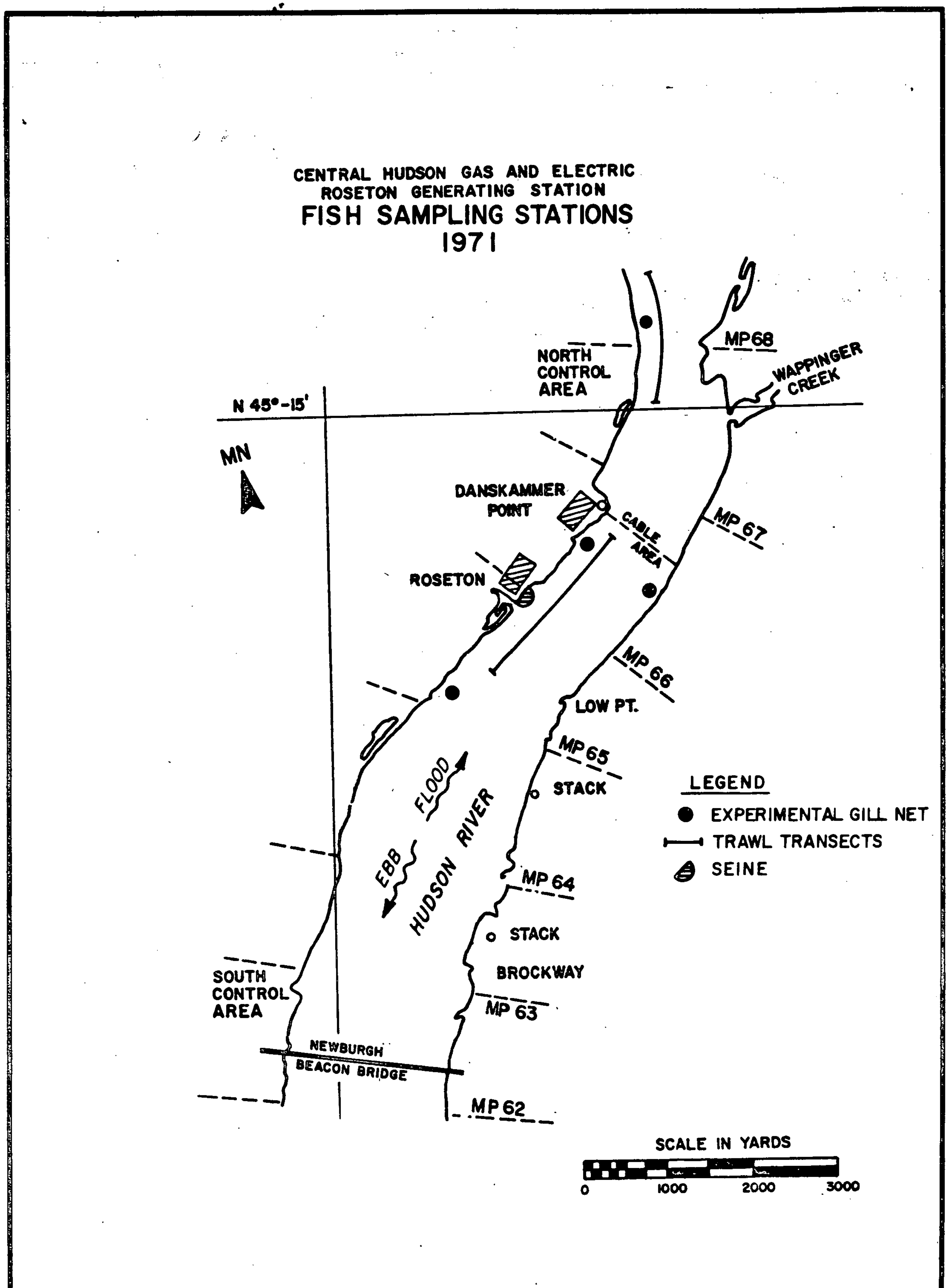
The Roseton control transect extended north of Wappinger Creek and was conducted in 40 to 50 feet of water. The experimental gill nets were set at the north control transect in 30 feet of water at the surface and bottom. The Roseton east gill nets were set in 30 feet of water.

4. Discussion of Procedures

(a) Sampling Locations. Sampling stations were selected in the immediate vicinity of the Roseton/Danskammer Point plants and at a location several miles north of these plants. These stations were selected to reflect the near-field effects of a thermal discharge and an area that would be expected to receive negligible impact from a thermal discharge.

Both shallow and deeper water fish communities were sampled for several reasons:

(1) The shallow sites were expected to experience greater temperature influence by the discharge and in addition provided comparative historic information from previous studies.


CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
FISH SAMPLING STATIONS
1971
NORTH CONTROL AREA
MP68
WAPPINGER CREEK
N 45°-15'
MN
DANSKAMMER POINT
CABLE AREA
MP 67
ROSETON
MP 66
LOW PT.
MP 65
STACK
FLOOD
EBB
HUDSON RIVER
MP 64
STACK
BROCKWAY
SOUTH CONTROL AREA
MP 63
NEWBURGH BEACON BRIDGE
MP 62
LEGEND
EXPERIMENTAL GILL NET
TRAWL TRANSECTS
SEINE
SCALE IN YARDS
0
1000
2000
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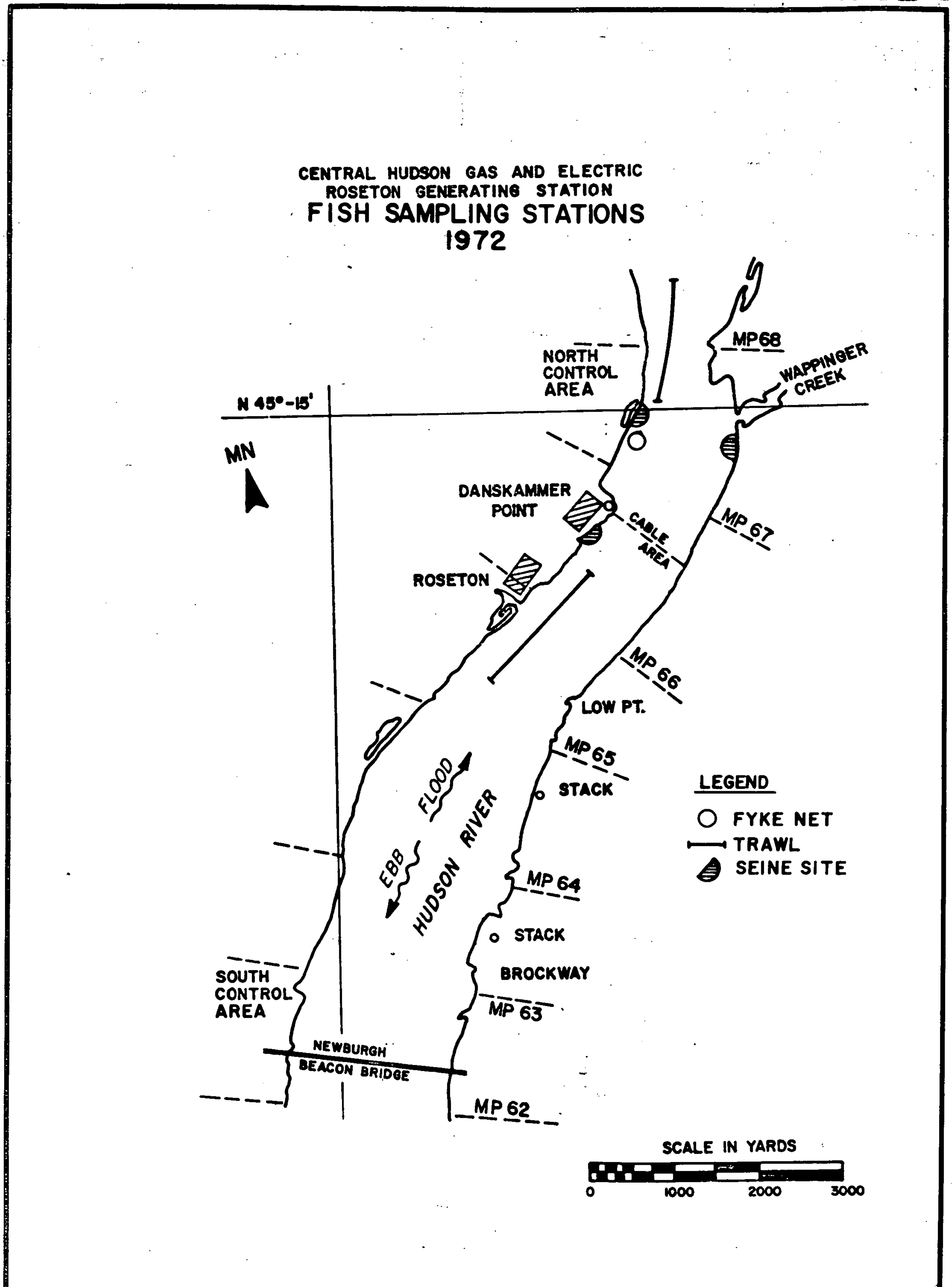

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
FISH SAMPLING STATIONS
1972
MP68
NORTH
CONTROL
AREA
WAPPINGER
CREEK
N 45°-15'
MN
DANSKAMMER
POINT
CABLE
AREA
MP 67
ROSETON
MP 66
LOW PT.
MP 65
STACK
FLOOD
HUDSON RIVER
EBB
MP 64
STACK
BROCKWAY
SOUTH
CONTROL
AREA
MP 63
NEWBURGH
BEACON BRIDGE
MP 62
LEGEND
FYKE NET
TRAWL
SEINE SITE
SCALE IN YARDS
0
1000
2000
3000

(2) Seine site selection was influenced by site suitability, i.e. availability of beach and river bottom areas to permit seining efforts.

(3) Fyke nets were used in shallow water areas as a passive means of fish capture for comparability to seine catch and provide information from shallow waters,within the desired study area, that were not suitable for seining.

(4) Deeper waters harbor various species and sizes of fish that are not generally represented by seine or fyke catches. The otter trawl was selected as the sampling apparatus for deep waters because it is less species selective than other sampling devices and, with the attachment of floats, became a surface trawl enabling catch comparison to bottom trawl results.

(5) Gill nets were anchored in 1971 as a passive means of capture for selected sizes of fish at specific locations. Their design permitted collection efforts in areas inaccessible by seine, fyke net or trawl.

5. Laboratory Analysis

Various physical measures and general observations are conducted on the captured fish. When standardized and computer processed, they enable not only the monitoring of selected population parameters, but also provide insight into some of the dynamics of a fish population. Fish are speciated, counted, lengthed and weighed in addition, a subsample is taken for scale samples and dissection to determine the sex and weight of the gonads.

(a) Length and Weight Measurements

Weight was measured to the nearest tenth of a gram on a calibrated Mettler balance. Total length was measured to the nearest millimeter. Total length is defined as the distance from the tip of the head (jaws closed) to the tip of the tail with the lobes compressed so as to give the maximum possible measurement.

(b) Age and Growth

Fish scales were removed from major species that were represented by all age groups. A tri-simplex projector was used to count the number of growth rings or annuli on the scale and to make scale measurements.

By counting the number of annuli, which are formed each year, it is possible to determine the age of the fish. Annulus formation was considered complete in January, and all fish after January 1 were placed in the next year group even if the area of the renewed growth was not evident on the margin of the scale. Young-of-the-year fish were in age group 0 until January 1 when they moved into age group I.

(c) Spawning Periodicity

Gonads (ovaries and testes) are dissected out of the fish and weighed to the nearest hundredth of a gram. The gonad weight is then translated into a coefficient of maturity expressed as (gonad weight/(fish wt.-gonad wt.))x 100. The time of spawning is defined by graphing the seasonal change in this relationship.

The course of development of the gonads is, to a significant extent, determined by the growth rate and age of the fish, as well as physiological factors. The moment of commencement of actual spawning is usually a reaction to some environmental stimulus. In many fishes, the stimulus for the start of spawning is a particular water temperature, which is closely associated with photo-period.

The coefficient of maturity can be graphed against time to show time of spawning. This is possible because the weight of the gonads increases until the fish spawns, at which time gonad weight drops off sharply. The shorter and more well-defined the spawning period, the more abrupt and obvious is the decrease in the coefficient of maturity.

D. RESULTS AND DISCUSSION

A listing of the various species of fish collected in the Roseton vicinity in 1971 and 1972 is presented in Table IV-1. A tabulation of the composition of these fish in surface trawl, bottom trawl and seine and fyke net collections is presented in Tables IV-2, 3 and 4 respectively. Abundance in 1972 seine collections in the Danskammer discharge area is presented in Table IV-5. Additional data tabulations on fish abundance are presented in Appendix D.

Temperature measurements taken during the fish sampling studies are presented in Figure IV-3. These measurements were taken in the cove area near the Danskammer Point Generating Station cooling water discharge and at surface and bottom at mid-channel of the Hudson River. The channel temperature shown in Figure IV-3 is the average of surface and bottom measurements. Little, if

TABLE IV-1

FAMILY, COMMON AND SCIENTIFIC NAMES OF FISHES COLLECTED IN THE VICINITY OF ROSETON, NEW YORK IN 1971 AND 1972

Family	Common Name	Scientific Name
Acipenseridae	Atlantic sturgeon	*Acipenser oxyrhynchus*
Clupeidae	Blueback herring	*Alosa aestivalis*
	Alewife	*A. pseudoharengus*
	American shad	*A. sapidissima*
	Atlantic menhaden	*Brevoortia tyrannus*
	Gizzard shad	*Dorosoma cepedianum*
Engraulidae	Bay anchovy	*Anchoa mitchilli*
Osmeridae	American smelt	*Osmerus mordax*
Cyprinidae	Goldfish	*Carassius auratus*
	Carp	*Cyprinus carpio*
	Golden shiner	*Notemigonus crysoleucas*
	Spottail shiner	*Notropis hudsonius*
Catostomidae	White sucker	*Catostomus commersoni*
Ictaluridae	White catfish	*Ictalurus catus*
	Brown bullhead	*I. nebulosus*
Anguillidae	American eel	*Anguilla rostrata*
Belonidae	Atlantic needlefish	*Strongylura marina*
Cyprinodontidae	Banded killifish	*Fundulus diaphanus*
Gadidae	Atlantic tomcod	*Microgadus tomcod*
Percichthyidae	White perch	*Morone americana*
	Striped bass	*M. saxatilis*
Centrarchidae	Redbreasted sunfish	*Lepomis auritus*
	Pumpkinseed sunfish	*L. gibbosus*
	Bluegill	*L. macrochirus*
	Largemouth bass	*Micropterus salmoides*
	Black crappie	*Pomoxis nigromaculatus*
Percidae	Tesselated darter	*Etheostoma nigrum*
	Yellow perch	*Perca flavescens*
Pomatomidae	Bluefish	*Pomatomus saltatrix*
Soleidae	Hogchoker	*Trinectes maculatus*
Gasterosteidae	Fourspine stickleback	*Apeltes quadracus*
Carangidae	Crevalle jack	*Caranx hippos*

TABLE IV-2

MAJOR SPECIES COMPOSITION OF FISH COLLECTED BY SURFACE TRAWL IN THE VICINITY OF ROSETON, NEW YORK, 1971-1972

	Percent of Total Catch											
	July		August		September		October		November		December	
Species	RID	RC	RID	RC	RID	RC	RID	RC	RID	RC	RID	RC
White perch	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Alewife	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
Blueback herring	100.0	100.0	59.6	39.2	45.3	40.0	45.4	63.2	96.3	93.5	0.0	0.0
Striped bass	0.0	0.0	0.0	0.0	0.0	0.0	18.2	15.8	0.0	4.8	100.0	0.0
American shad	0.0	0.0	0.3	0.0	1.3	8.9	22.7	10.5	3.7	0.0	0.0	0.0
Bay anchovy	0.0	0.0	39.8	60.8	52.8	44.4	9.1	0.0	0.0	0.0	0.0	0.0
Subtotal	100.0	100.0	100.0	100.0	99.7	95.5	95.4	89.5	100.0	98.3	100.0	100.0
Others	0.0	0.0	0.0	0.0	0.3	4.5	4.6	10.5	0.0	1.7	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of fish	23	7	319	635	309	45	22	19	27	62	1	3

Key: RID = Roseton intake-discharge
RC = Roseton control.

Note: Data combined for 1971 and 1972

TABLE IV-3

MAJOR SPECIES COMPOSITION OF FISH COLLECTED BY BOTTOM TRAWL IN THE VICINITY OF ROSETON, NEW YORK, 1971-1972

	Percent of Total Catch						
	April	May		June		July	
Species	RID	RID	RC	RID	RC	RID	RC
White perch	50.0	77.6	61.3	62.7	42.8	66.8	45.0
Alewife	50.0	2.0	0.0	0.0	0.0	0.0	2.0
Blueback herring	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Spottail shiner	0.0	6.1	17.3	17.0	14.3	4.0	0.0
Hogchoker	0.0	6.1	9.3	9.8	33.9	1.6	2.0
Tomcod	0.0	0.0	0.0	2.0	7.1	16.7	36.1
Striped bass	0.0	0.0	0.0	1.3	0.0	0.7	9.4
Rainbow smelt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	100.0	91.8	87.9	92.8	98.1	89.8	96.1
Others	0.0	8.2	12.1	7.2	1.9	11.2	3.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of fish	2	49	75	153	56	126	255

Key: RID = Roseton intake-discharge
RC = Roseton control.

Note: Data combined for 1971 and 1972.

TABLE IV-3
(continued)

Species	Percent of Total Catch									
	August		September		October		November		December	
	RID	RC	RID	RC	RID	RC	RID	RC	RID	RC
White perch	68.9	48.4	29.5	22.8	40.9	46.7	38.7	16.3	68.3	30.8
Alewife	2.5	27.3	0.9	3.9	3.2	1.6	3.2	2.0	0.0	0.0
Blueback herring	0.0	1.5	11.6	0.0	0.0	0.0	6.4	0.0	0.0	0.0
Spottail shiner	10.2	1.3	0.0	0.5	2.2	0.0	0.0	0.0	0.0	0.0
Hogchoker	2.9	1.3	4.5	17.1	5.4	0.0	3.2	0.0	0.0	0.0
Tomcod	8.3	2.9	42.8	51.2	46.2	38.7	41.9	24.5	29.3	61.5
Striped bass	0.3	2.4	7.1	0.6	0.0	1.6	3.2	0.0	0.0	0.0
Rainbow smelt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.0	0.0	0.0
Subtotal	93.1	85.1	96.4	96.1	97.9	88.6	96.6	93.8	97.6	92.3
Others	6.9	14.9	3.6	3.9	2.1	11.4	3.4	6.2	2.4	7.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of fish	312	454	112	334	93	62	31	49	41	13

Key: RID = Roseton intake-discharge
RC = Roseton control.

Note: Data combined for 1971 and 1972.

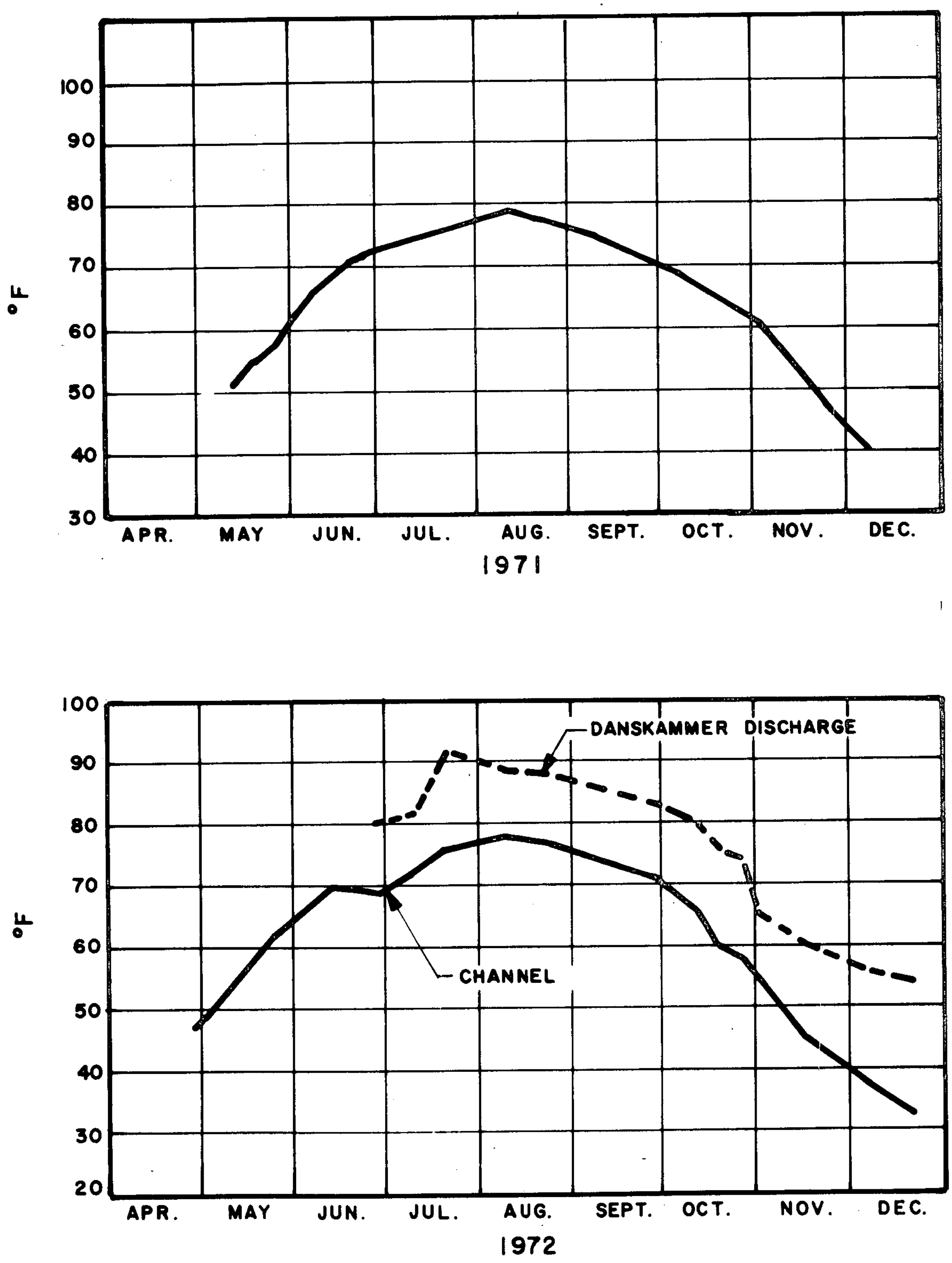
TABLE IV-4

SPECIES COMPOSITION OF FISH COLLECTED BY SEINE AND FYKE NET IN COVE NORTH OF DANSKAMMER PLANT, 1972

	Percent of Total Catch										
	June		July		August		September		October	December	
Species	Seine	Fyke Net	Seine	Fyke Net	Seine	Fyke Net	Seine	Fyke Net	Seine	Seine	Fyke Net
White perch	6.4	10.3	20.0	60.0	14.3	20.8			25.0		
Blueback herring					7.1		73.3				
American shad							6.7				
Striped bass											
Spottail shiner	71.1	29.0	11.4		28.6	35.4	13.3	28.6	30.0	50.0	100.0
Tesselated darter			14.3						25.0		
Brown bullhead	3.2	2.8	8.6	4.4		2.1					
Goldfish	3.2		2.8	1.1							
Banded killifish	9.7	32.7	11.4	1.1	7.1	12.5				16.7	
Bluegill	6.4	1.9				2.1			5.0		
Carp											
Golden shiner			8.6		35.7					33.3	
Pumpkinseed		16.8	11.4	29.0		18.8	3.3	28.6	15.0		
Yellow perch		3.7				4.2		42.8			
Redbreasted sunfish				1.1			3.4				
American eel			2.8	2.2	7.2						
White catfish			2.8								
Fourspine stickleback			5.9								
Black crappie				1.1		4.1					
Subtotal	100.0	97.2	100.0	100.0	100.0	100.0	99.9	100.0	100.0	100.0	100.0
Others	0.0	2.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of fish	31	107	35	90	14	48	30	7	20	6	2

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

AVERAGE-OF SURFACE AND BOTTOM WATER TEMPERATURES IN THE VICINITY OF ROSETON, N.Y.



any, variation between surface and bottom temperatures was observed.

Fish catch per 10 minute trawling effort is presented in Figures IV-4 and IV-5 for the dominant species of fish.

1. Distribution and Abundance

(a) Spring (April-June). White Perch and spottail shiners were the most abundant species in trawl collections during the spring of 1971. Differences in distribution of these species was evident in June, when substantially more fish were caught at the Roseton intake-discharge station than at the control station.

May and June collections for 1972 were dominated by white perch and hog-chokers, with spottail shiners present in fewer numbers than in 1971.

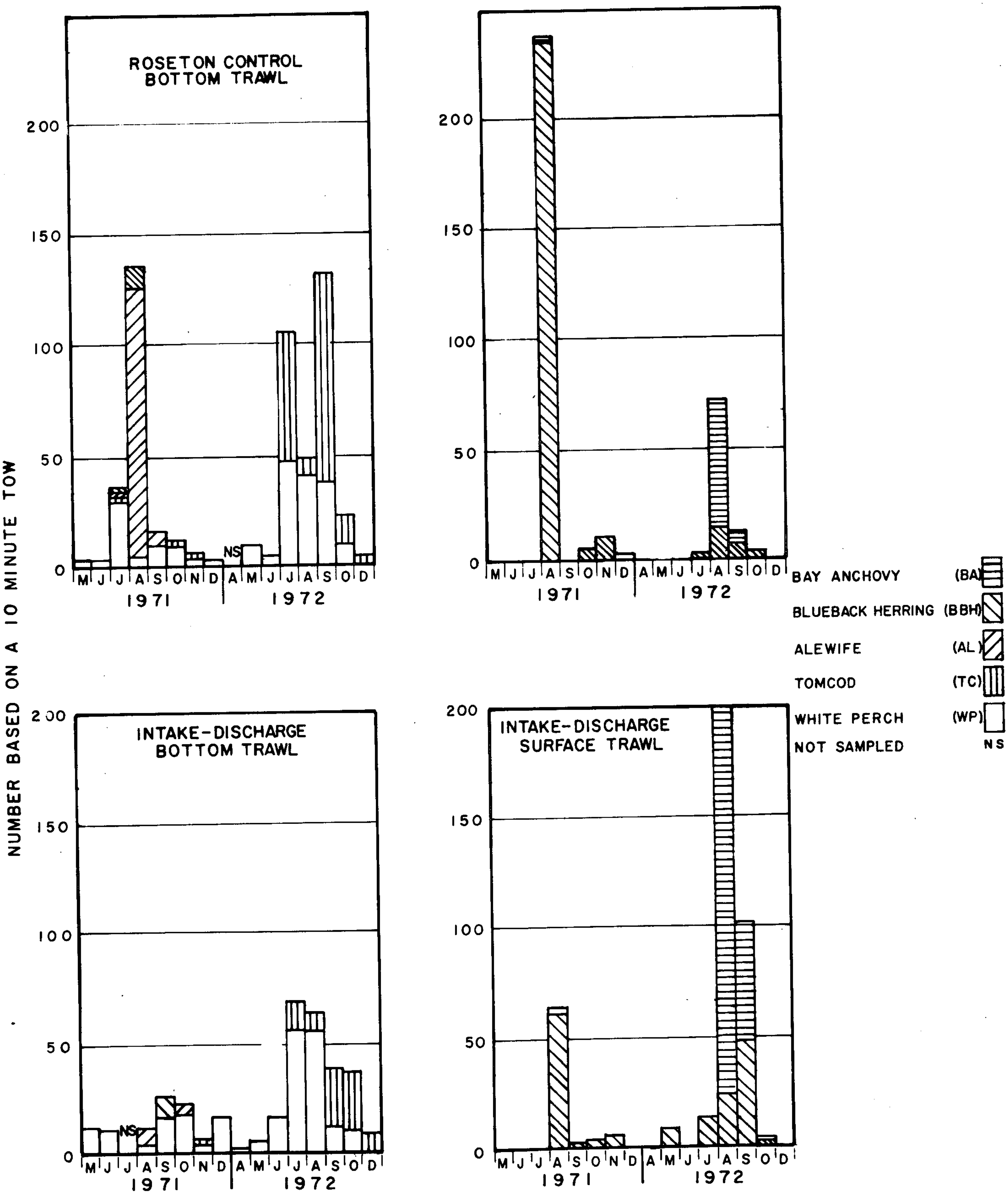
Seine and fyke net collections (1972 only) were dominated by white perch, spottail shiners, banded killifish and pumpkinseed sunfish (Table IV-4). Distribution of the 1972 catch among gears showed that the white perch and spottail shiner utilized the entire zone from shore to 30 foot depths, whereas near shore preference existed for the killifish and sunfish.

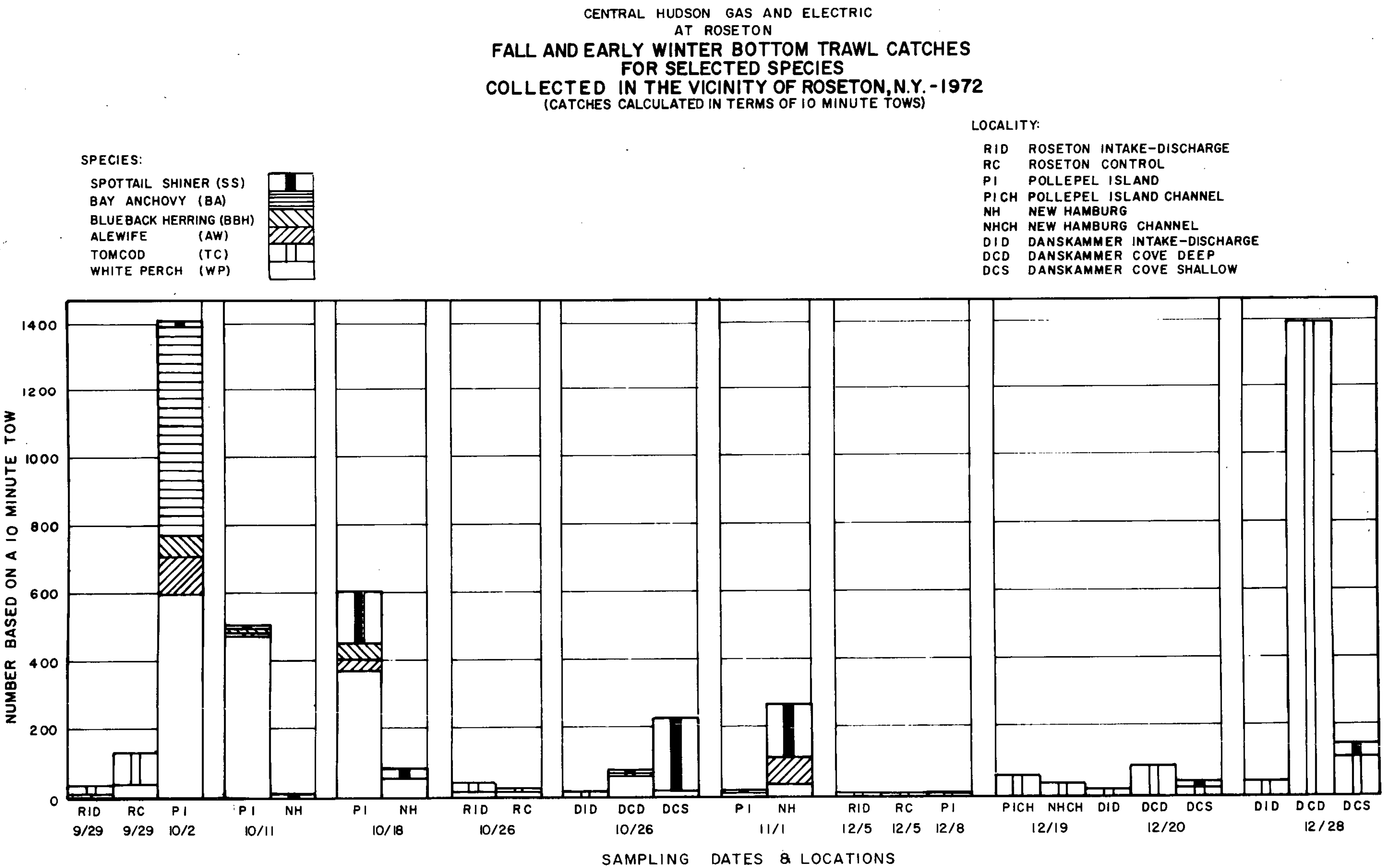
(b) Summer (July-September). A difference in distribution of fish occurred between the summer months of 1971 and 1972. In 1971 bottom trawls for July had substantial catches of striped bass in addition to white perch. Spottail shiners, dominant in June 1971 were absent from bottom trawls through September. Alewife appeared in low numbers in July 1971 and formed a major portion of the catch in August and September 1971. In August 1971 the majority of fish collected by trawl were from the control station.

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

SURFACE AND BOTTOM TRAWL CATCHES FOR SELECTED SPECIES COLLECTED IN THE VICINITY OF ROSETON, N.Y. 1971-1972

(CATCHES CALCULATED IN TERMS OF 10 MINUTE TOWS)





CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON
FALL AND EARLY WINTER BOTTOM TRAWL CATCHES
FOR SELECTED SPECIES
COLLECTED IN THE VICINITY OF ROSETON, N.Y. - 1972
(CATCHES CALCULATED IN TERMS OF 10 MINUTE TOWS)
SPECIES:
SPOTTAIL SHINER (SS)
BAY ANCHOVY (BA)
BLUEBACK HERRING (BBH)
ALEWIFE (AW)
TOMCOD (TC)
WHITE PERCH (WP)
LOCALITY:
RID ROSETON INTAKE-DISCHARGE
RC ROSETON CONTROL
PI POLLEPEL ISLAND
PICH POLLEPEL ISLAND CHANNEL
NH NEW HAMBURG
NHCH NEW HAMBURG CHANNEL
DID DANSKAMMER INTAKE-DISCHARGE
DCD DANSKAMMER COVE DEEP
DCS DANSKAMMER COVE SHALLOW
NUMBER BASED ON A 10 MINUTE TOW
1400
1200
1000
800
600
400
200
0
RID 9/29
RC 9/29
PI 10/2
PI NH 10/11
PI NH 10/18
RID RC 10/26
DID DCD DCS 10/26
PI NH 11/1
RID 12/5
RC 12/5
PI 12/8
PICH NHCH DID 12/19
DCD DCS 12/20
DID DCD DCS 12/28
SAMPLING DATES & LOCATIONS

FIGURE IV-5

Surface trawl collections in August 1971 were dominated by catches of juvenile blueback herring.

Bottom trawls in summer of 1972 differed from those in 1971 in that a much greater abundance of white perch and tomcod were collected and almost no juvenile clupeids. Hogchokers, which were virtually absent in 1971, were moderately abundant throughout the summer of 1972 and formed a large proportion of the September catch at the control station.

A total of three tomcod were caught in the summer 1971 bottom trawls. In 1972, however, tomcod were very abundant throughout the summer, particularly at the control station in September.

Surface trawl collections in 1972 showed an abundance of juvenile blueback herring in July increasing through August into September. The greatest abundance was at the intake-discharge station. Very large quantities of juvenile bay anchovies were captured at the intake-discharge station in August. The numbers of anchovies decreased markedly in September, however, the greater concentration remained at the intake-discharge station.

The inshore community in July 1972 was dominated by white perch and pumpkinseed sunfish. A distribution of ten species was observed in shore seine collections, while fyke nets collected mostly white perch, sunfish and bullheads (Table IV-4). Blueback herring appeared in shore seine collections in September.

The white perch population was composed of several age groups as shown in Figure IV-6. In August 1971 the small fish that hatched the previous spring had replaced the larger fish in the Roseton area. Mansueti (1961) found that white perch tagged during the spring spawning season in the Patuxent River, Maryland traveled upstream to spawn and that after spawning would move back downstream. This movement would explain the disappearance of the larger fish at Roseton by August in 1971 and by September 1972.

Tables IV-2 and 3 suggests a difference in distribution of the more abundant species. The tomcod and alewife were most abundant in the offshore deep stratum of the river, while the blueback herring and bay anchovy stayed near the surface in the river channel. However, by the end of August the blueback herring had expanded their distribution to the inshore area near the Danskammer plant discharge as shown in Table IV-5. White perch resided both inshore and at the river bottom.

The appearance of large concentrations of alewife, bay anchovy and tomcod in one year and not the other indicates that their distribution in the Hudson can fluctuate annually. It is also possible that the species may have moved out of the Roston area in between sampling dates or that the species were located in other sections of the river.

Large differences in abundance of the bay anchovy, blueback herring, alewife and tomcod between the Roseton intake-discharge and Roseton control stations were observed. Since these are all schooling species the catch differences between stations were probably due to the presence or absence of a school in that vicinity at that particular time of sampling.

In the summer of 1971 young-of-the-year striped bass were present near the the river bottom. In 1972 none were collected near shore and only three were taken from the bottom waters.

During July and August of 1972 the fish population in the cove north of the Danskammer plant, consisted of primarily white perch, spottail shiner,

TABLE IV-5

SPECIES COMPOSITION OF FISH COLLECTED BY SEINE AT THE DANSKAMMER PLANT DISCHARGE IN 1972

Species	Total Number Collected												
	6/27	7/9	7/20	8/8*	8/23	9/29	10/11	10/18	10/26	11/1	11/16	12/5	12/19
American shad					18	13	10		1	2			
Blueback herring			1		88	90	40	5					
White perch		4				10	9		24	2	1	1	3
Striped bass						73	61	4	9				
American eel		1											
Spottail shiner	3	6				1	7	4				1	6
White catfish						4							
Goldfish								1					
Banded killifish								1					
Bluegill	2						1		1				
Carp	3	1			1								6
Golden shiner	2	7	1		1	1		2	1	1	5	1	1
White sucker							1						
Redbreasted sunfish						1							
Black crappie		1						1					
Gizzard shad								1		5	12		2
Atlantic needlefish							1						
Unidentified shiner						1							

*No fish.

golden shiner, pumpkinseed and banded killifish (Table IV-4). There were more species near shore than in deeper water in July, however, the total number of individuals was less. By August there was a decrease in both the number of species and individuals in the shore area. The water temperature had reached a maximum in August probably causing the species to move to deeper water.

As the water temperature increased during the summer there was a decline in numbers of species and individuals at the Danskammer plant discharge (Table IV-5).

Figure IV-3 shows that there was a 10-16°F difference between the ambient water and discharge water temperature during the summer of 1972. In late August, however, there was a reappearance of fish near the discharge. The majority of these fish were young-of-the-year blueback herring and American shad. Relatively few blueback herring and no shad were collected at other stations. The discharge water temperature at that time was approximately 86°F; 9° above ambient temperature. It appears, then, that these species may be tolerant of these temperatures.

The fish population in this section of the Hudson during the summer can be divided into the following three distinct communities.

(1) an inshore community of pumpkinseed, banded killifish, white perch, spottail shiner, golden shiner and, late in the summer, juvenile blueback herring;

(2) a surface community composed of juvenile bay anchovy and blueback herring, and

(3) bottom dwelling juvenile tomcod and alewife and juvenile and older white perch.

There was some movement from the inshore water to deeper areas as the water temperature rose during the summer. This was particularly evident at the Danskammer Plant discharge.

(c) Fall (October-December) Fish were less abundant in fall collections in 1971 and 1972. Bottom trawl collections in 1971 were dominated by white perch and tomcod except in NOvember, when smelt were abundant at the control station. The summer abundance of juvenile alewife decreased through October and November 1971; no alewives were captured in the December samples. White perch were abundant throughout the fall. In December abundance of young-of-the-year tomcod decreased and abundance of adults increased. The greatest abundance of fish and of different species of fish through the fall was at the Roseton intake-discharge station.

Surface trawl catches in fall 1971 were generally dominated by juvenile blueback herring, juvenile shad and striped bass. Fall bottom trawl samples in 1972 were dominated by tomcod and white perch in October and by tomcod in December. Fewer species were in the 1972 bottom trawl collection than in the 1971 collections, although the two years were similar in numbers of fish captured.

Surface trawls in the fall of 1972 caught very few fish; four blueback herring, two shad, two anchovies, one hogchoker, one spottail shiner and one smelt.

Near shore sampling in 1972 also yielded relatively few fish; 28 fish from October through December. Eleven of these were spottail shiners.

Examination of length frequency data for the most abundant species in the Roseton vicinity revealed that most were juvenile, or young-of-the-year fish which were seasonally transient at the Roseton site (Figures IV-6,7 and 8).

2. Life History Parameters of Dominant Species

The presence of immature and mature white perch and Atlantic tomcod year round in the Roseton/Danskammer area necessitates an understanding of their life history. Parameters that were analyzed for each species were age composition, growth and spawning behavior.

(a) White Perch

White perch was one of the most abundant species in the Roseton vicinity in 1971 and 1972. To gain insight into the dynamics of white perch populations, age structure, growth and spawning periodicity were examined in detail.

The length distribution as shown in Figure IV-6 illustrates the size range and age composition of the white perch population. The peak for smaller fish indicates the modal length for the youngest age group. In the spring these would be age group I fish. By the middle of the sumemr age group 0 or young-of-the-year have entered the fishery, i.e. have reached a catchable size.

The age composition of the larger fish is not as evident because of the considerable overlap in the distributions around peaks. Scale analysis revealed that no white perch over age group VII were collected and relatively few over age group V.

Fish were collected with three types of gear (trawls, seines and fyke nets)

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

LENGTH DISTRIBUTION
OF WHITE PERCH COLLECTED IN THE VICINITY OF ROSETON, NEW YORK 1971 & 1972

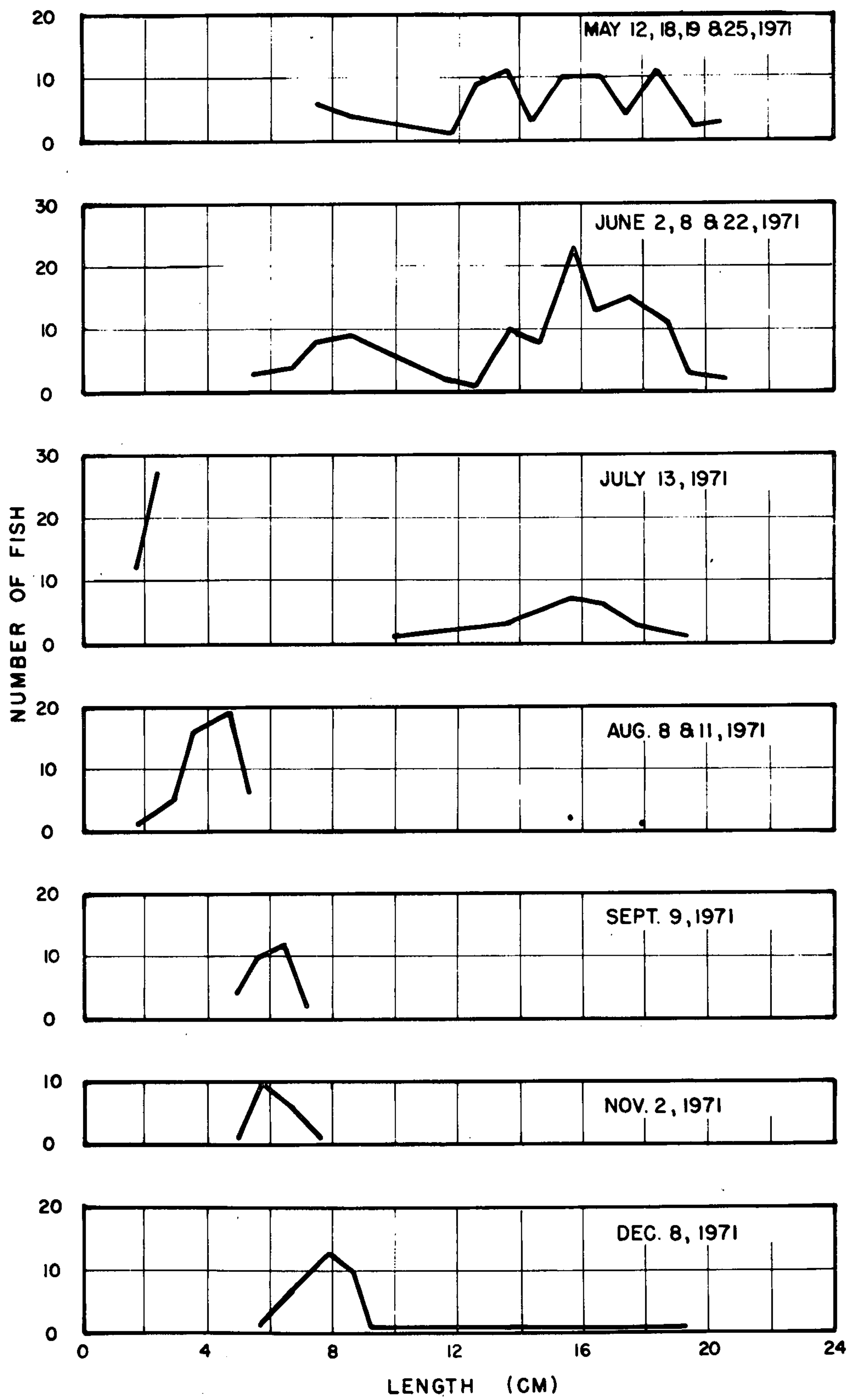
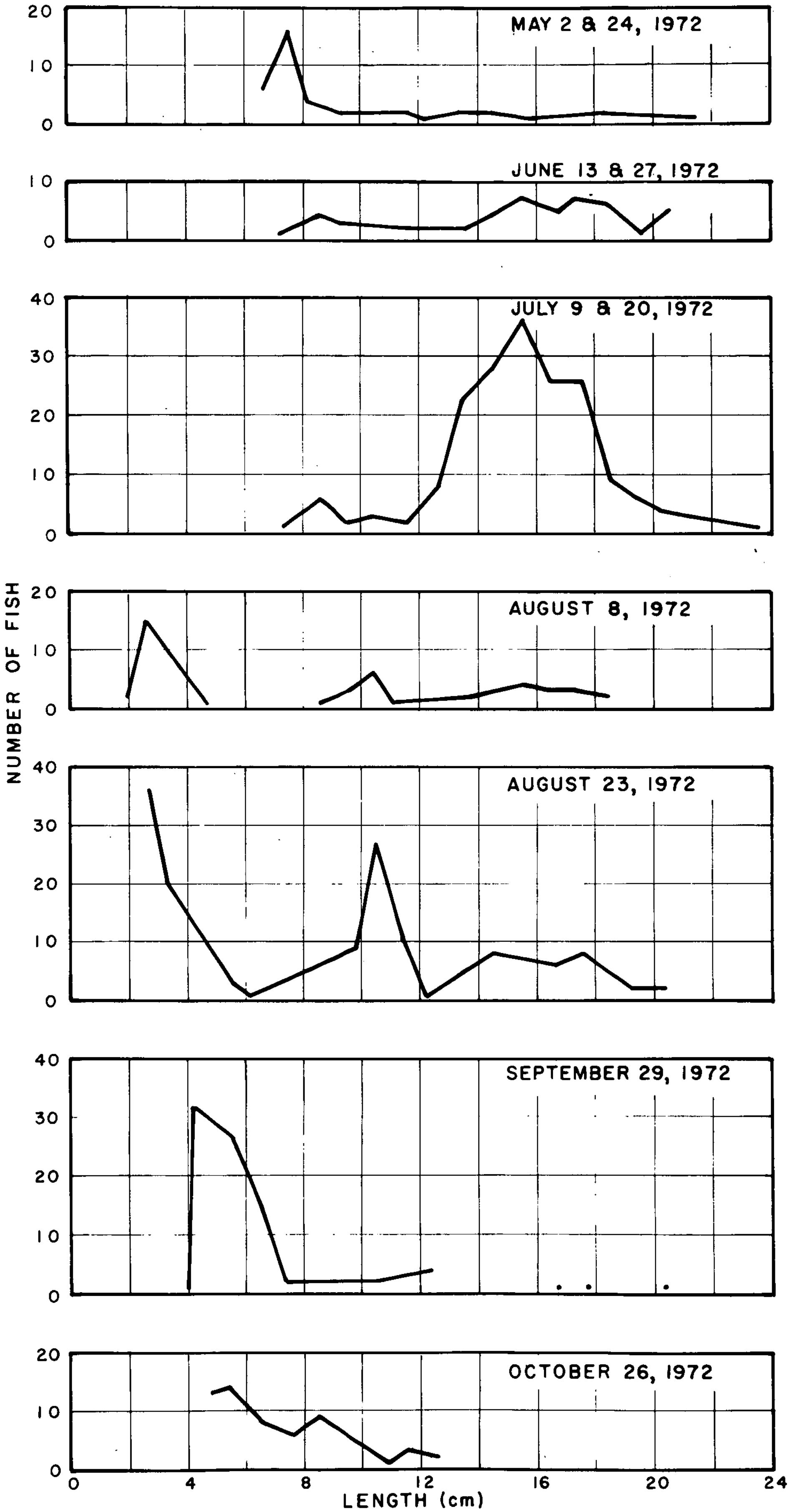


FIGURE IV-6
SHT. 2 OF 2

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

LENGTH DISTRIBUTION
OF WHITE PERCH COLLECTED IN THE VICINITY OF
ROSETON, NEW YORK 1971 & 1972



CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

LENGTH DISTRIBUTION OF ATLANTIC TOMCOD COLLECTED IN THE VICINITY OF ROSETON, N.Y.

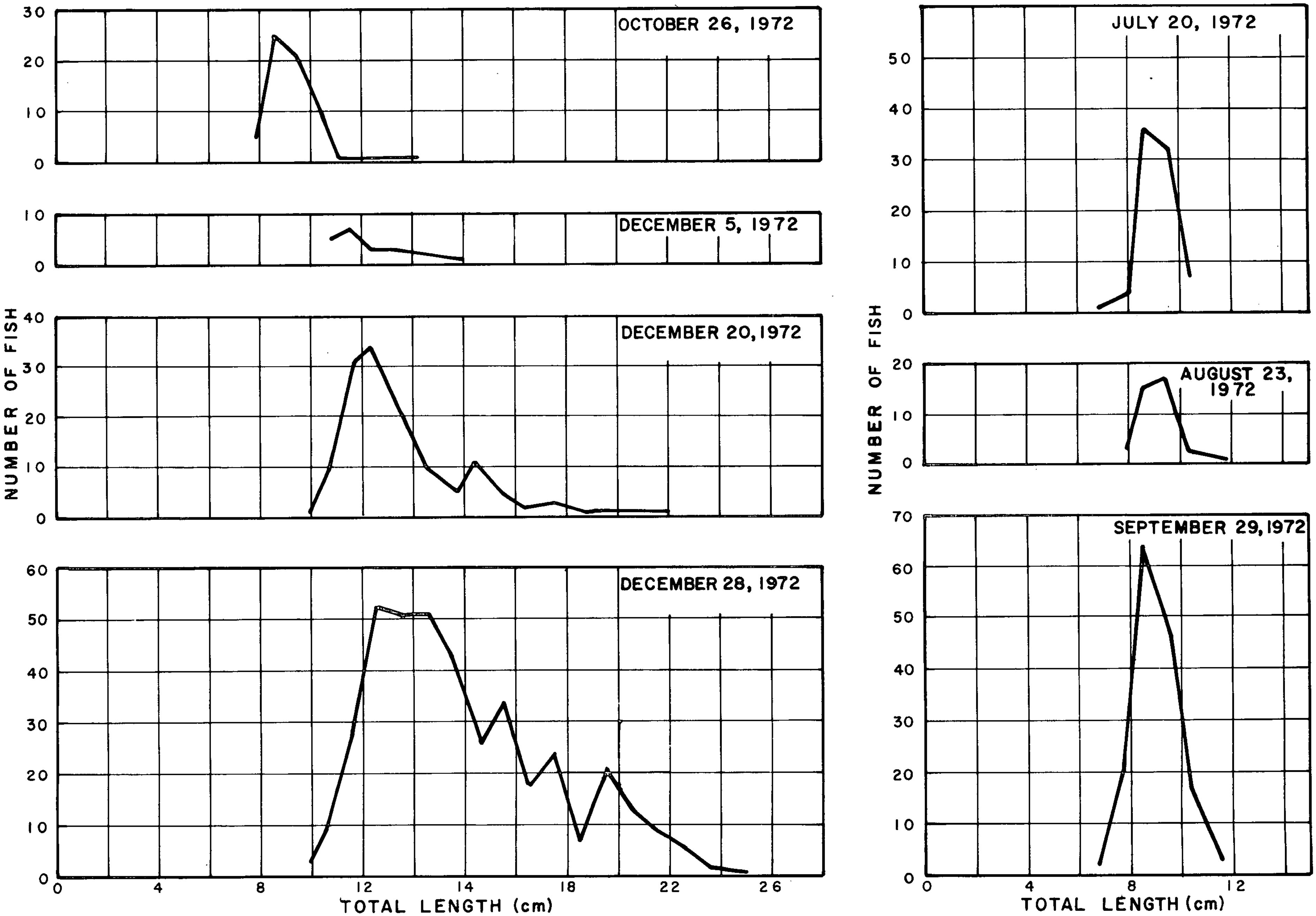


FIGURE IV-7

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

LENGTH DISTRIBUTION OF IMMATURE BLUEBACK HERRING COLLECTED IN THE VICINITY OF ROSETON, N.Y. 1971-1972

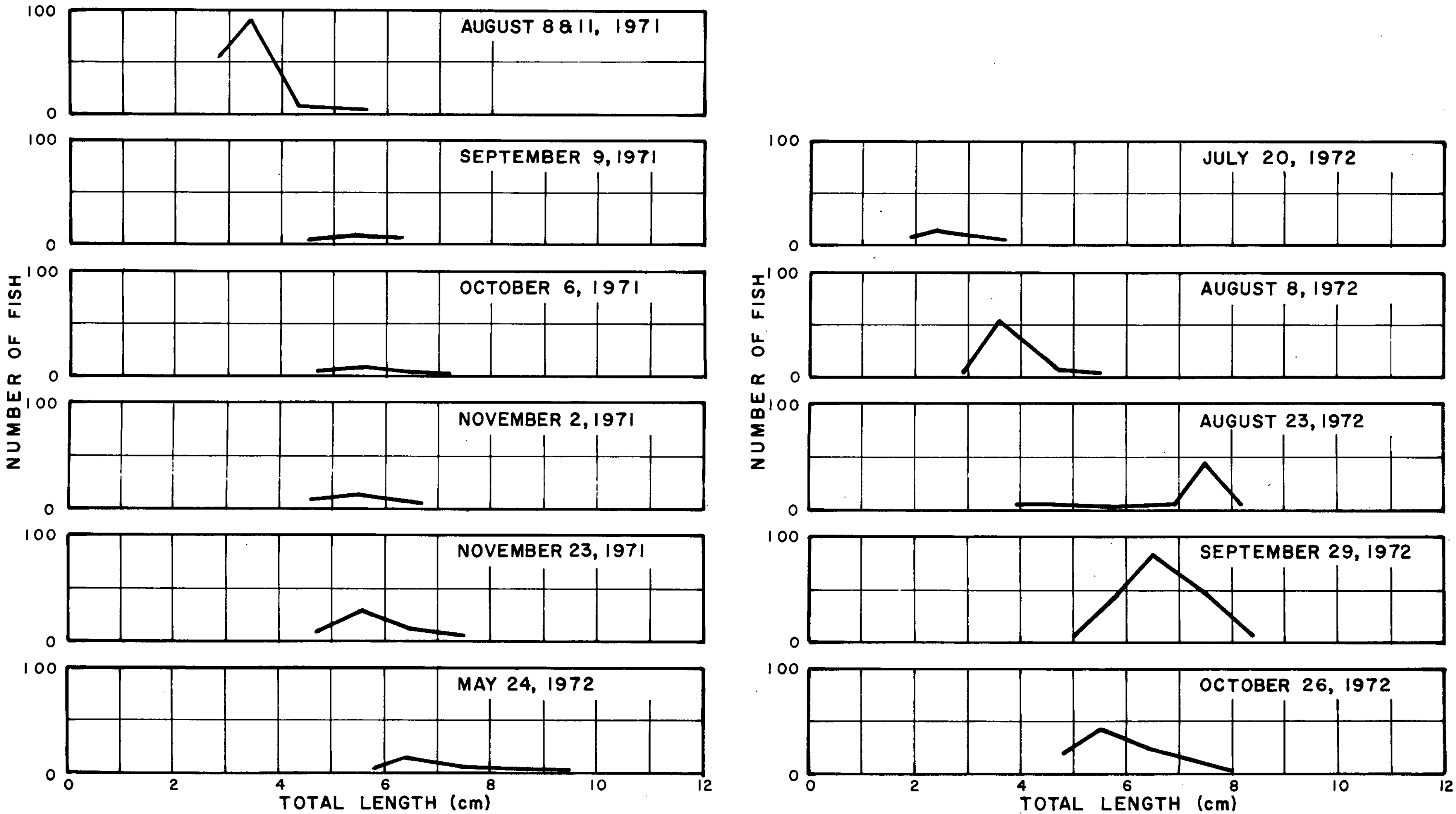


FIGURE IV-8

to reduce bias in size and age composition in the catches. Smaller fish tended to predominate in the seine collections, while large fish were collected by trawl and fyke net.

The weighted mean calculated length at the end of the first year of life of the fish was 7.8 cm. This agreed with the mean length of 7.7 cm attained by young-of-the-year white perch at the end of their growing season in December 1971 (Table IV-6).

The observed length at capture of 10.2 cm (Table IV-6) for age group I was larger because it was computed from fish that had already resumed growth in the summer. This probably accounts for the differences between the calculated mean length and observed length for age groups II and III fish, as well. The smaller sample sizes for the V, VI, VII age groups prevent adequate comparisons.

Maximum growth occurred in the first year and decreased after age II with the exception of age group VII fish.

Mean lengths of young-of-the-year white perch collected on a particular date were computed to determine their growth rate (Table IV-7). Growth continued through October and into November. Young-of-the-year white perch in the Delaware River continue their growth through November (Wallace, 1971) while those in the Patuxent River stop growth in late October and early November (Mansueti, 1961).

The spawning period of white perch near Roseton was determined using the coefficient of maturity. Spawning appears to have taken place sometime in June as indicated by the sharp decline in this coefficient (Figure IV-9 and 10). The length distribution indicates the white perch population near

TABLE IV-6

CALCULATED GROWTH OF WHITE PERCH IN THE HUDSON RIVER NEAR ROSETON, NEW YORK
SEXES COMBINED

Year Class	Age Group	Number	Calculated Total Length at End of Year 1	2	3	4	5	6	7
1971	1	22	7.8						
1970	2	30	8.0	13.1					
1969	3	13	7.6	13.1	15.9				
1968	4	14	7.3	12.5	15.6	17.1			
1967	5	2	7.6	13.3	15.6	16.9	18.1		
1966	6	3	8.2	14.5	16.7	17.9	18.7	19.5	
1965	7	1	8.1	14.1	16.9	18.8	20.4	21.2	21.8
Weighted calculated mean			7.8	13.1	15.9	17.3	18.8	19.9	21.8
Growth increment			7.8	5.3	2.8	1.4	1.5	1.1	1.9
Observed length at capture			10.2	13.9	16.5	17.3	18.1	19.5	21.8

TABLE IV-7

GROWTH OF YOUNG-OF-THE-YEAR WHITE PERCH
COLLECTED NEAR ROSETON, NEW YORK

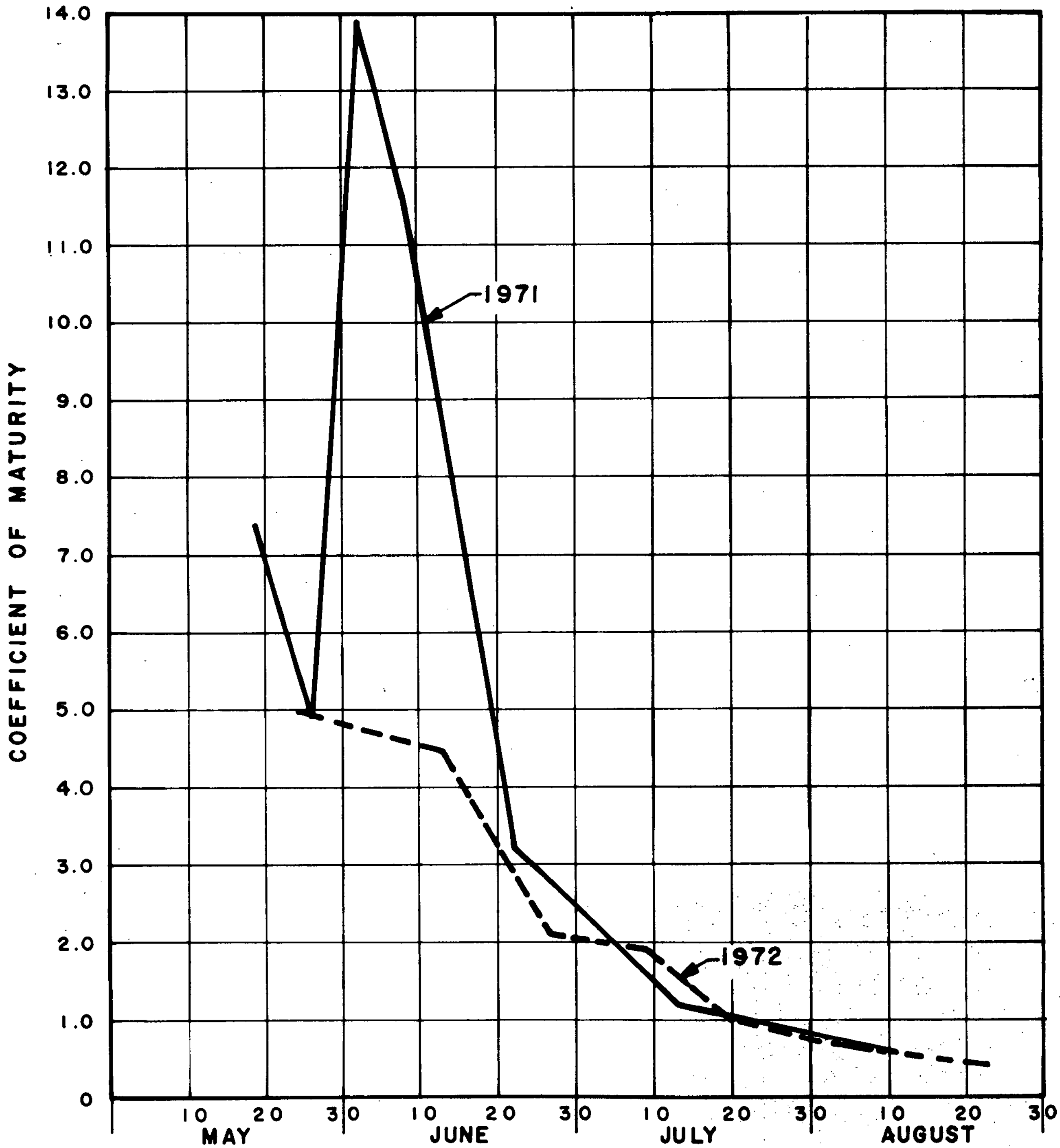
	1971										
	7/13		8/8		9/9		10/6		11/2		12/8
Number of fish	39		47		28		42		18		32
Mean length (cm)	2.1		4.1		6.0		5.8		6.1		7.7
Growth increment		2.0		1.9		-0.2		0.3		1.6	

	1972						
	8/8		8/23		9/29		10/26
Number of fish	20		57		77		50
Mean length (cm)	2.5		3.2		5.4		6.2
Growth increment		0.7		2.2		0.8	

FIGURE IV - 9

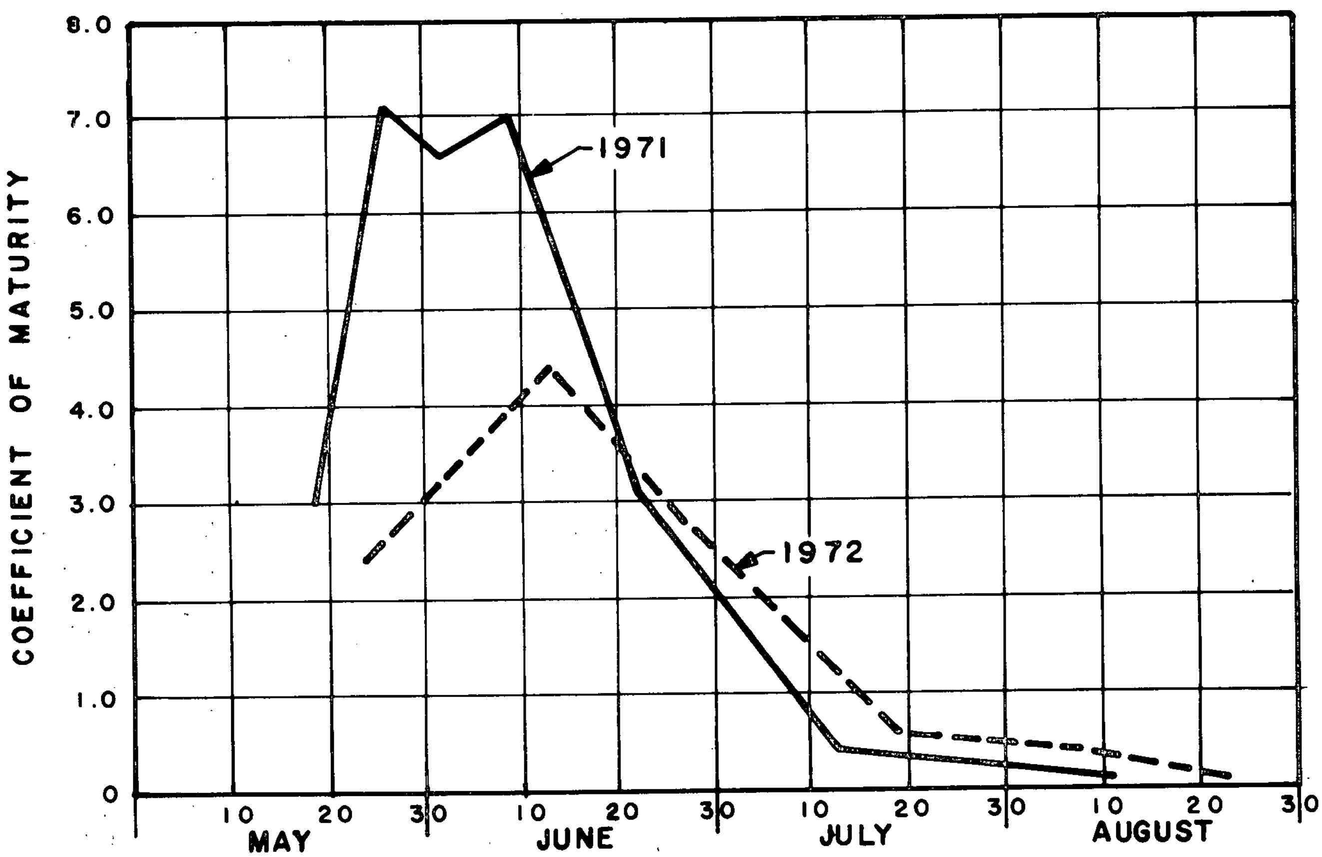
CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

COEFFICIENT OF MATURITY OF FEMALE WHITE PERCH COLLECTED IN THE VICINITY OF ROSETON, N.Y.



CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

COEFFICIENT OF MATURITY OF MALE WHITE PERCH COLLECTED IN THE VICINITY OF ROSETON, N.Y.



Roseton were composed of primarily large adults in June and July of 1971 and 1972.

(b) Atlantic Tomcod

The Atlantic tomcod (*Microgadus tomcod*) is an anadromous species that migrates up the Hudson River to spawn in the winter. The length distribution of tomcod that were collected in 1972 is shown in Figure IV-7.

As shown below little growth occurred from July to October:

Date	6/26	7/20	8/23	9/29	10/26
Number of Fish	2	80	39	152	62
Mean Length (cm)	8.4	9.1	9.1	9.0	9.2
Growth Increment	0.6	0.0	-0.1		0.2

A similar observation was made by Howe (1971) who found that the young-of the-year tomcod in the Weweantic River in Massachusetts grew rapidly from June until mid-July and slowly thereafter.

As the young-of-the-year moved out of the Roseton vicinity they were replaced by the adult spawners in December. The high frequency of fish collected in the 11.0 to 15.0 cm range in late December indicates that this was one age group. Howe (1971) states that tomcod from 12.0 to 20.4 cm long are in age group I. It is probable then that the majority of the young-of-the-year fish collected at Roseton were in age group I.

The age composition of the larger fish is not as apparent as that for the smaller individuals because of the overlap in the length frequency distributions. Howe's results and the length frequency distributions suggest that the adult tomcod found in the Roseton area are in age group II, but none in age group III.

The length distribution for each sex indicates that the smaller individuals in age group I were primarily males, while the larger ones were mostly females. Howe (1971) found no differences between sexes in calculated growth. However, larger samples than those collected at Roseton would be required to determine if such a growth difference is significant.

The coefficients of maturity which provides an index as to the time of sapwning was computed for each of the December collections and are presented below.

	DECEMBER 5			DECEMBER 20			DECEMBER 28		
	Length Range	No. Fish	CM	Length Range	No. Fish	CM	Length Range	No. Fish	CM
Males	10.5-16.0	10	16.4	10.7-21.2	33	15.3	9.5-21.5	69	17.2
Females	10.7-13.6	9	7.8	11.5-24.0	9	26.4	11.6-25.3	47	37.0

CM = coefficient of maturity

During this month there is a gradual increase in the coefficient of maturity for the males and a substantial increase for the females.

E. SUMMARY OF RESULTS

1. Three types of fish communities in the Hudson River were found near the Roseton and Danskammer plants:

   (1) juvenile blueback herring and bay anchovy that reside in the surface waters of the channel;

   (2) white perch of a number of age groups, tomcod and occasionally hog-chokers and spottail shiners, found near the river bottom; and

   (3) pumpkinseed, banded killifsih, white perch, spottail shiner and golden shiner found in the shallow cove area north of the Danskammer plant.

2. The white perch and spottail shiner do not show any definite seasonal movements between the shallows and the deep channel. Their movements are probably somewhat random.

3. The shore community composition near the discharge of the Danskammer plant fluctuates on a seasonal basis. The maximum number of species occupied this area in the spring and fall. The maximum number of individuals occurred in the fall when there was an abundance of young-of the-year striped bass and blueback herring present. Few, if any, fish remained in this area in mid-summer.

4. The two most prevalent species in the Hudson River near the Roseton plant were white perch and Atlantic tomcod. Adult white perch were particularly abundant during the spring spawning season, while the young-of-the-year of both species were abundant from summer through the fall. Adult tomcod appeared in early December.

5. Scale analysis of white perch indicated that the age composition ranged up to age group VII with the majority below age group V. A length distribution of adult tomcod showed that the majority of the December immigrants were in age group I with some possibly in age group II.

6. Growth of the juvenile white perch continues through October up to late November and declines for juvenile tomcod in July.

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Mansueti, R. J., 1961, Movements, reproduction, and mortality of the white perch, Roccus americanus, in the Patuxent Estuary, Maryland. Ches. Sci. 2(3-4): 142-205.

Wallace, D. C., 1971, Age, growth, year class strength, and survival rates of the white perch, Morone americana (Gmelin) in the Delaware River in the vicinity of Artificial Island. Ches. Sci. 12(4): 205-218.

V. FISH LARVAE

V. FISH LARVAE

A. INTRODUCTION

Information on the distribution and abundance of fish larvae is of prime importance in providing a description of the general aquatic ecology of an area. However, with respect to power generating stations with once-through cooling facilities fish larvae take particular importance when one considers the possibility of passage of these organisms through the condenser cooling system.

The organisms of concern are those fish larvae that are entrained in the cooling water flow and are small enough to pass through the travelling screens. These fish larvae, and other small organisms are then subjected to mechanical, pressure and temperature changes within the cooling water system. It is the fate of these organisms and their abundance and distribution in the river that forms the basis of entrainment studies at power plants.

B. STUDY OBJECTIVES

The objective of the studies described herein were to provide preliminary estimates of the abundance and distribution of fish larvae in the Roseton/ Danskammer Point vicinity. Several studies have been conducted in the past on the distribution and abundance of fish eggs and larvae in the Hudson River. The first of these studies was the Hudson River Fisheries Investigation

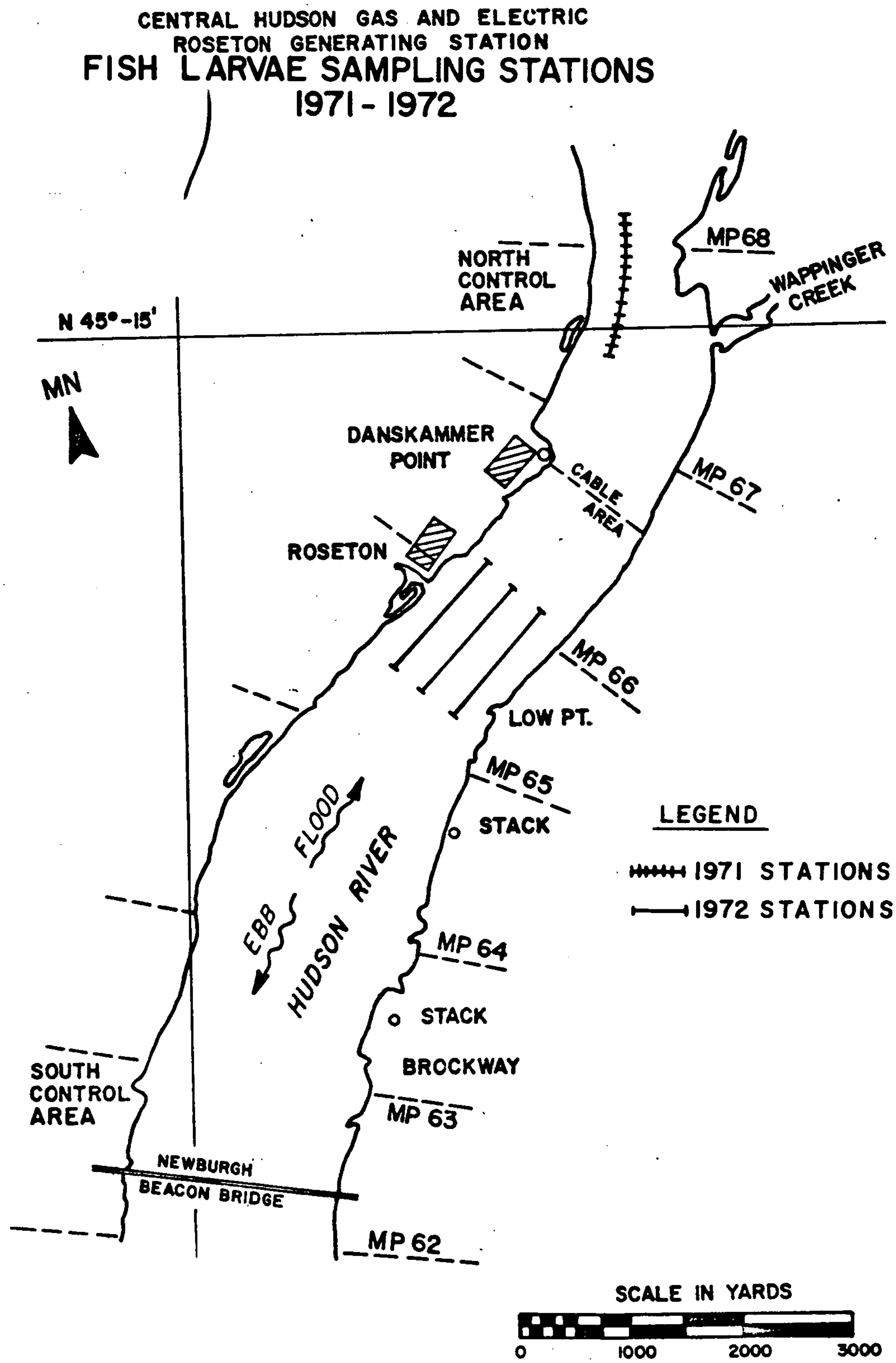
(Carlson and McCann, 1969) designed to evaluate the potential adverse effects of a proposed pumped storage plant at Cornwall, New York on fish populations. In this study, conducted from 1966 through 1968, fish eggs and larvae were collected at eight stations on the River, from Croton Point to Coxsachie, with the major sampling effort in the Cornwall area. Data were collected for all larvae occurring in the samples; however, detailed analysis was carried out only for striped bass. This report, together with earlier work by Rathjen and Miller (1957), forms the basis of our present knowledge of the distribution of the early life stages of the striped bass in the Hudson River.

Some published data on Hudson River larval fish populations is included in a series of reports prepared by the Raytheon Corporation (1972). These reports contain information on the distribution of several species of larval fish in the Indian Point vicinity related to time, depth, temperature, and salinity.

C. MATERIALS AND METHODS

1. Field Procedures

(a) 1971 Program. Sampling was conducted on the west side of the River at Roseton Generating Station and at a point approximately 2-1/2 miles up river designated North Control as shown in Figure V-1. Collections were made utilizing #2 mesh (363 microns) plankton nets with a mouth diameter of 1/2 meter and a length of 1-1/2 meters. Polyvinyl chloride buckets were


CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
FISH LARVAE SAMPLING STATIONS
1971 - 1972
NORTH CONTROL AREA
MP68
WAPPINGER CREEK
N 45°-15'
MN
DANSKAMMER POINT
CABLE AREA
MP 67
ROSETON
MP 66
LOW PT.
MP 65
STACK
FLOOD
EBB
HUDSON RIVER
LEGEND
1971 STATIONS
1972 STATIONS
MP 64
STACK
BROCKWAY
SOUTH CONTROL AREA
MP 63
NEWBURGH BEACON BRIDGE
MP 62
SCALE IN YARDS
0
1000
2000
3000

fastened to the cod end of the net with hose clamps. Each bucket was 3-1/2 inches in diameter and seven inches long with a screen in the side. Nets were equipped with TSK flow meters to estimate the volume of water sampled.

Larval tows were made on the following dates:

May 12, 19 and 26

June 8 and 22

July 13

August 11.

Sample depths varied during the sampling period.

(b) <u>1972 Program</u>. Two larval sampling programs were carried out in the Roseton area in 1972. The main sampling program was performed as part of an extensive study on larval distribution in the Hudson River and was conducted from Croton Point (mile point 34) to Green Flats (mile point 106). Collections made in this program are referred to as regular river samples.

The second program was designed to provide preliminary information on the effectiveness of utilizing a vacuum chamber pump device to sample larvae in power plant intakes and discharges in conjunction with entrainment studies. Samples taken with the pumping device are referred to as pump samples. Samples taken by plankton nets in the river simultaneously with pump samples are designated pump comparison samples.

<u>Regular River Sampling</u>. Regular river larval collections at Roseton were made at two stations designated Roseton West and Roseton East as shown in

Figure V-1. Roseton West was located directly in front of the plant intake-discharge about 300 feet from shore in 40 feet of water. Roseton East was located on the east side of the River 600 feet from shore in 50 feet of water, directly opposite the west station.

All regular river collections were made utilizing 1/2 meter plankton nets of the type described previously except that a #0 mesh (571 micron) was used. Samples were collected at Roseton on:

May 24,

June 7, 15 and 29

July 13 and 27

August 10

In all cases, three nets were towed simultaneously, at surface, mid and bottom depths, for five minutes against the tide.

Pump-River Comparison Sampling. A vacuum chamber pumping device was evaluated as a larval sampler for use in entrainment studies. The objectives in designing the pump sampler were:

1. To construct a device which could sample in intake or discharge structures where limited access or physical peculiarities made the use of conventional nets either difficult or impossible.

2. To construct the sampler in such a fashion that larvae could be captured with a minimum of injury so that by sampling at the intake and discharge of a plant the mortality due to entrainment could be determined.

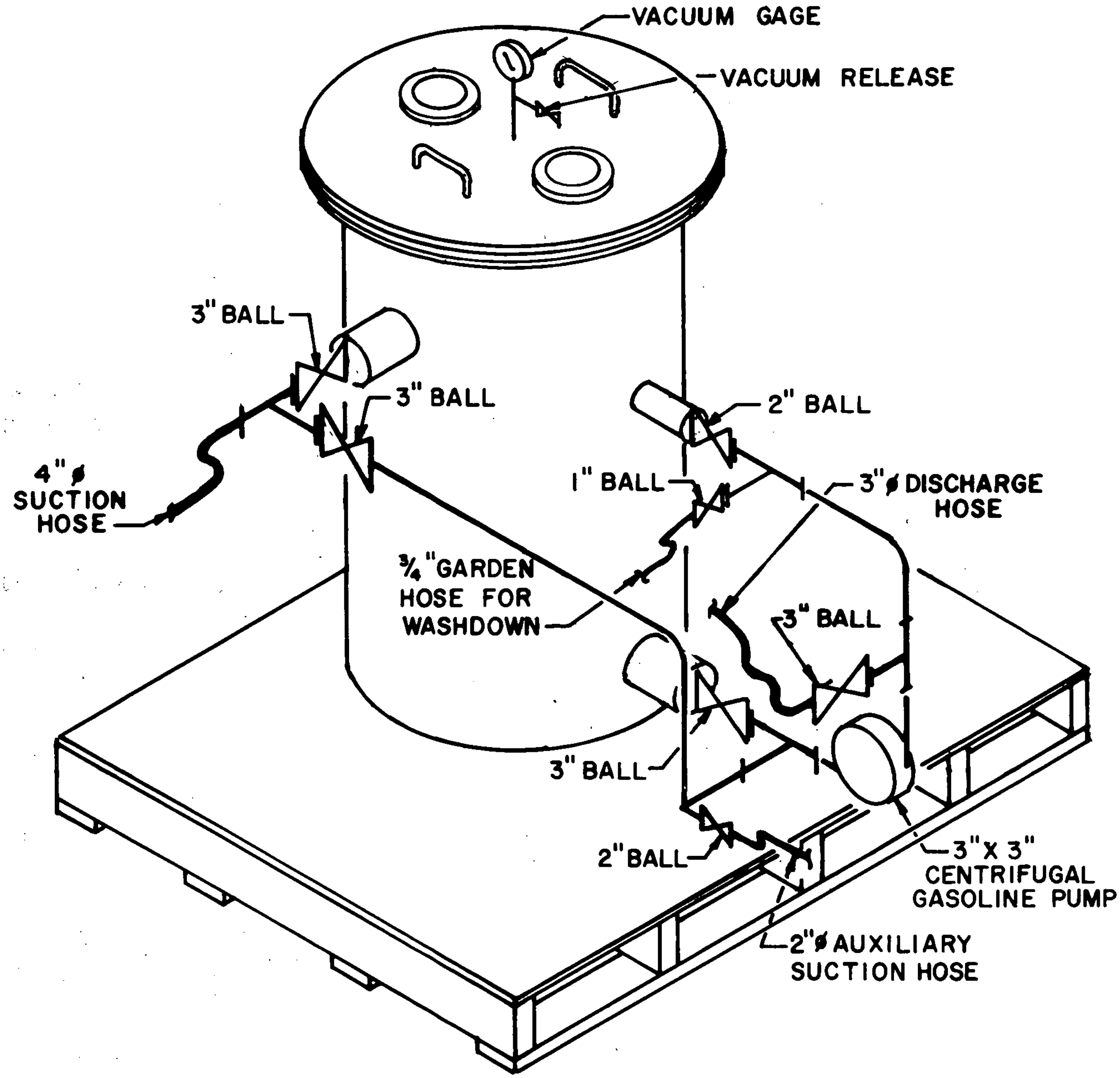
The pump sampler consists of a gasoline-fueled pump which draws water through a large steel chamber and is shown schematically in Figures V-2 and V-3. The water enters at the top of the chamber, passes through a 500 micron wire mesh basket, and exits at the bottom. Fish larvae or eggs which enter with the water are retained in the basket.

In actual use, the inlet hose was lowered into the intake or the discharge to be sampled. The pump was started and the water was pumped through a bypass pipe directly from the inlet hose, through the pump, and out the discharge hose. This bypass has the function of allowing the pump to run continuously, without losing prime, while the chamber is open and samples are being removed.

When a sample was to be taken, the basket was placed in the chamber, the lid sealed with attached toggle clamps, and the chamber filled with water through an accessory inlet pipe provided for this purpose. Sampling was begun by directing the water into the chamber through the main inlet pipe and out the outlet. This was accomplished by means of the various valves illustrated in Figure V-2.

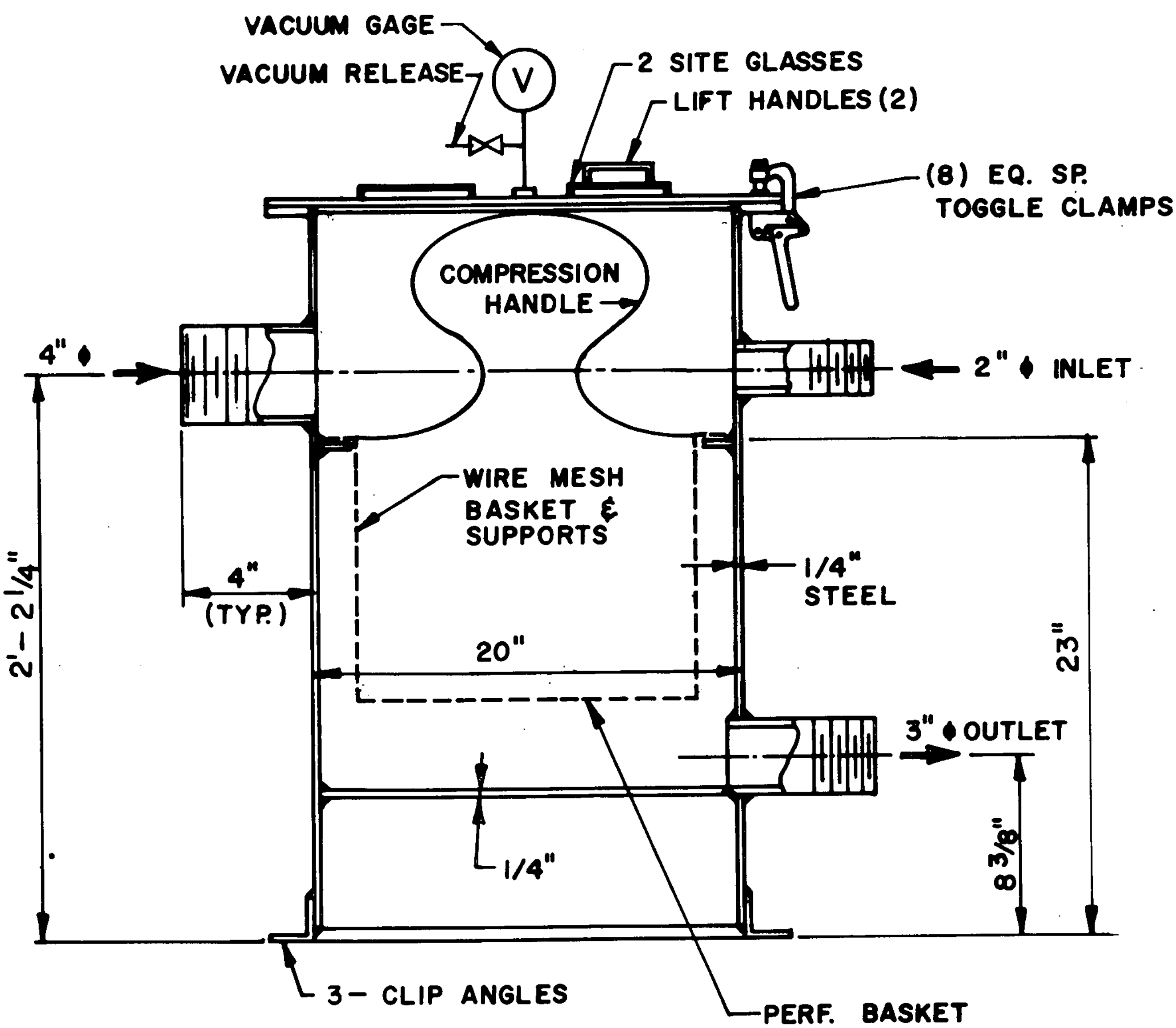
In operation, the chamber remained filled with water throughout the sampling period to minimize damage to eggs and larvae entering the basket. Samples were generally collected for one hour. At the end of that time the water is redirected through the bypass, the chamber opened, the basket removed, and the sample washed from the basket into a sample jar or holding tank for observation.

PORTABLE LARVAL FISH SAMPLER



QUIRK, LAWLER & MATUSKY ENGINEERS
TAPPAN, NEW YORK

VACUUM CHAMBER W/ REMOVABLE FISH STRAINER



QUIRK, LAWLER & MATUSKY ENGINEERS
TAPPAN, NEW YORK

A second type of pump was also tested. The major difference in design was this pump utilized a larger vacuum chamber with a conical collecting net equipped with a stopper in the bottom. This modification was made to allow for easier removal of larvae than from the flat bottomed baskets originally used.

On July 23, August 8, 15 and 16 and September 6th samples were taken in the river using plankton nets simultaneous with pump collections at the Danskammer plant intake. These samples were taken at several stations and depths in order to compare the larval population of the river with samples being collected at the plant. These pump comparison samples were taken with a Hensen-type plankton net one meter in diameter at the mouth, six meters long, made of #0 (571 micron) mesh. A TSK flow meter was mounted in the mouth to determine volume of water passing through the net.

2. Laboratory Procedures

(a) 1971 Program. Larval samples collected in 1971 were analyzed for the total number of larvae and fish eggs occurring in each sample

(b) 1972 Program. Laboratory analysis of 1972 larval samples was performed in two stages. The first stage consisted of removing fish eggs and larvae from other material in the sample and separating them into easily recognizable type groups, *Morone*, *Alosa* and others. The second stage was the identification, where possible, of larvae to species.

Individuals of the genus Morone were identified to species using the characteristics defined by Mansueti (1964). Care was taken in the proper identification of white perch and striped bass due to the importance placed upon these species and the difficulties in distinguishing between them at certain stages of larval development. The members of the genus Alosa, the American shad, alewife, and blueback herring, were not speciated since distinguishing between these larvae is extremely difficult. Other larvae identified in the samples were those of the hogchoker (American sole), silverside, and rainbow smelt.

During analysis, all specimens, unless the sample was excessively large, were measured to the nearest tenth of a millimeter in length using an occular micrometer. In large samples, a subsample was taken for measurement. After analysis, each species in a sample was placed in a vial and stored for possible future reference.

The number of larvae in each sample was converted to number of larvae per thousand cubic meters of water by the formula:

$$\text{larvae}/1000\text{m}^3 = \frac{\#\ \text{larvae}}{a \times r \times \alpha} \times 1000$$

where: a = area of net mouth in m^2

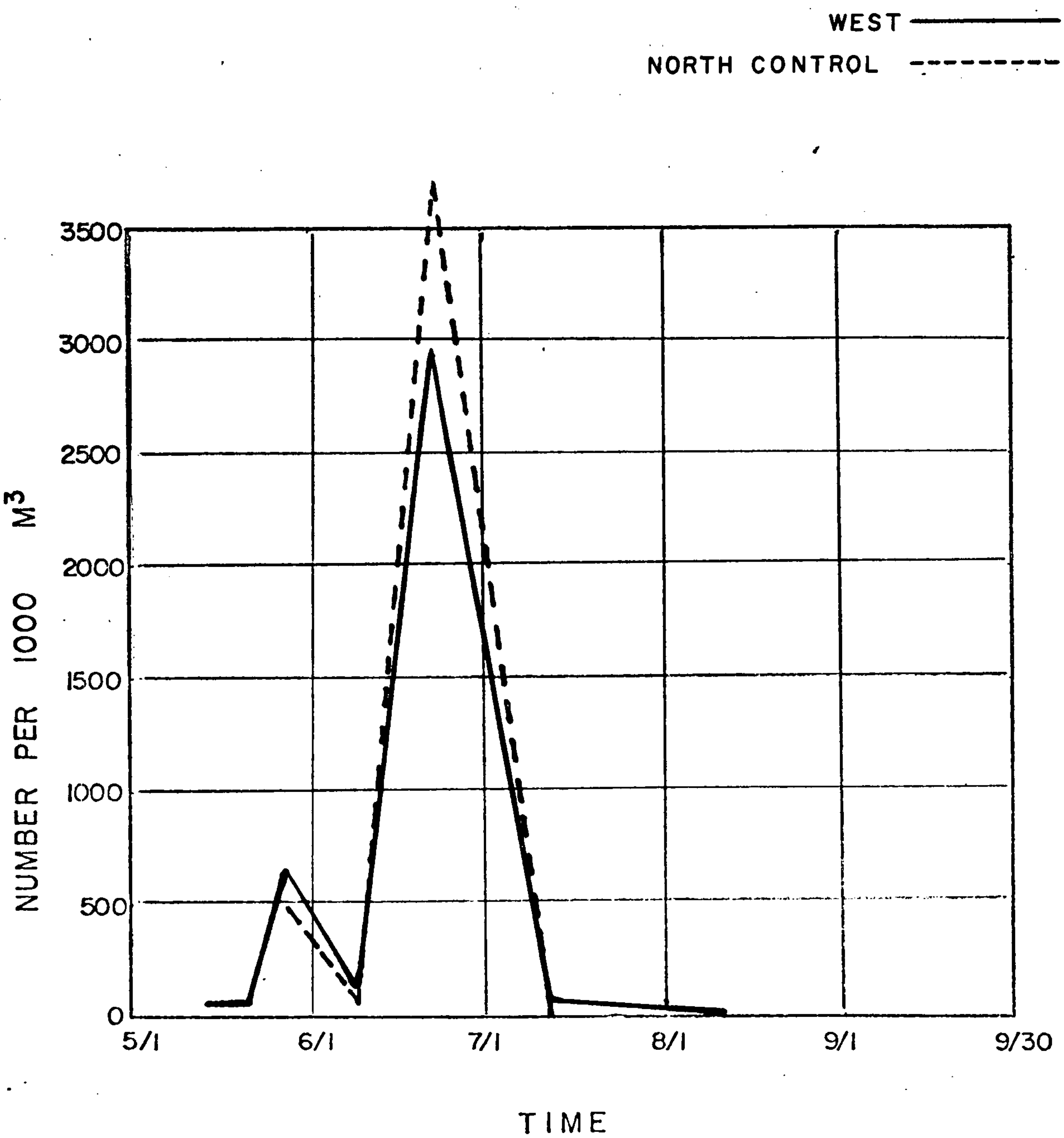
r = number of meter revolutions

α = meter calibration coefficient

FIGURE V-4

CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

AVERAGE CONCENTRATION
ALL LARVAE
1971



D. RESULTS AND DISCUSSION

1. 1971

The intent of the 1971 larval program was to provide a qualitative description of larval distribution in the Roseton/Danskammer Point vicinity. Comparison of the average concentration of larvae at the west station and at the North Control (Figure V-4) shows a basic similarity in the number and temporal distribution of larvae at these two stations. Larvae were collected from the time of initiation of sampling on May 12 until July 13 with the greatest concentrations occurring on June 22. No further analysis of this data was attempted because of small sample size and lack of species identification.

2. 1972

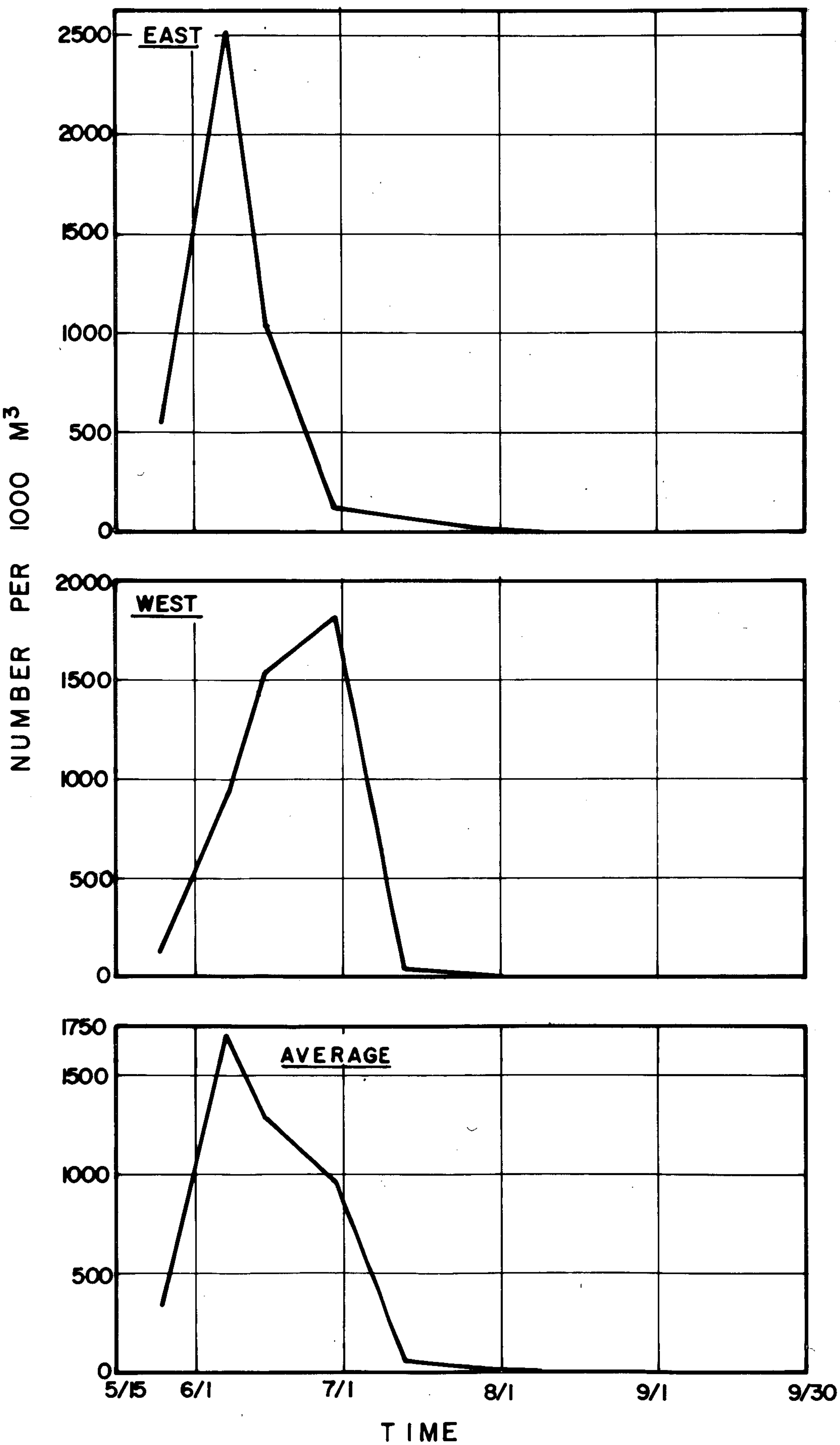
(a) General Larval Distribution. For the purpose of this analysis, all samples taken on a given day were averaged together to present a general picture of larval distribution with time. Analysis by depth and larval size is presented in the section on species occurrence.

Larvae occurred at the Roseton site from some time prior to the initiation of sampling, on May 24, until the end of July. Peak concentrations occurred in June (Figure V-5). Greatest concentrations of larvae were found at the east station on June 7. At the west station the maximum concentration of larvae was lower and occurred on June 29. Figures V-6 through V-9 present a comparison of the average larval concentration at Roseton with those of the ten other stations in the regular River sampling program.

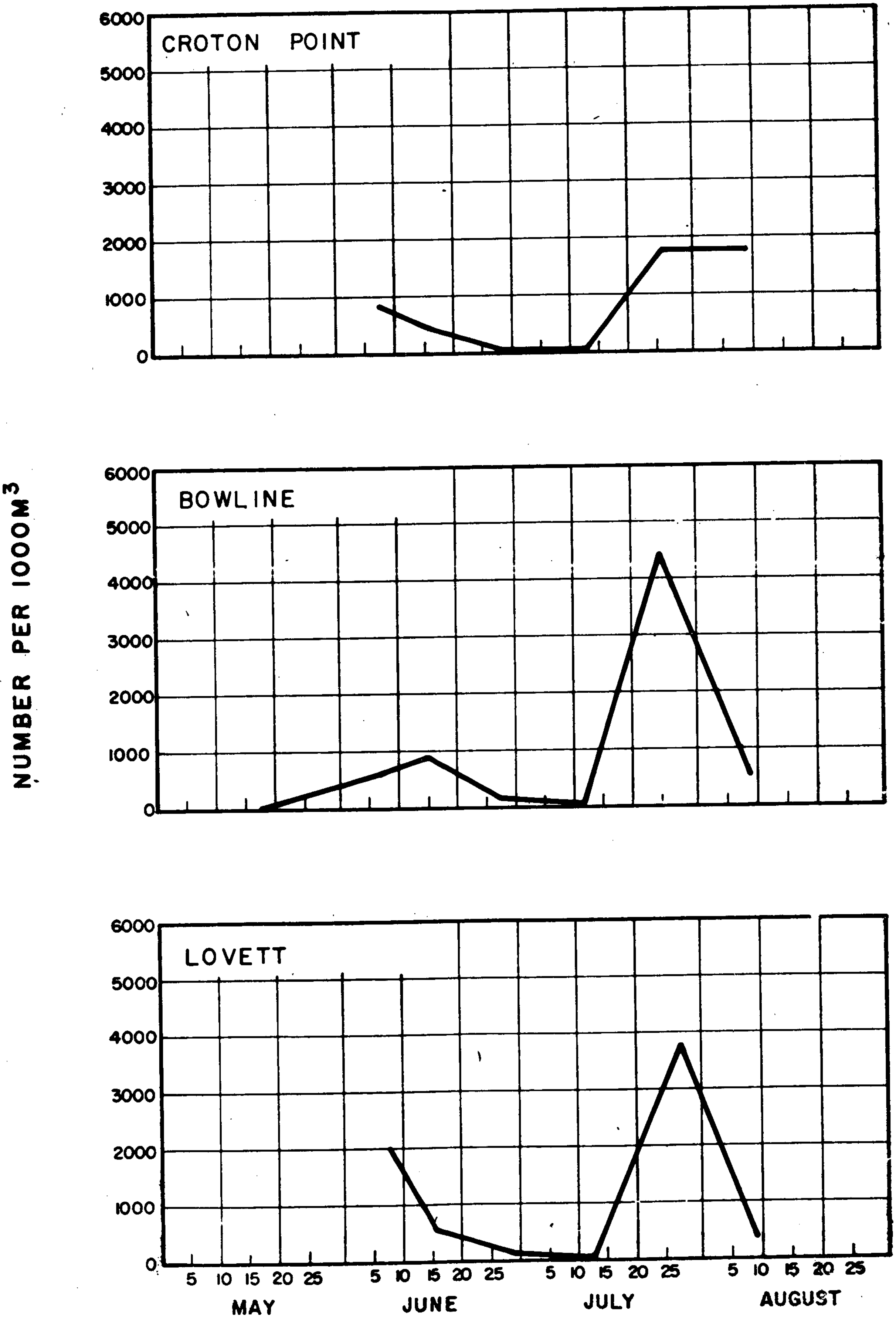
FIGURE V-5

CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

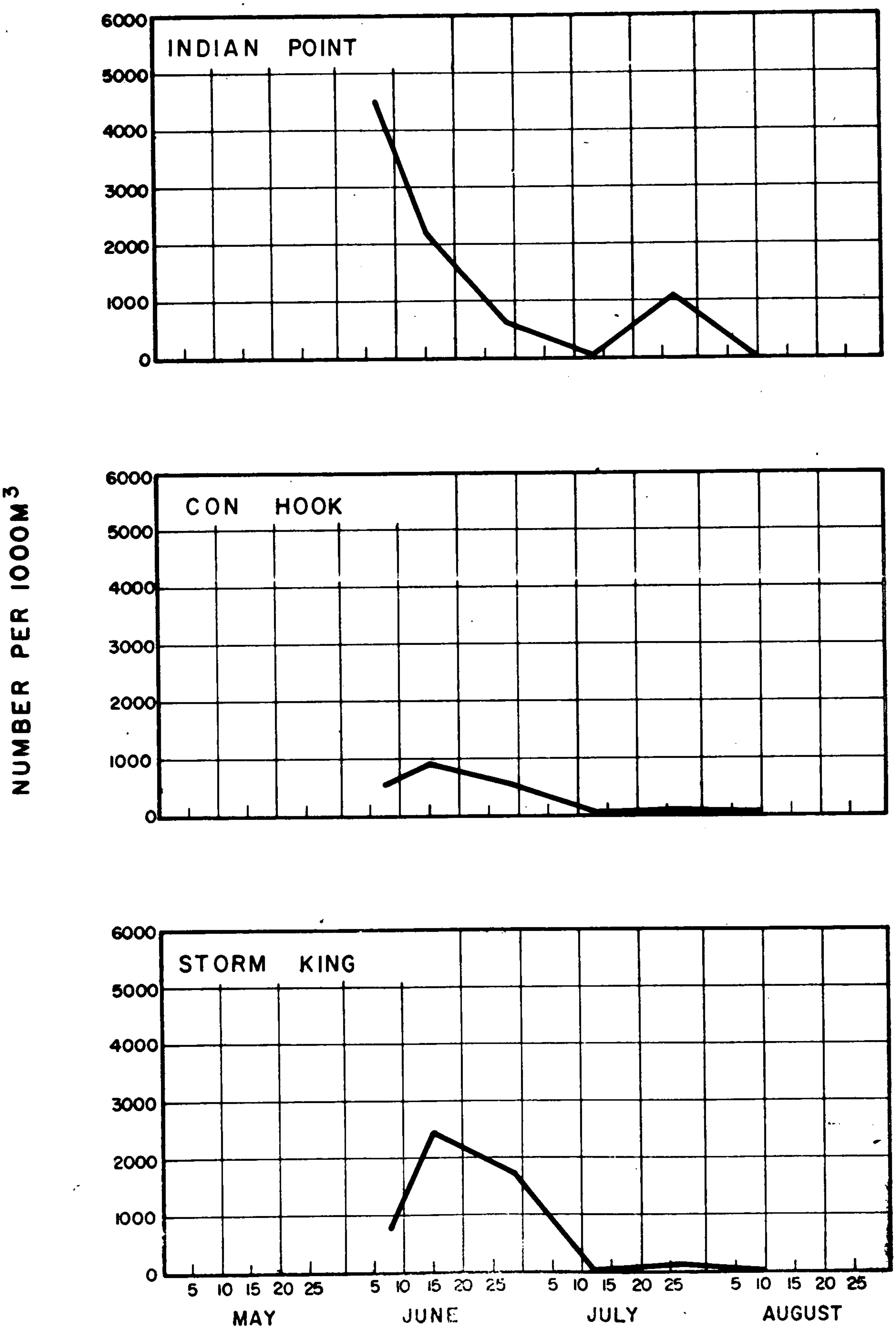
AVERAGE CONCENTRATION
ALL LARVAE – 1972



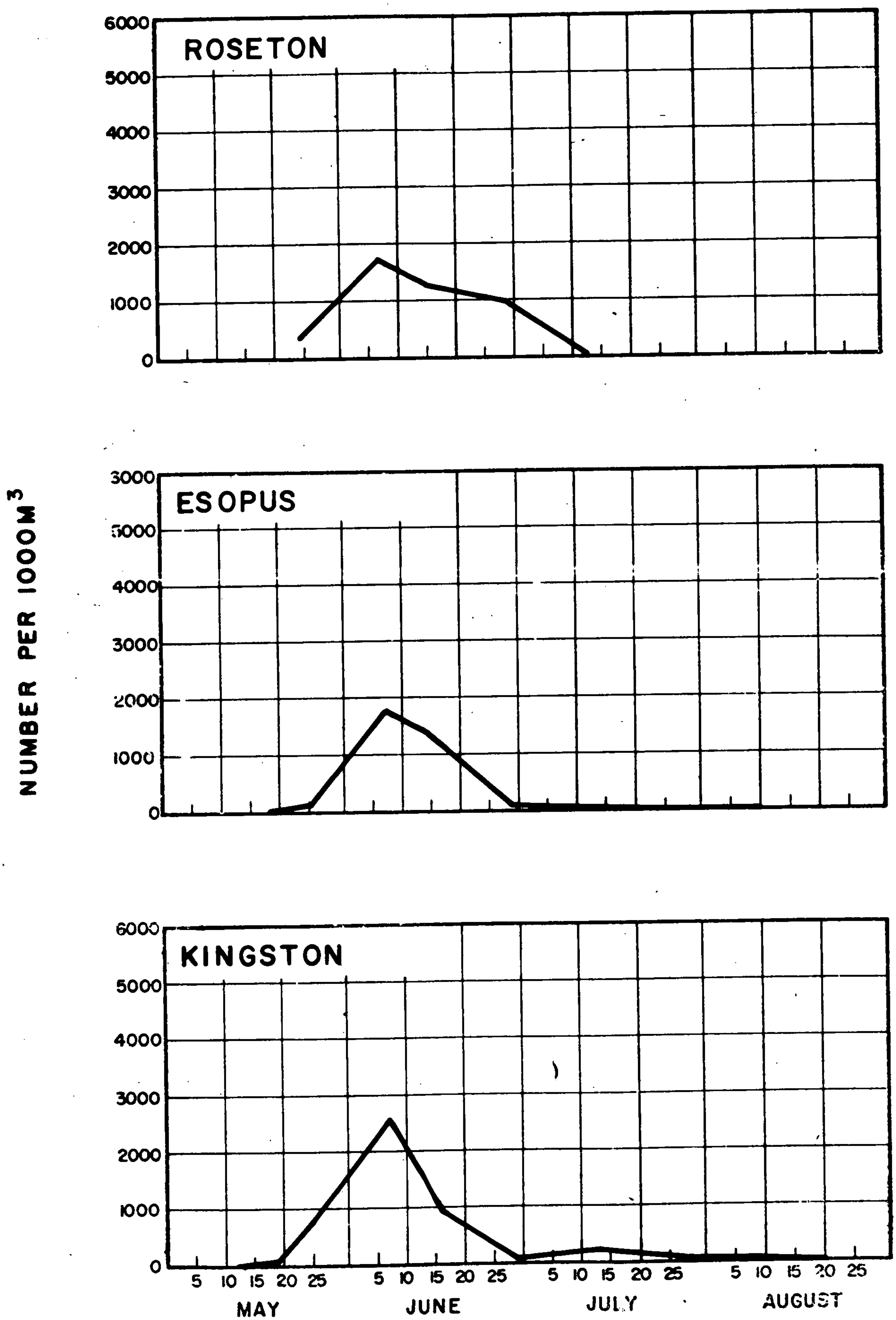
AVERAGE LARVAL CONCENTRATION 1972 ALL LARVAE



AVERAGE LARVAL CONCENTRATION 1972 ALL LARVAE



AVERAGE LARVAL CONCENTRATION 1972 ALL LARVAE



At no point during the sampling period do average concentrations at Roseton exceed 1700 larvae per 1000m^3. This is contrasted to stations such as Indian Point, Saddle Bags and Green Flats, which show concentrations greater than 4,500 in late May and early June and the Bowline and Lovett stations which have concentrations in excess of 3,500 in late July. On the basis of this evidence, larval concentrations at Roseton might be termed moderate.

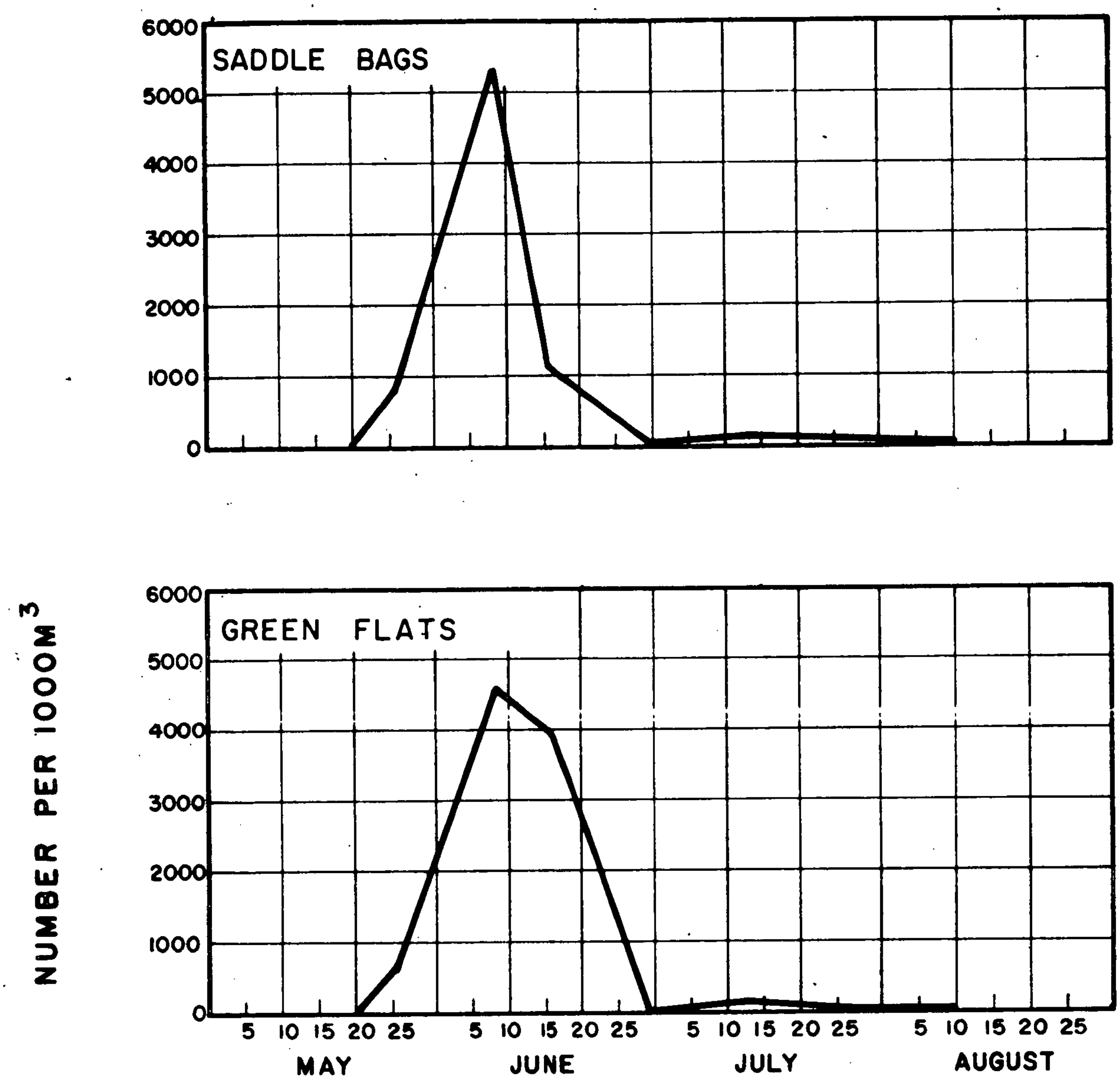
Comparison of results of Roseton west collections from 1971 and 1972 shows the same basic pattern of temporal distribution (Figure V-10). 1971 collections show a much greater concentration of larvae in mid to late June than do collections made in 1972. This may indicate that larvae were more plentiful in 1971, but it may also be an artifact of the sampling schedule. Peak larval occurrences equal to those recorded in 1971 may actually have been present in the River during the two week period between sampling dates in 1972. The data do demonstrate, however, that there were no dramatic changes in spatial distribution of larvae on the west side of the River at Roseton from 1971 to 1972.

(b) <u>Species Occurrence.</u> The species principally collected in larval tows at Roseton were white perch and river herring; striped bass occurred in very low numbers. The bay anchovy which was quite common in down-stream sections of the River did not occur in any regular river samples taken at Roseton.

(i) <u>White Perch</u>

Figure V-11 illustrates the distribution of white perch larvae through-

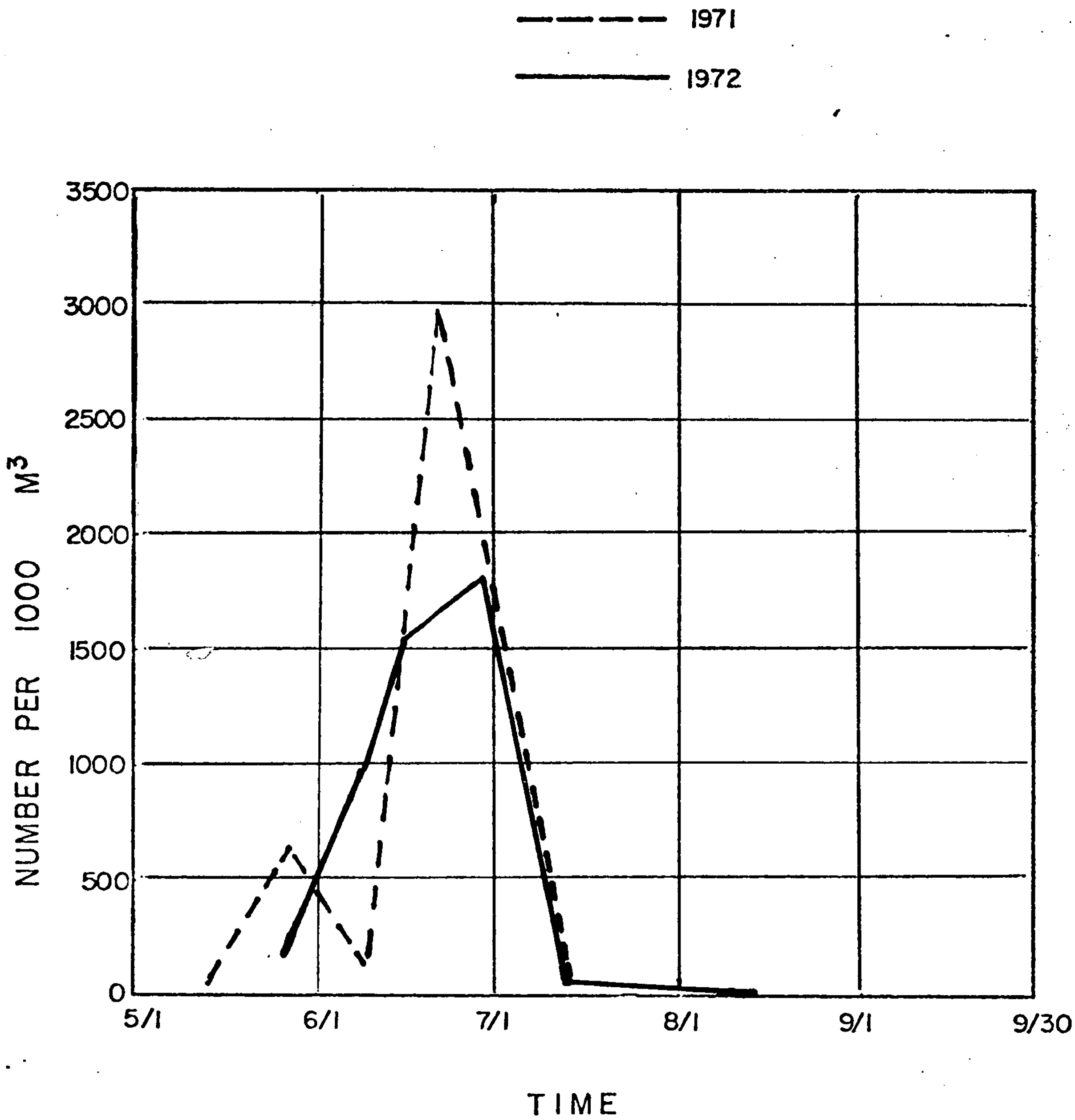
AVERAGE LARVAL CONCENTRATION 1972 ALL LARVAE



CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

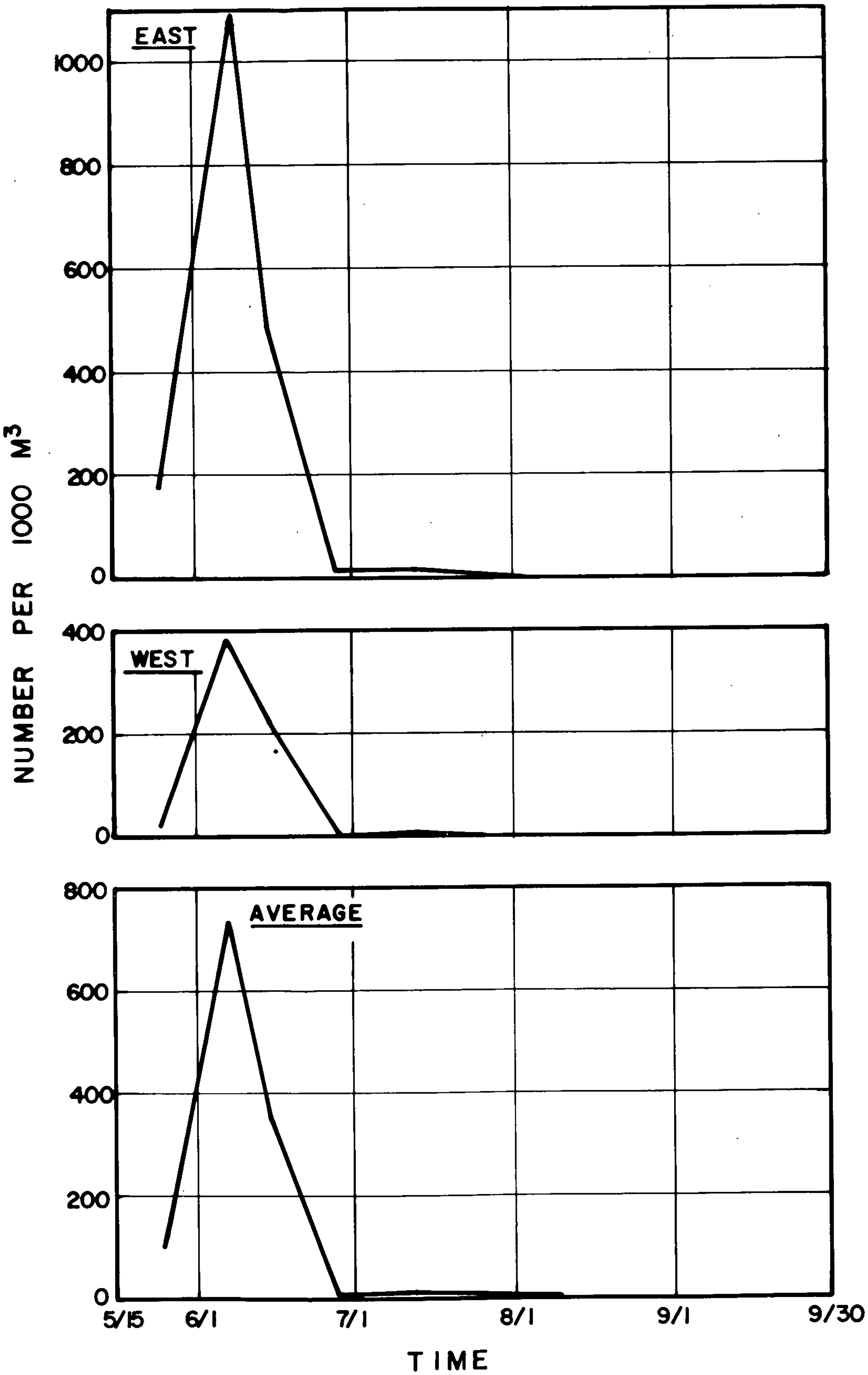
FIGURE V-10

AVERAGE CONCENTRATION ALL LARVAE AT WEST STATION 1971 & 1972



CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

AVERAGE CONCENTRATION WHITE PERCH LARVAE 1972



out the sampling period. The period of larval occurrence extended from before the first sampling date until the end of June, with occasional individuals being collected throughout July. A considerable difference existed in concentration of white perch larvae collected at the east and west stations. Concentrations at Roseton east were consistently greater than those at Roseton west. Maximum concentration, which occurred on June 7, was found to be about three times as greater on the east side of the River as on the west side.

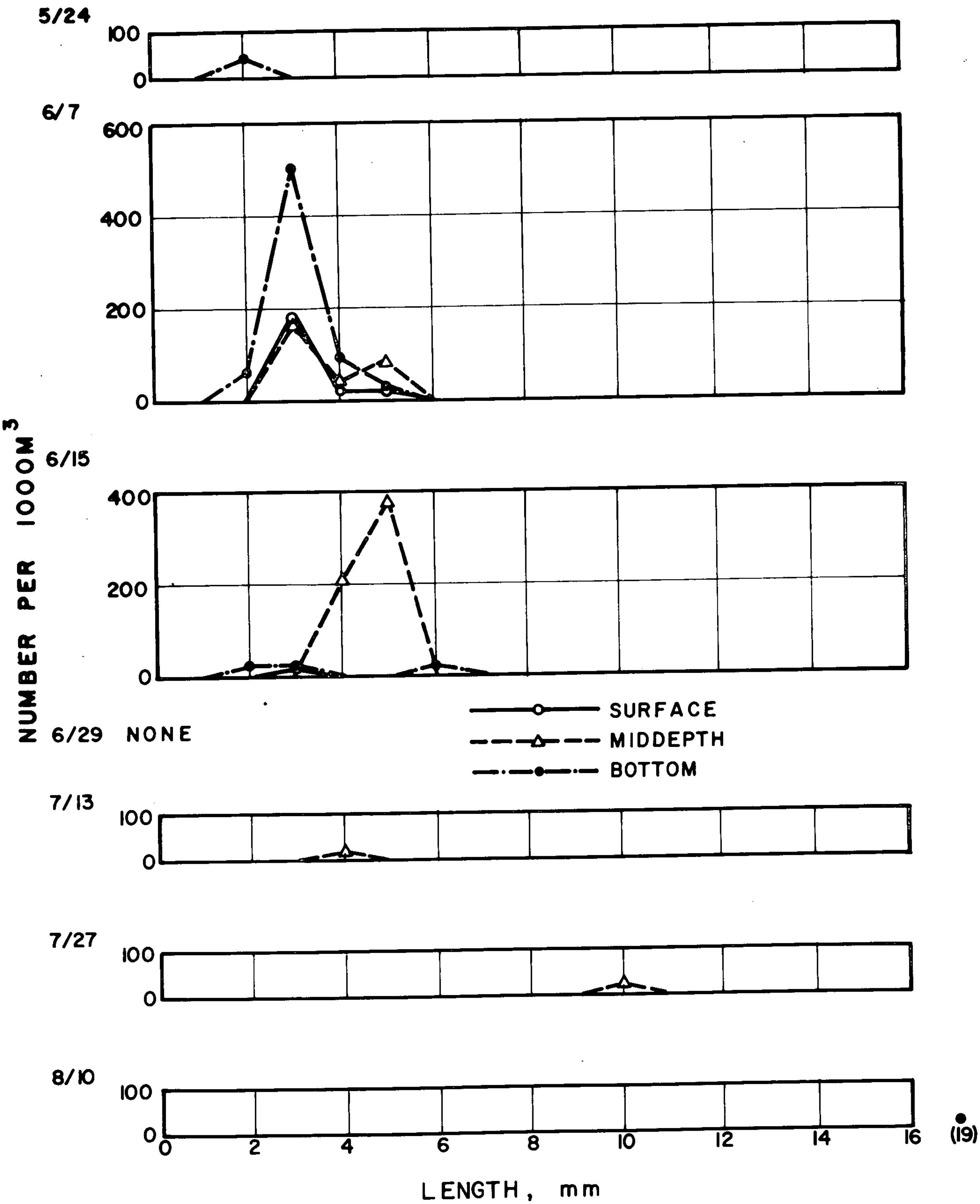
White perch larvae were divided into 1mm size intervals and the number per $1000m^3$ in each interval at surface, mid and bottom depths was plotted for each sampling date (Figure V-12 and V-13).

Maximum concentrations of larvae were found to occur in either mid-depth or bottom samples. Large concentrations of larvae in the 1 to 3mm size range (yolk sac) were present at the east station on May 24 and June 7. Few fish of this size were collected at Roseton west on June 15, the majority of larvae collected were 4 to 6mm in size; only one specimen in the 2-3mm range was collected. The number of white perch larvae at Roseton declined rapidly after June 15. Nine specimens of various lengths were collected during the remainder of the sampling period.

These data suggest that spawning of white perch in the Roseton area took place primarily in the eastern part of the River from mid-May to mid-June. White perch were reported to range from 1.7 to 3.00mm at hatching (Mansueti, 1964) and larvae in this size range were collected primarily at the east station. Larvae collected at the west station were generally

CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

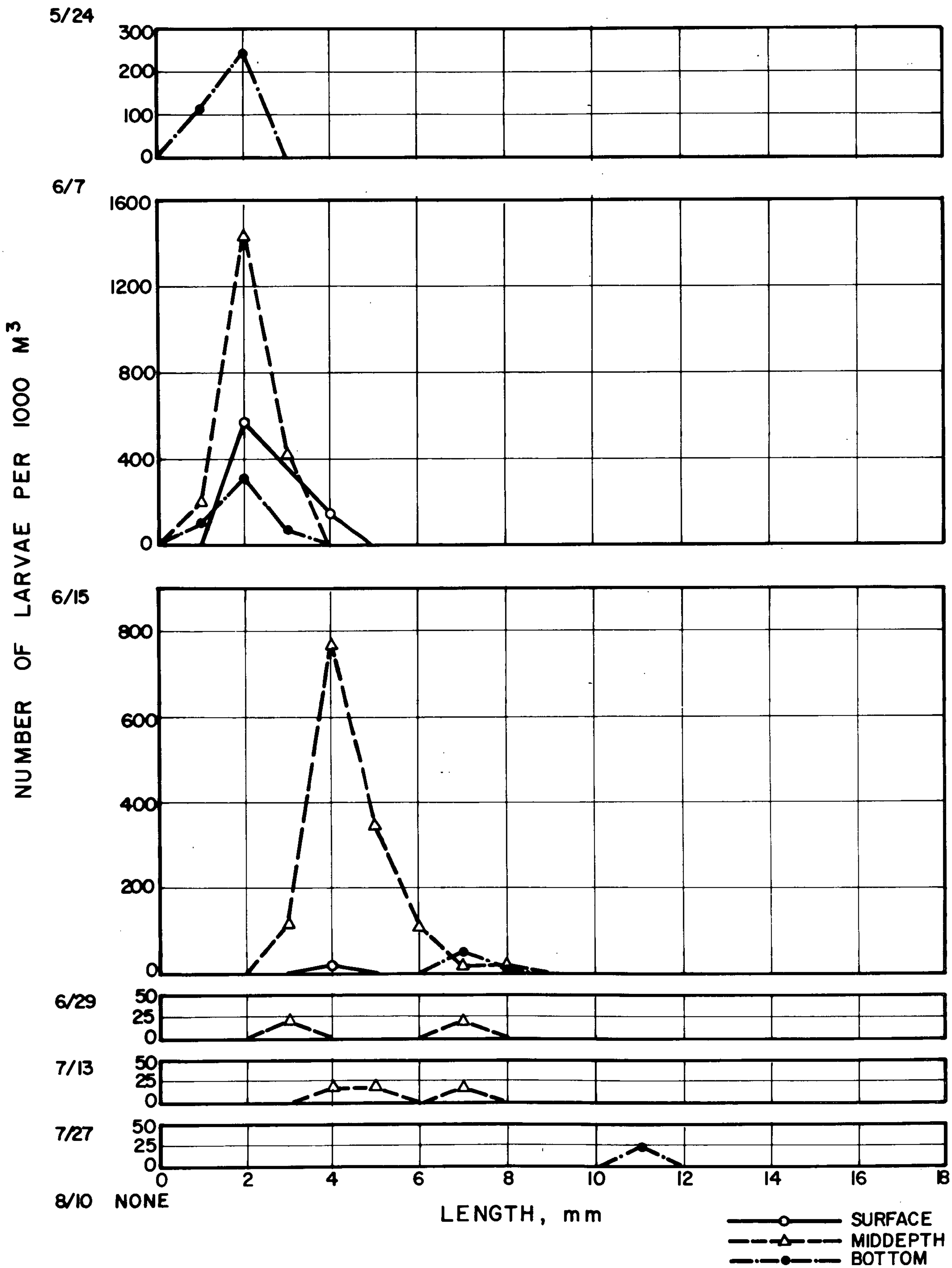
SIZE CONCENTRATION
WHITE PERCH LARVAE AT WEST STATION
1972



CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

FIGURE V-13

SIZE CONCENTRATION
WHITE PERCH LARVAE AT EAST STATION
1972



larger, older, individuals, which presumably were transported to that part of the River by currents and/or diffusion.

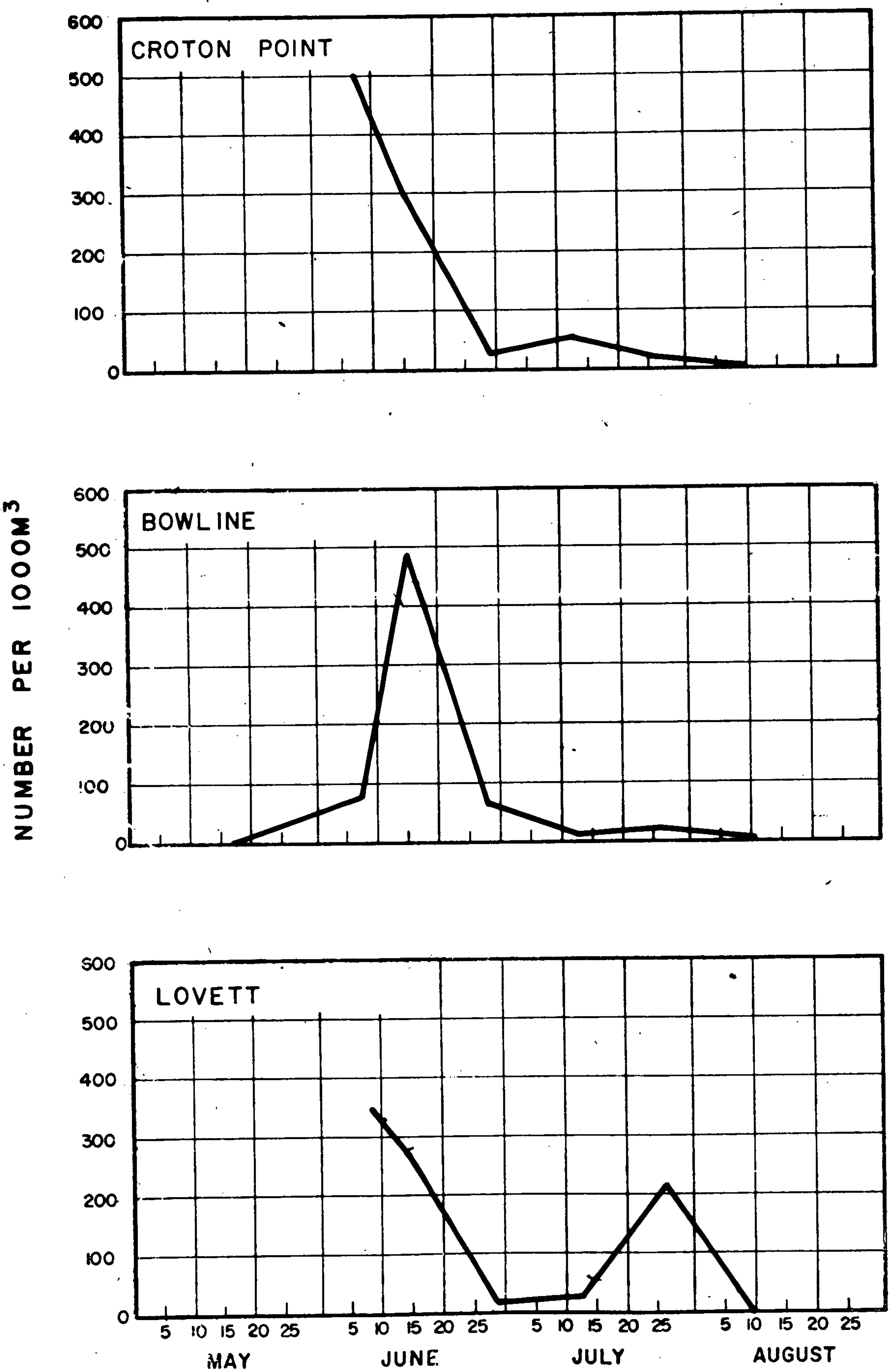
Graphic presentations (Figures V-14 through V-17) show that, of the eleven stations sampled, greatest concentrations of white perch larvae were observed in the Roseton area. It is not possible to state whether or not greatest concentrations actually did occur at Roseton since the intial collections made both at the Croton Point and Lovett stations on June 7 contained large numbers of white perch larvae suggesting the possibility that peak concentrations equal to or exceeding those found at Roseton may have occurred prior to the initiation of sampling. The high concentrations of small larvae collected at the east station suggests that in 1972 the Roseton vicinity was one of possibly several spawning areas for white perch.

(ii) Alosa

Alosa larvae were found to occur at Roseton from the first sampling date until July 13. Maximum concentration was present at the west station on June 29 while peak concentration at the east station was lower and occurred on June 7 (Figure V-18).

On May 24, primarily small larvae in the 2-4mm size range, were present; a few larvae up to 10mm were taken. On June 7, the size range covered 2 to 15mm with the majority in the six to 10mm range. On June 15, the majority of larvae were in the 7 to 12mm range. On June 29, however, larvae most frequently occurred in the 4 to 8mm size range. A few

AVERAGE LARVAL CONCENTRATION 1972 WHITE PERCH



AVERAGE LARVAL CONCENTRATION
1972
WHITE PERCH

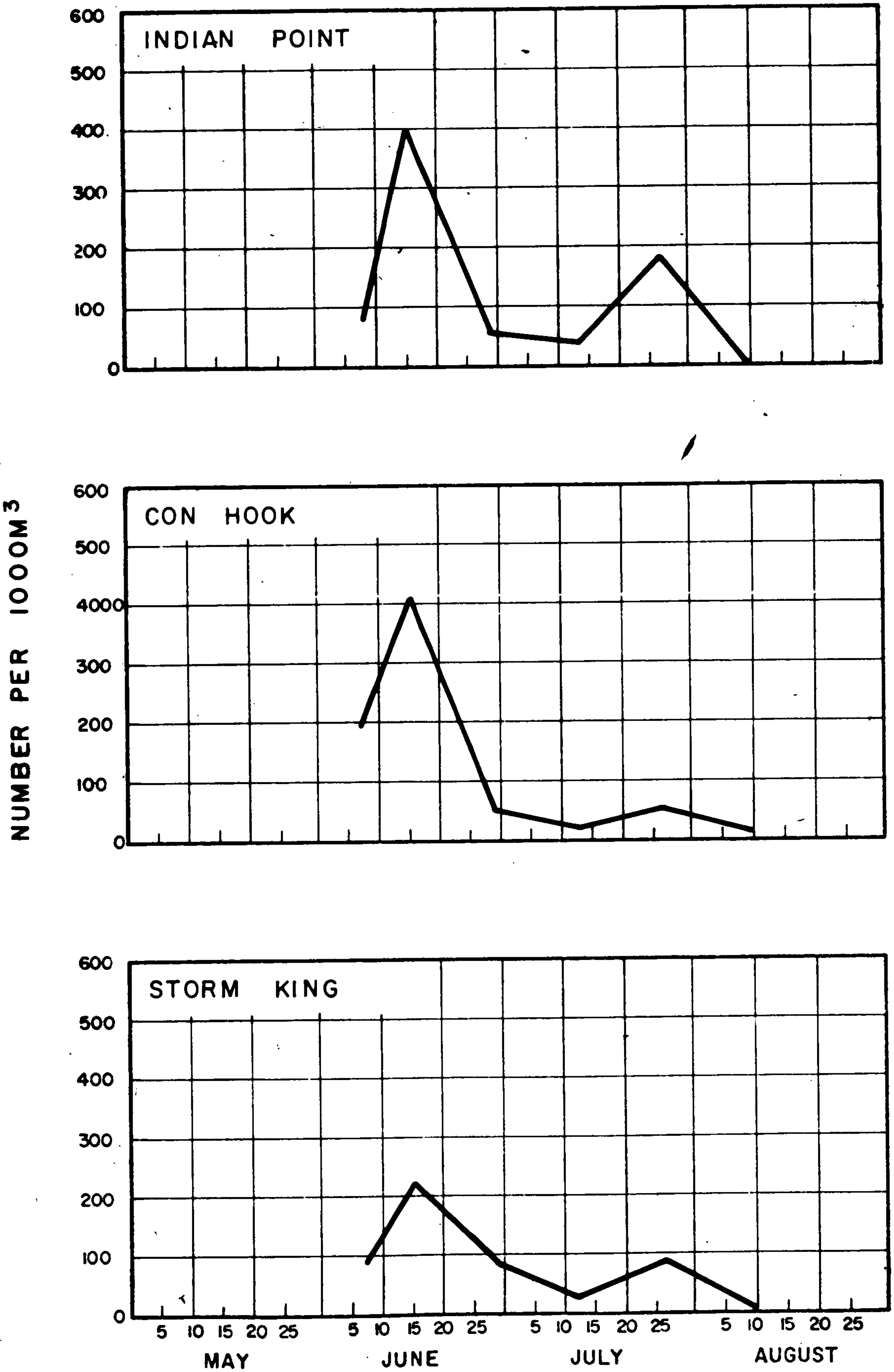
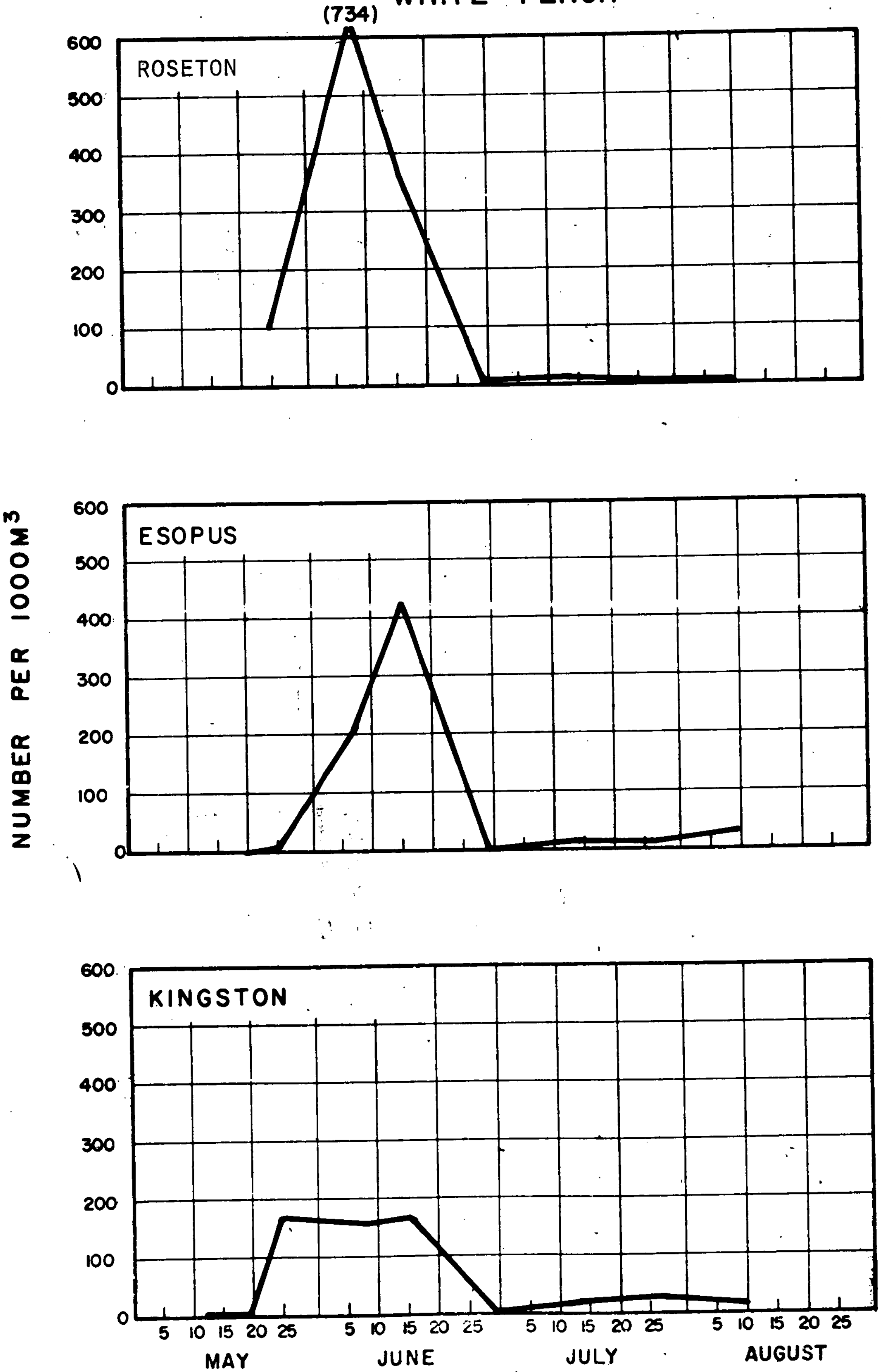
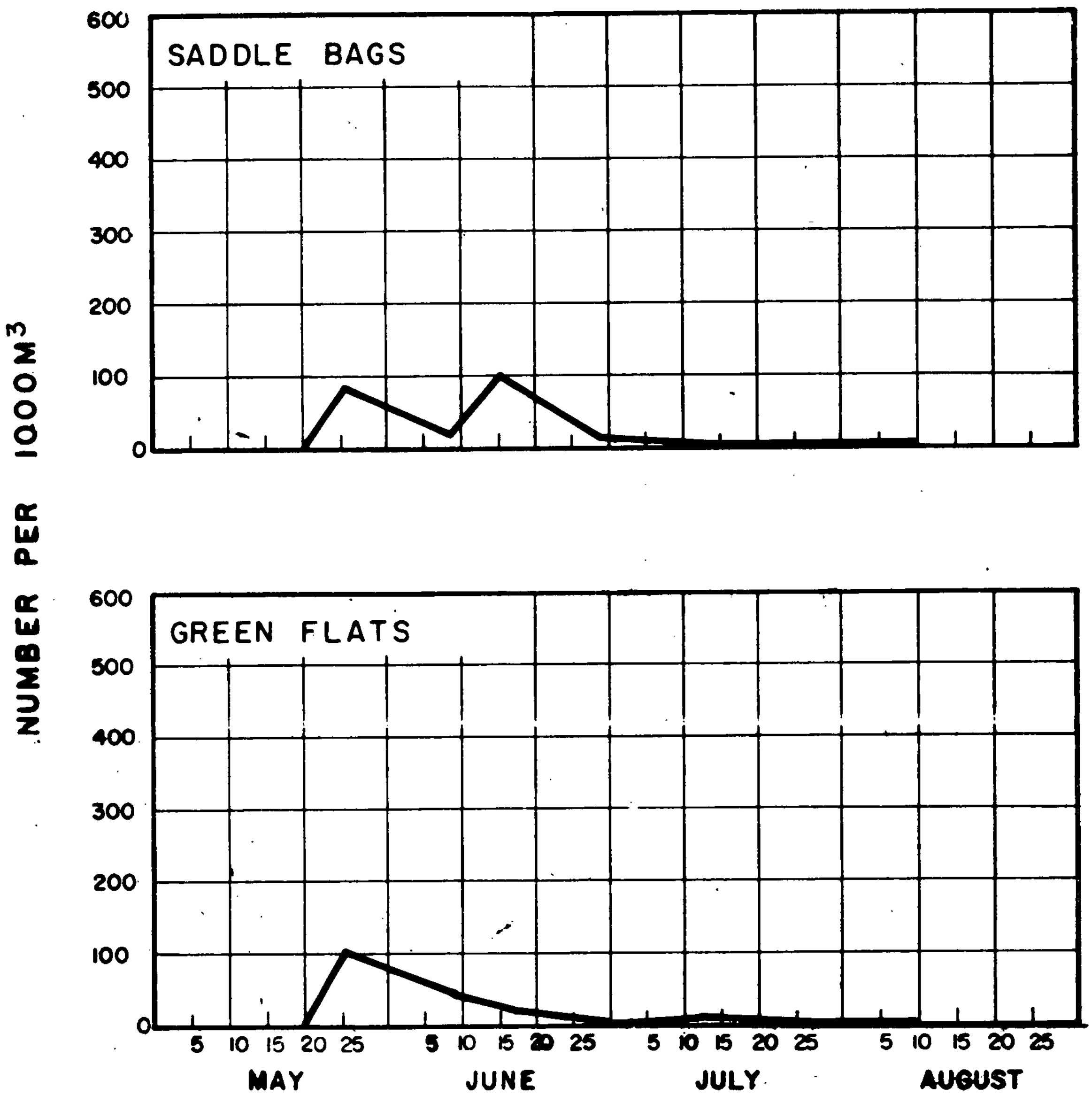


FIGURE V-16

AVERAGE LARVAL CONCENTRATION
1972
WHITE PERCH



AVERAGE LARVAL CONCENTRATION 1972 WHITE PERCH



larvae were found on July 13 in the 7 to 9mm size range. No alosa larvae were collected in later samples (Figures V-19 and V-20).

The majority of Alosa larvae were found at surface or at mid-depth. The larval concentrations at mid-depth were greater than those at the surface only in the collection made at Roseton West on June 15.

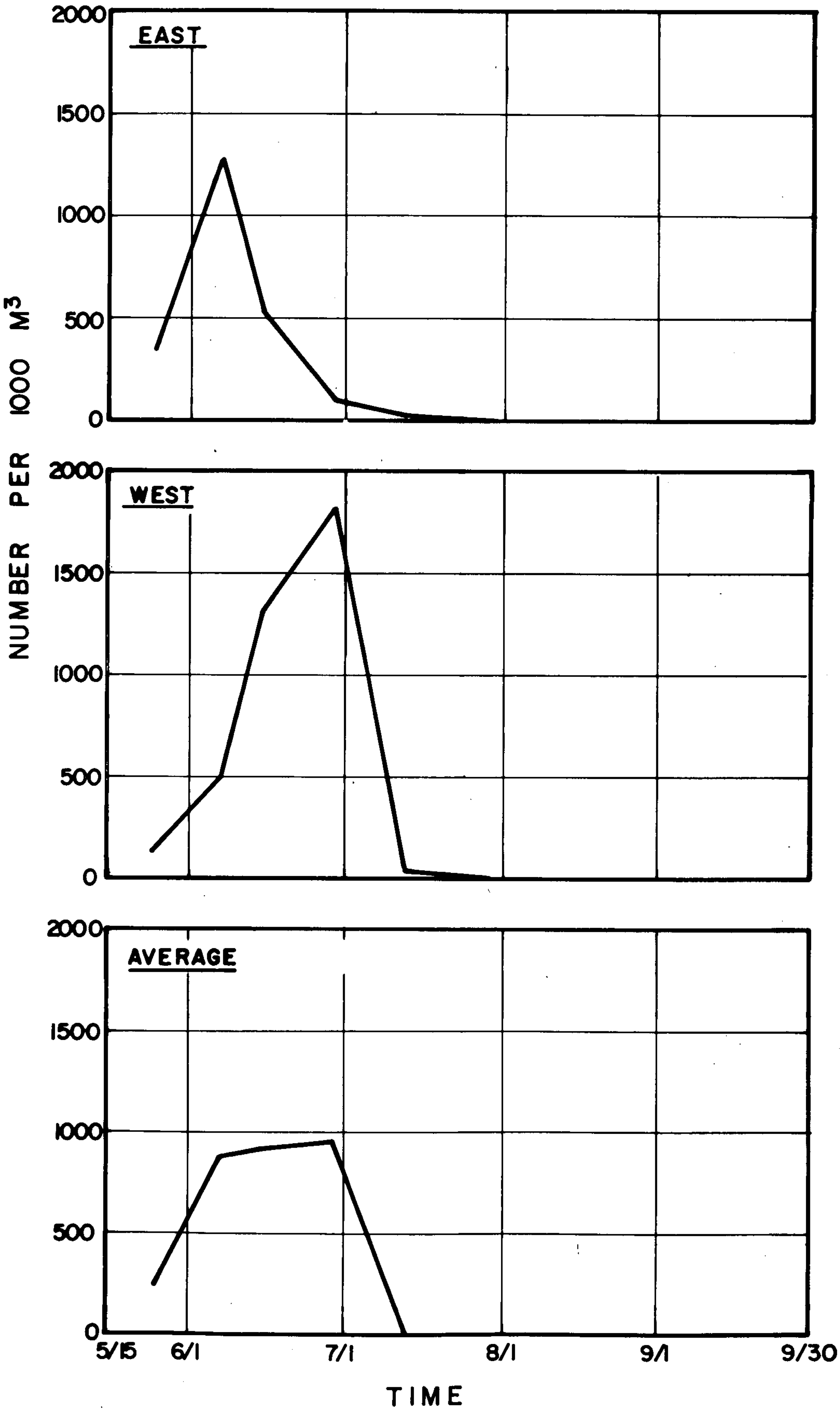
It is difficult to draw conclusions concerning the distribution of Alosa at Roseton since this genus may include three species of larvae, American shad, blueback herring, and alewife, which were not identified separately in the laboratory and all of which might be present in the study area. The data from Figures V-19 and V-20 may, however, indicate the presence of at least two distinct groups of Alosa larvae at Roseton, one accounting for peak concentrations on the east side of the River on June 7, and the other for peak concentrations on the west side on June 29.

Figures V-21 through V-24 indicate that in 1972 lowest concentrations of Alosa larvae were observed at Croton Point, the most southerly station sampled, with slightly higher concentrations occurring in the Lovett and Bowline Station. At Indian Point peak concentrations increased markedly to over 4,000 larvae/1000m^3 then dropped off again in the Con Hook area. Peak concentrations of over 2,000 larvae/1000m^3 occurred at Storm King, dropping down to about 1,000 in the Roseton area, then steadily increasing upriver to a high of over 5,000 at Saddle Bags. From these data it appears that while considerable numbers of Alosa may spawn in the Roseton area, it cannot be considered to have been one of the major spawning

FIGURE V-18

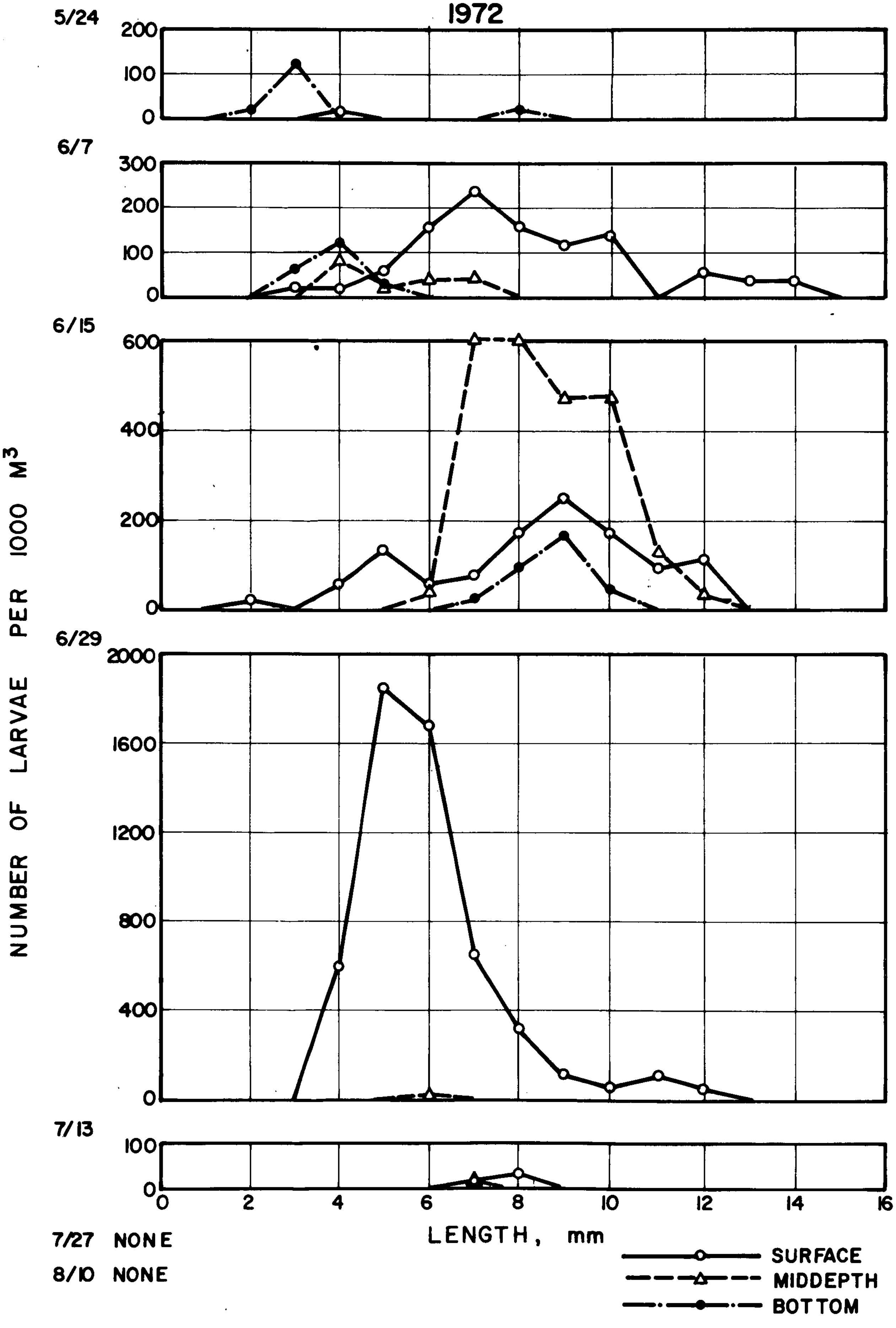
CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

AVERAGE CONCENTRATION ALOSA LARVAE 1972



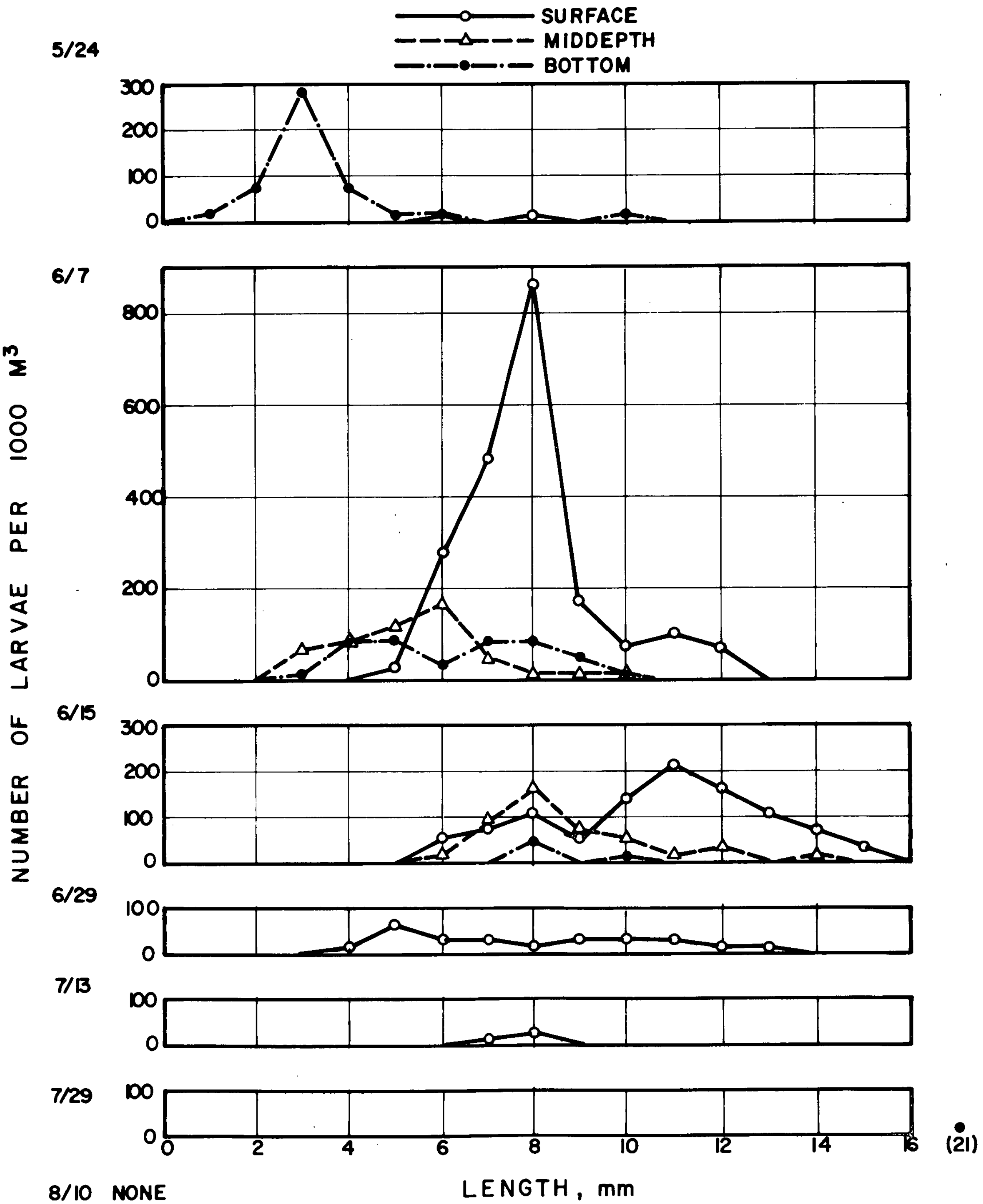
CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

SIZE CONCENTRATION ALOSA LARVAE AT WEST STATION 1972

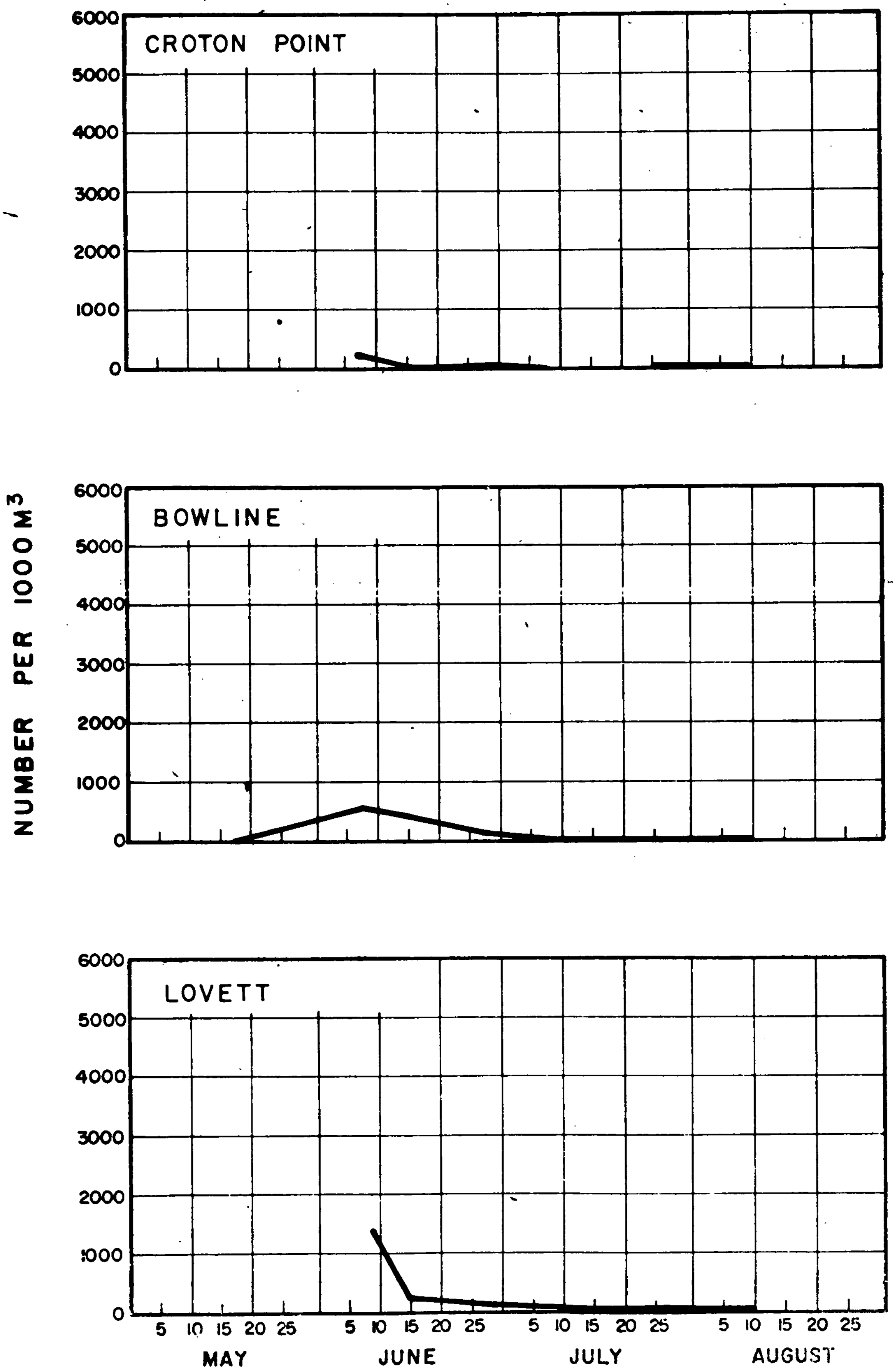


CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

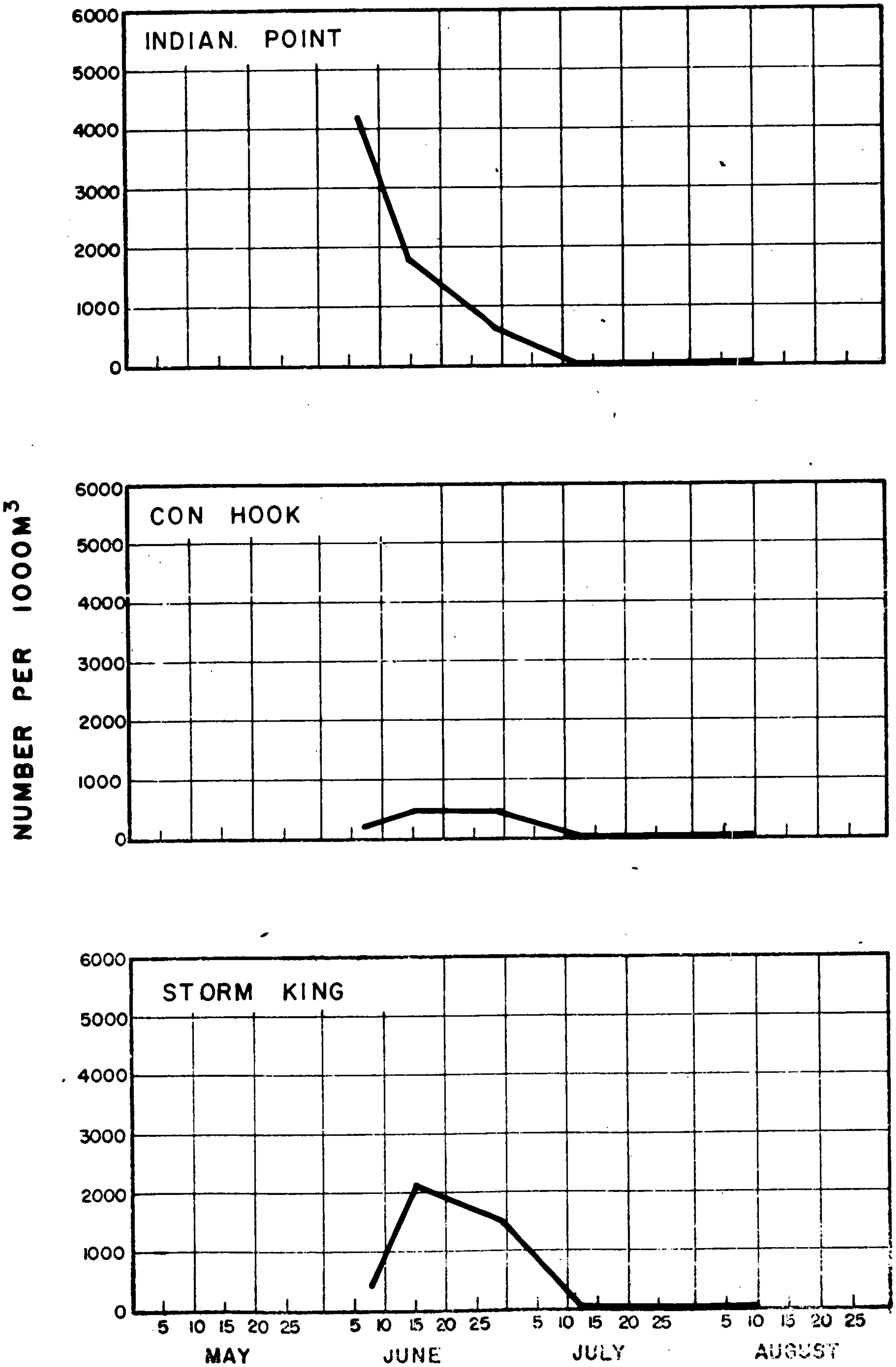
SIZE CONCENTRATION ALOSA LARVAE AT EAST STATION 1972



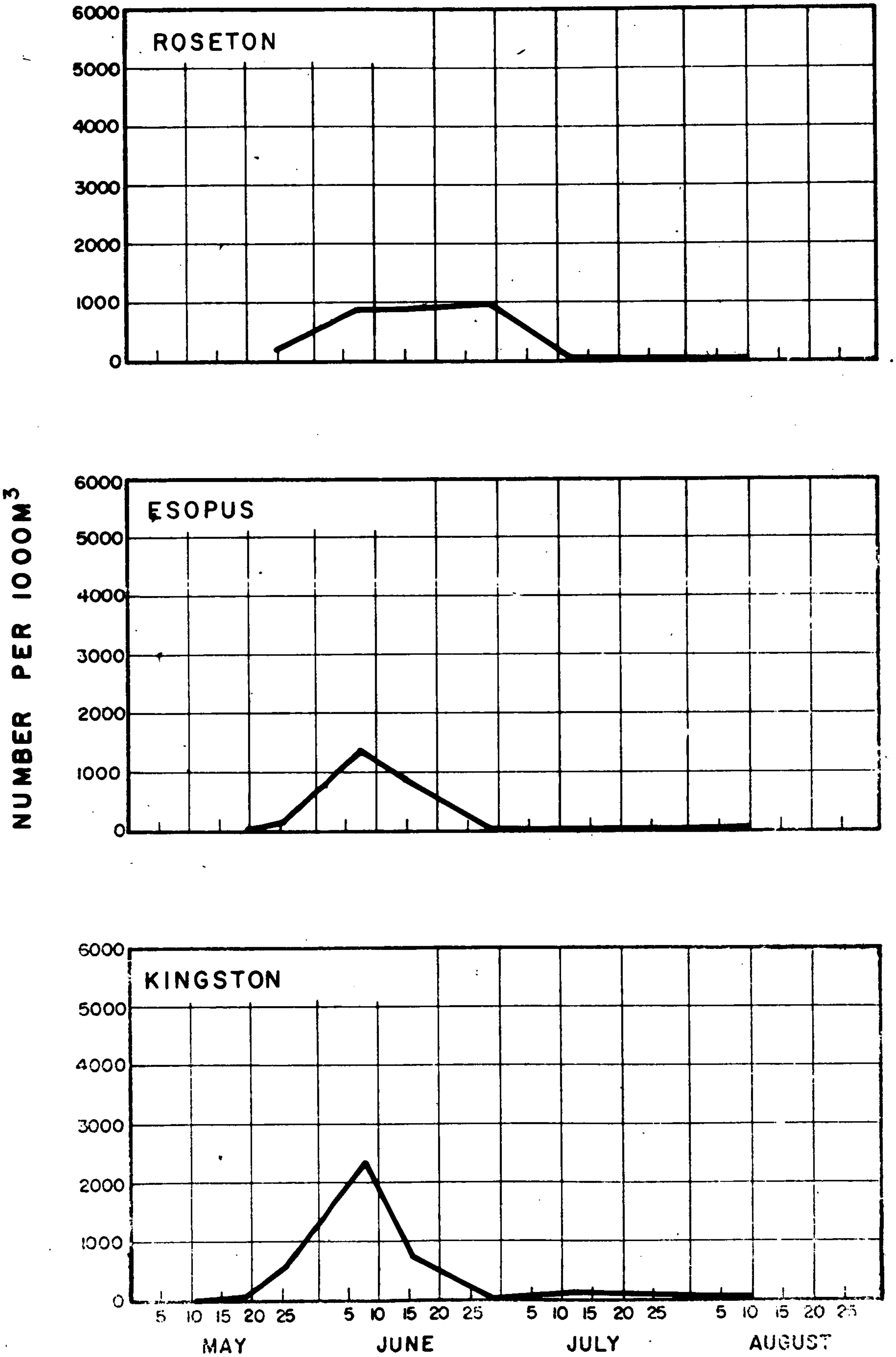
AVERAGE LARVAL CONCENTRATION
1972
ALOSA



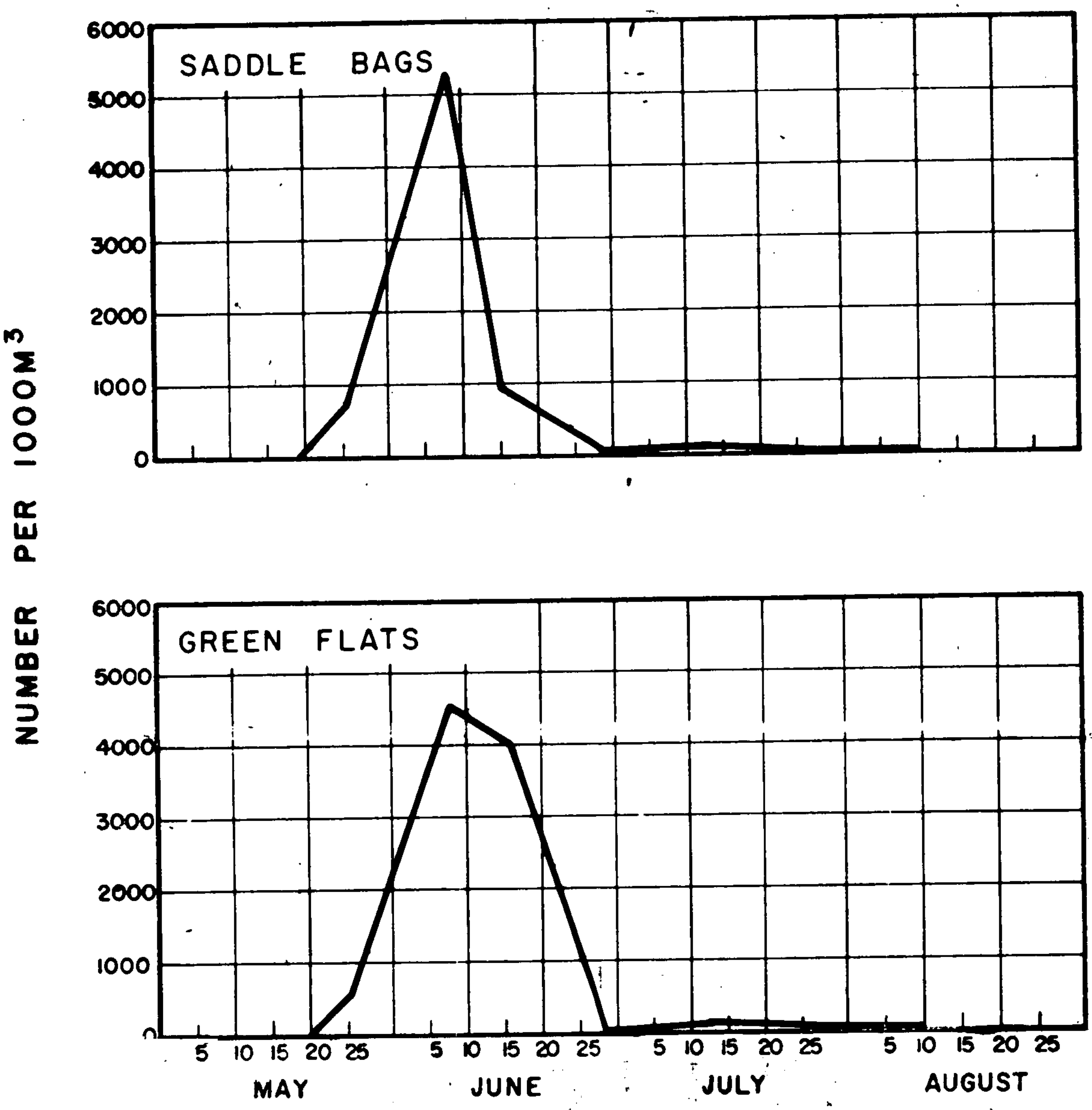
AVERAGE LARVAL CONCENTRATION
1972
ALOSA



AVERAGE LARVAL CONCENTRATION
1972
ALOSA

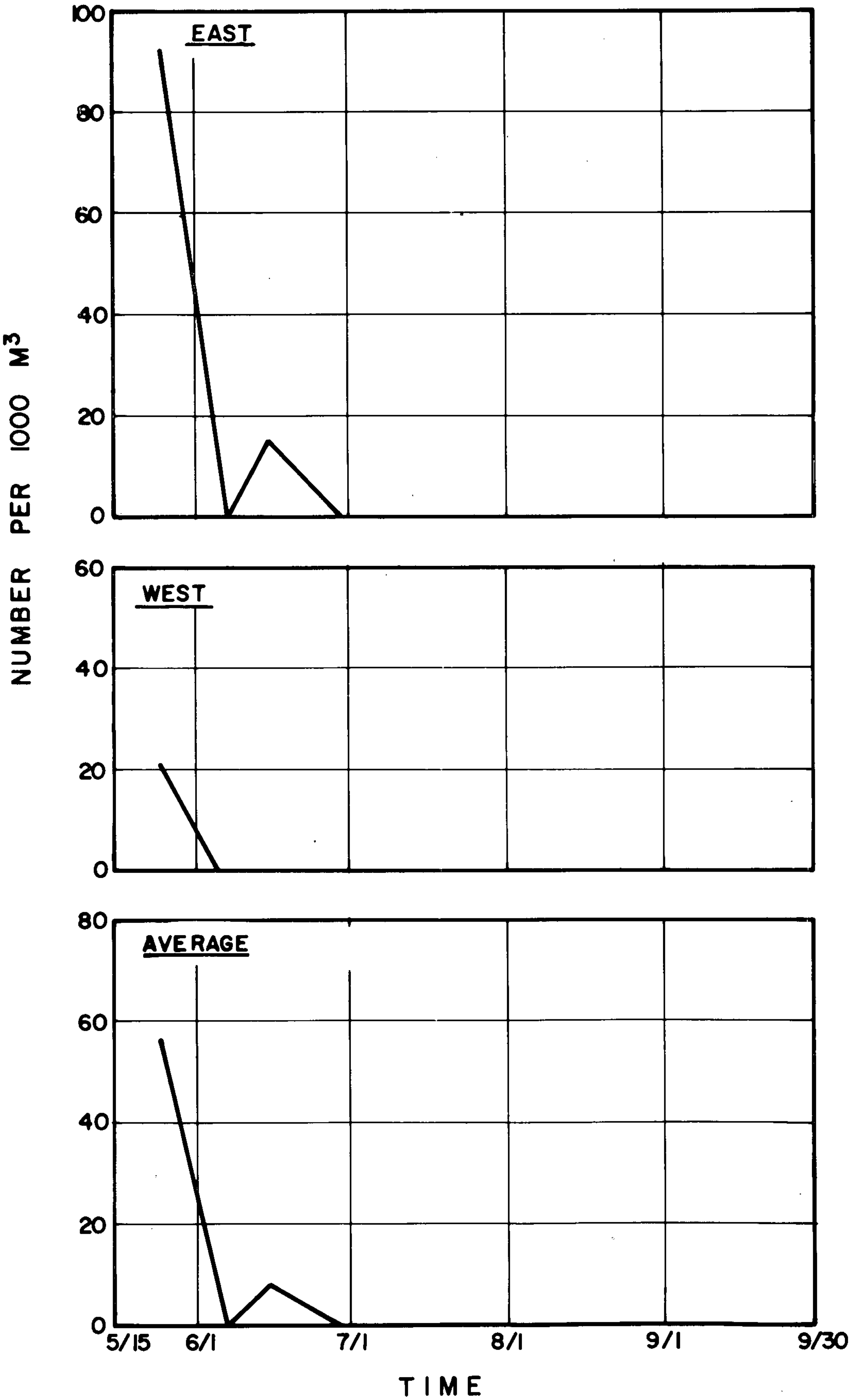


AVERAGE LARVAL CONCENTRATION 1972 ALOSA



CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

AVERAGE CONCENTRATION STRIPED BASS LARVAE 1972



areas for these fish in the Hudson River in 1972.

(iii) Striped Bass

Fourteen striped bass larvae (out of a total of 1073 larvae) were collected in the Roseton/Danskammer Point vicinity during the period from May 24 to June 15 1972 (concentrations are presented in Figures V-25 and 26). With the exception of one larva, all of these occurred in bottom samples. The majority of the larvae were caught on the first sampling date indicating the possibility that most spawning occurred prior to the initiation of sampling. This possibility is further supported by the fact that larvae up to 8mm. in length were captured on May 24 while newly hatched striped bass range in size from 2.0 to 3.7mm. and larvae 8mm. in length are reported to be between 10-15 days old. (Mansueti, 1958).

Very low concentrations of striped bass were observed throughout the area sampled (Figures V-27 to V-30). Highest average concentrations of about 250 larvae/1000m^3 were found in the Lovett-Indian Point area with the highest average concentration at Roseton being 55 larvae/1000m^3. The greatest concentration of larvae taken in any one sample at Roseton equalled 170/1000m^3. All of these high values were observed in samples taken June 7, 1972.

In Table V-1 and V-2 the results of 1972 analysis of striped bass larvae are compared with those made by Carlson and McCann for 1968 collections at Cornwall (Storm King) and by the Raytheon Corporation in 1971 in the Indian Point vicinity. This information indicates that concentrations of larvae observed by QLM in 1972 are similar in magnitude to

CENTRAL HUDSON GAS & ELECTRIC
AT ROSETON

FIGURE V-26

SIZE CONCENTRATION
STRIPED BASS LARVAE AT ALL STATIONS
1972

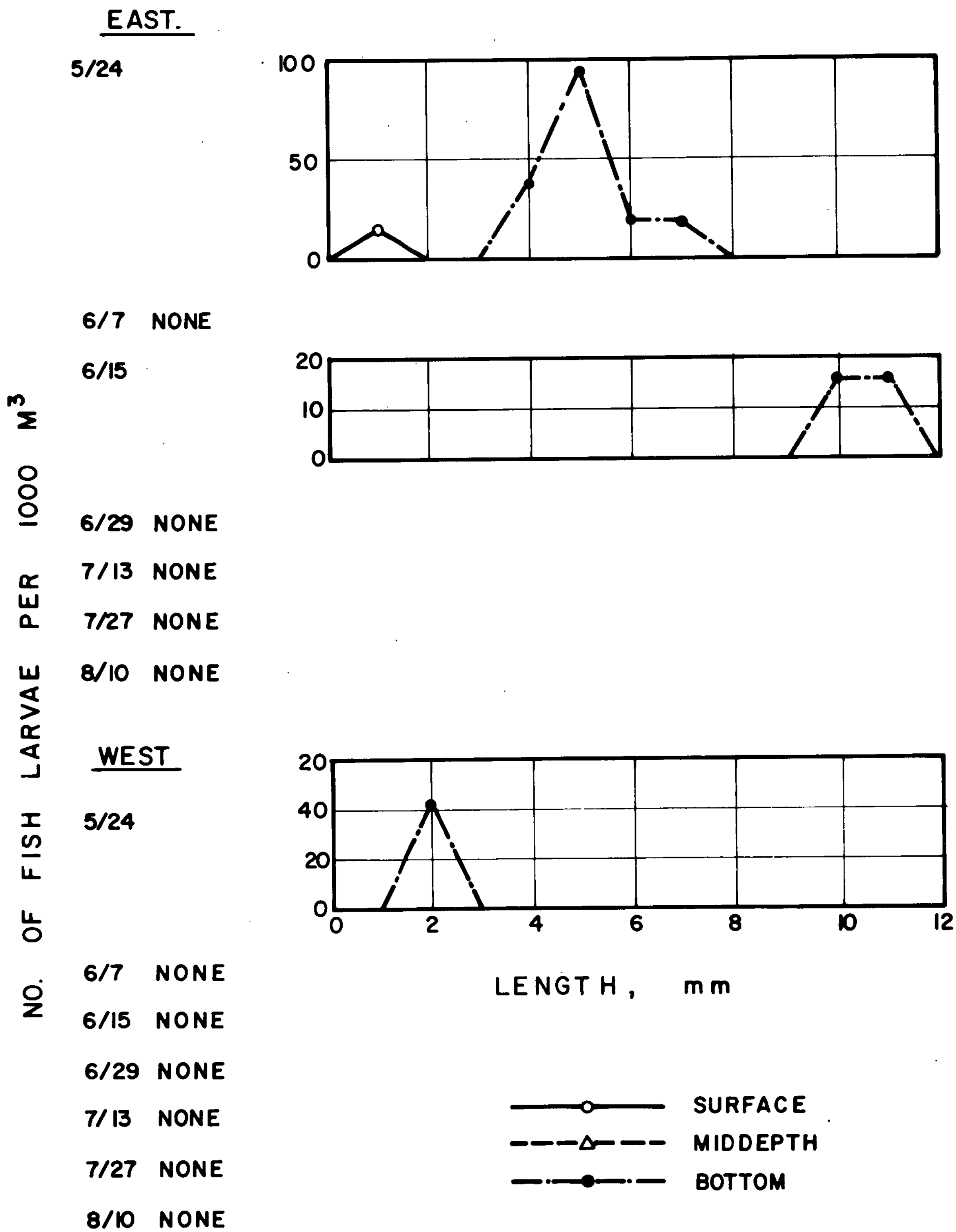
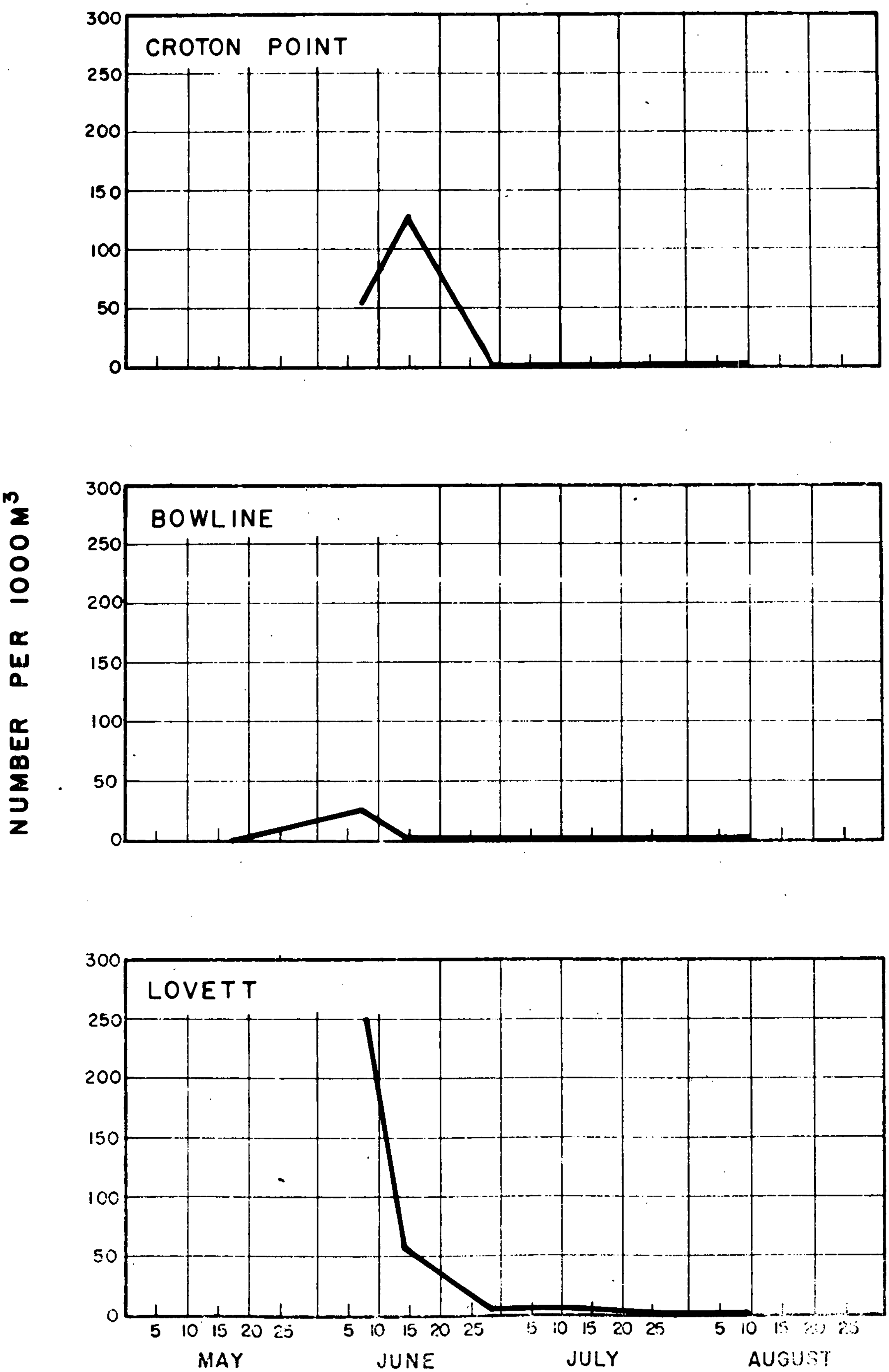
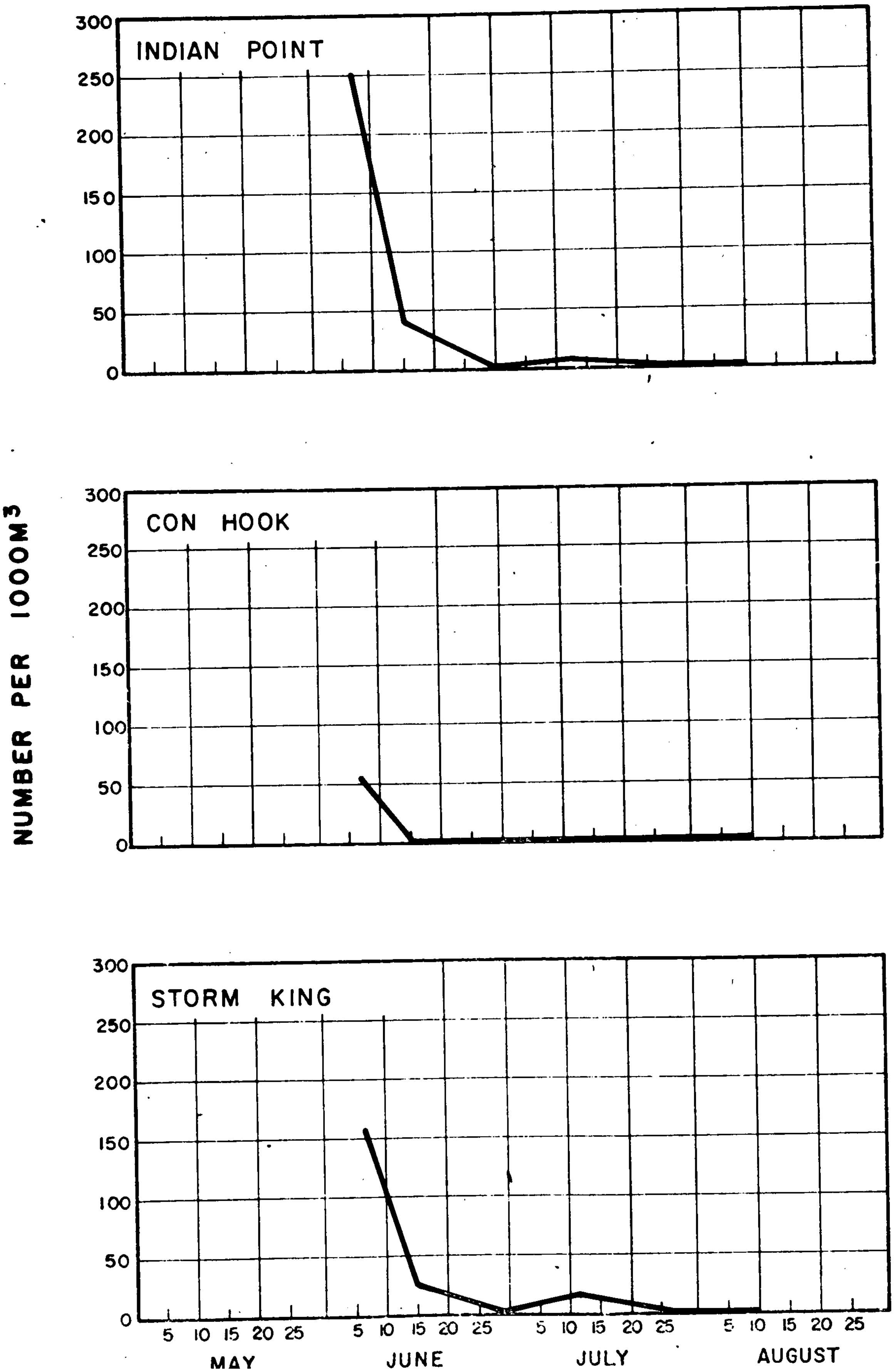


FIGURE V-27

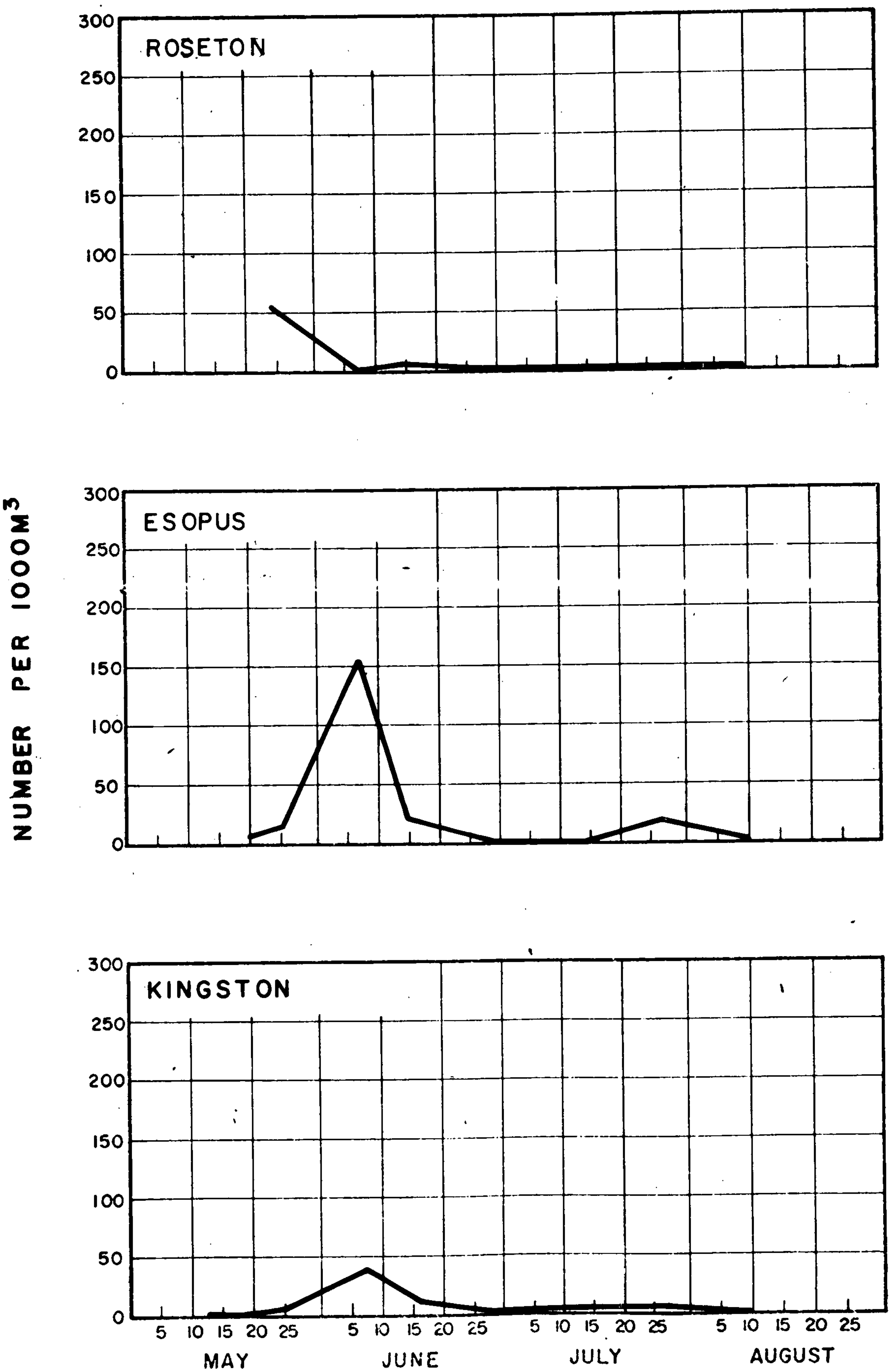
AVERAGE LARVAL CONCENTRATION
1972
STRIPED BASS



AVERAGE LARVAL CONCENTRATION 1972 STRIPED BASS



AVERAGE LARVAL CONCENTRATION 1972 STRIPED BASS



AVERAGE LARVAL CONCENTRATION 1972

STRIPED BASS

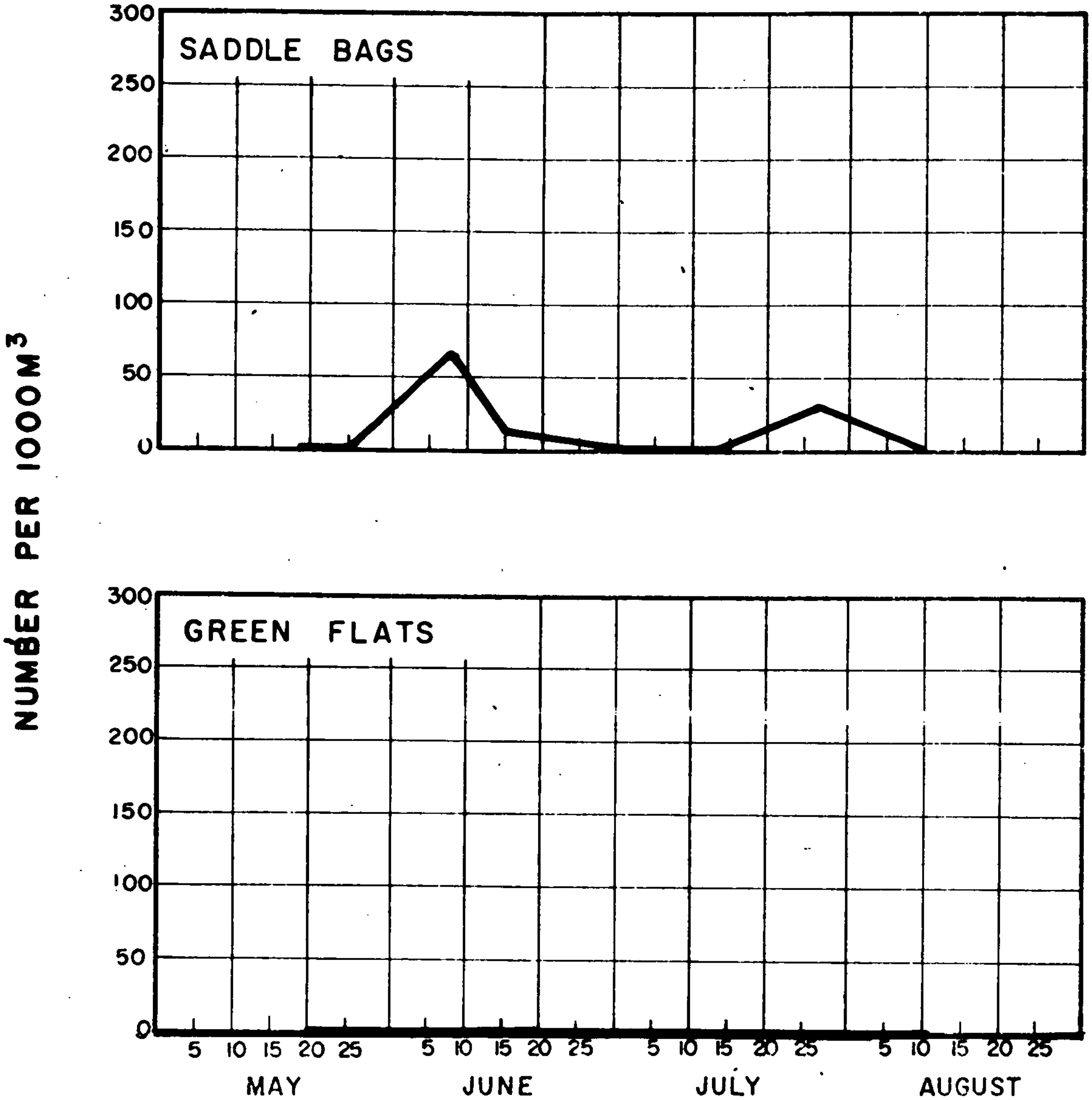


TABLE V-1

STRIPED BASS LARVAL CONCENTRATIONS
INDIAN POINT, 1971 VERSUS 1972

(Number per 1,000 m^3)

Week of:	1971* Raytheon	1972 QL&M
Surface Tows		
6/7	0	29
6/15	15	0
6/29	50	0
7/13	0	0
7/27	0	0
8/10	0	0
Mid-Depth Tows		
6/7	5	217
6/15	50	41
6/29	20	0
7/13	0	13
7/27	0	0
8/10	0	0
Bottom Tows		
6/7	40	515
6/15	100	82
6/29	120	6
7/13	0	6
7/27	0	0
8/10	0	0

*1971 values have been taken from graphic presentations. No listing of actual data was presented.

TABLE V-2

STRIPED BASS LARVAL CONCENTRATIONS
AVERAGE VALUE OF ALL DEPTHS
CORNWALL (STORM KING), 1968 VERSUS 1972

(Number per 1,000 m^3)

Week of:	1968 Carlson & McCann	1972 QL&M
6/7	23.9 - 31.6	160
6/15	139.2 - 199.0	27
6/29	17.9 - 38.7	0
7/13	16.5 - 17.6	16

those observed in 1968 and 1971, and therefore may be representative of the typical situation in the River.

E. STATISTICAL ANALYSIS

A variety of statistical analyses including the Paired t, 1-way ANOVA, Kruskal-Wallis, and Sign test were applied to the larval data in an attempt to determine if differences illustrated by the graphic presentations were significant. No significant differences were found. This is possibly due to the fact that although sampling effort is constant between sites and dates there is simply not enough data to provide meaningful analyses. Even when, for example, the three samples from a collection site on a single day are arbitrarily considered as replicates, comparisons with the other site, when those data are treated the same way, are non-significant. This is due to the large variance of the replicate samples and to the small number of degrees of freedom associated with small numbers of samples.

F. PUMP SAMPLES

Extensive testing of vacuum chamber pump sampling devices (larval pumps) at the Danskammer Generating Station have indicated that such devices are capable of sampling fish larvae in intake and discharge structures, but that further refinements will be necessary before they are capable of producing satisfactory results.

Pump samples were taken at Danskammer on the following dates:

July 21, 1972	August 8, 1972
July 27, 1972	August 15, 1972
July 28, 1972	August 16, 1972
August 3, 1972	September 6, 1972

Number of larvae per sample ranged from 0 to 34 with the average number being 1.5 and the mode 0. The low numbers of larvae collected was primarily due to the fact that most sampling took place during a period when larvae are not abundant in the Danskammer region (Figure V-4). The results do indicate, however, that the sampler is capable of collecting larvae if and when they are present.

Sampling by plankton net was carried out in the River at Danskammer at east, west, and mid-channel stations, on July 28, August 8, August 15 and 16, and September 6, 1972, simultaneously with pump samples for the purpose of comparing concentrations of larvae in the River with concentrations collected by the pumps. A relationship between pump and River samples was not observed.

This lack of correlation was most probably due to the scarcity of larvae during the sampling period. Such low concentrations of larvae would have required sampling extremely large volumes of water to obtain a representative larval sample. Additional factors contributing to the randomness of pump samples were the fact that pumping rates varied due to clogging of intake hoses and pump impellers and the fact that the intake hose was fixed in position so that the depth at which the sample was taken varied with the level of the tide.

On-site observations of larval pump samples indicated that the majority of larvae collected were in a mangled or distressed condition. This was particularly true of the river herring and bay anchovy larvae which are known to be extremely delicate. Post-larvae and early juveniles of the white perch showed better survival and individuals transported to the laboratory remained in good condition for periods up to three weeks.

The poor condition of the larvae was apparently due to pump construction features. Intake pipes were assembled with several sharp angles which may have subjected larvae to mechanical damage. Water level in the vacuum chamber was found to have a tendency to drop below the level of the inlet so that larvae were often subject to a "waterfall" effect when entering the chamber which might also cause severe damage to delicate organisms. Larval pumps are currently being designed with the object of eliminating or minimizing these harmful effects and there is reason to believe that improved design will enable accurate samples to be taken without damage to larvae.

G. SUMMARY OF RESULTS

1. The period of larval occurrence at Roseton in 1972 extended from the initiation of sampling in mid-May until the end of July, with peak concentrations occurring in June.

2. The larvae occurring in greatest concentrations at Roseton were the white perch and river herring (Alosa).

3. Spawning of white perch occurred primarily in the eastern part of the River at Roseton from mid-May until mid-June. Maximum concentrations of perch occurred in the first half of June and declined rapidly thereafter.

4. Of the locations studied, the Roseton area represented one of the most important spawning areas for white perch in 1972.

5. White perch larvae occurred primarily in mid-depth and bottom samples.

6. River herring (Alosa) were found to occur at Roseton between May 24 and July 13. Data suggests two distinct groups of fish spawning in the area, one on the east side of the River during late May and early June and another on the west side from mid to late June.

7. Alosa larvae were found in highest concentrations in surface samples.

8. A total of only 14 striped bass larvae (out of a total of 1073 larvae) were collected during the period from late May to mid June at the Roseton sampling stations. All but one striped bass larva occurred in bottom samples.

9. Striped bass occurred in very low concentrations throughout the River.

10. Larval pumps were found capable of collecting larvae in intake and discharge structures, but most larvae were found to be in either mangled or distressed conditions. It is believed that improved design will eliminate or reduce such damage.

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VI. CHEMICAL AND PHYSICAL STUDIES

VI. CHEMICAL AND PHYSICAL STUDIES

A. INTRODUCTION

The lower Hudson River, from the Troy Dam to the New York Bight may be more properly termed the Hudson River Estuary. Technically speaking, an estuary has been defined by Pritchard (1967) as a "semi-enclosed coastal body of water which has a free conversion with the open sea and within which sea water is measureably diluted with fresh water derived from land drainage." This definition is often expanded to establish the upper limit of an estuary as the area in which tidal movements of the waterbody, due to the connected sea, are no longer measureable (i.e., Troy Dam, for the Hudson River). However, the word " estuary" has come to connote a vastly active biological area where a myriad of marine, freshwater and land biota thrive in a watery, nutrient-rich environment.

Man also thrives in this environment, and estuarines are of specific importance to many of man's activities. The availability of large quantities of water and and the advantages of water transportation have led to extensive urban, industrial and commerical developments in estuarine areas.

The many advantages that estuaries provide create extensive and varied demands for water use. The protection and regulation of these uses requires detailed studies on the chemical, physical and biological characteristics of estuaries, but the very nature of estuaries complicates the execution of these studies.

The definition of an estuary implies the non-steady state nature of the system. Its hydrodynamics are determined primarily by the interaction of regular, periodic tides from the ocean and the periodic and random influx of fresh water.

These two current systems oppose each other: the unidirectional stream current and the oscillating tidal currents interact and exert complicated effects on processes, such as sedimentation and local mixing, and upon various chemical and physical characteristics. The result is a highly variable system with periodic and random fluctuations in three dimensions. Water masses, organisms, and pollutants are distributed alternately upsteam and downstream, along the surface or the bottom of the estuary, mixing along the way with water masses in bays and from inputs.

The hydrodynamics of the Hudson River Estuary has been studied and reported in previous reports (e.g., Quirk, Lawler & Matusky Engineers, 1971). The Hudson River is unique for its length, its steep banks, its low fresh water flow, and its high current velocities. It is often vertically stratified with respect to velocity and chemical characteristics, so that, at times, there is a flow of dense, saline water upstream and a flow of fresh water downstream.

The physical and chemical nature of the Hudson River has been studied extensively. The history of investigations is discussed in a subsequent section. The specific interpretation of these is difficult because of the system and the long reaches over which changes take place during tidal, seasonal, and long term cycles. Suffice it to say, that the activities and hydrodynamics discussed above create unique but constantly changing areas of the River, each of which has characteristics which change over cycles of a few hours to many years.

B. WATER QUALITY ANALYSES AND THEIR OBJECTIVES

The uses of the Hudson River Estuary water vary from drinking water use and aquatic organism propagation to cooling water and navigational uses. The quality of water commensurate with these uses obviously vary. Criteria have been developed and closely defined for drinking water. Quality criteria for organism propagation are obviously critical, but are difficult to define exactly and have not been clearly established; many important interactions between consitutents in water occur, so that lists cannot be interpreted in a simplistic manner. Criteria for other uses are less stringent or non-existent. Table VI-1 summarizes several lists of water quality criteria by use. These lists are condensed, and many items in them must be interpreted for the specific situations concerned (e.g., in estuaries, consideration may have to be given to specific fish or shellfish within specific areas).

Natural waters may also be polluted by each of the uses to which they are put. An estimate of the extent of pollution by these uses can be made in some cases, although specific investigations are necessary for careful delineation of unique sources. Tables VI-2 through VI-7 give several estimates of these sources. Table VI-2 presents the concentrations of trace elements characteristic of igneous rock, reflecting a possible geological influence on sources of trace elements at low levels.

TABLE VI-1

CONDENSED LISTS OF WATER QUALITY CRITERIA

	USPHS DRINKING WATER STANDARDS		SURFACE WATER CRITERIA FOR PUBLIC WATER SUPPLIES			
	Recommended Limit	Maximum Permissible Limit	Permissible	Desireable	Cooling Water Once Through	Makeup For Recirculated Cooling Water
Bacteriological						
Total Coliforms (membrane Filter Technique)	$\leq$1/100 ml		10,000/100ml	<100/100ml		
Fecal Coliforms			2,000/100ml	< 20/100ml		
Physical						
Turbidity (JTU)	5		Narrative	Virtually Absent		
Color (Pt-Co Color Units)	15		75	<10		
Threshold Odor Number	3		Narrative	Virtually Absent		
Taste			Narrative	Narrative		
Chemical (Mg/l)						
Alkyl Benzene Sulfonate (ABS)	0.5					
Arsenic (As)	0.01	0.05	0.05	Absent		
Barium (Ba)		1.0	1.0	Absent		
Cadmium (Cd)		0.01	0.01	Absent		
Carbon Chloroform Extract (CCE)	0.2		0.15	<0.04		
Chloride (Cl)	250		250	< 25	600-19,000	500-19,000
Chromium (Hexavalent) (Cr^{+6})		0.05	0.05	Absent		
Copper (Cu)	1.0		1.0	Virtually Absent		
Cyanide (Cn)	0.01		0.2	Absent		
Flouride (F) - Temperature dependent	0.8-1.7		Narrative	Narrative		
Iron (Fe)	0.3		0.3	Virtually Absent	No. Std.	0.5
Oil and Grease			Virtually Absent	Absent		
Uranyl ion (U)			5	Virtually Abseht		
Silica					25-50	25-50
pH			6.0-8.5	Narrative	5.0-8.3	
Manganese (Mn)			0.05	Absent	No. Std.	0.02-0.5
Hardness					850-6250	130-6250
Lead (Pb)		0.05	0.05	Absent		
Nitrate (NO_3-N)	10		10	Virtually Absent		
Phenols	0.001		0.001	Absent		
Selenium (Se)		0.01	0.01	Absent		
Silver (Ag)		0.05	0.05	Absent		
Sulfate (SO_4)	250		250	<50	680-2700	200-2700
Total Dissolved Solids (TDS)	500		500	<200	100-35000	500-35000
Zinc (Zn)	5.0					
Alkalinity			Narrative	Narrative	115-500	20-115
Ammonia (NH_3-N)			0.5	<0.01		
Boron (B)			1.0	Absent		
Dissolved Oxygen			$\geq$3(Individual sample)	Near Saturation		
Aluminum (Al)					No Std.	0.1
Calcium (Ca)					200-420	50-420
Bicarbonate (HCO_3)					140-600	24-140
Chemical Oxygen Demand (COD)					75	75
Total Suspended Solids (TSS)					2500-5000	100
Radioactive (p Ci/l)						
Radium-226	3		3	<1		
Strontium-90	10		10	<2		
Gross Beta	1,000		1,000	<100		

TABLE VI-2

CONCENTRATION OF SOME TRACE ELEMENTS

IN IGNEOUS ROCK

(From Pinta, 1962)

ELEMENT	VALUE, ppm	ELEMENT	VALUE, ppm
Ag	0.1	Mo	2.5
As	5	Ni	80
Au	0.005	P	800
B	3	S	520
Ba	250	Se	0.09
Be	6	Sn	40
Bi	0.2	Sr	150
Cd	0.15	Ti	4,400
Ce	480	V	150
Co	23	Zn	80
Cr	200		
Cu	70		
F	300		
Hg	0.5		
Li	65		
Mn	1,000		

TABLE VI-3

DISTRIBUTION OF TRACE ELEMENTS IN SOIL

(From Pinta, 1962)

ELEMENT	RANGE OF VALUES, ppm
Ti	1,000-10,000
Mn	200- 3,000
Ba	100- 3,000
Cr	4- 1,000
V	20- 500
Ni	5- 500
Zn	10- 300
Li	5- 200
Pb	2- 200
Cu	2- 100
B	2- 100
As	1- 50
Co	1- 40
Sn	1- 10
Be	0.3- 10
Mo	0.2- 5
Se	0.1- 2
Ag	0.1- 1

TABLE VI-4

ELEMENTS PRESENT IN SOLUTION

IN SEA WATER EXCLUDING DISSOLVED GASES

(From the Handbook of Chemistry and Physics, 1961)

ELEMENT	CONCENTRATION, ppm
Cl	18,980
Na	10,561
Mg	1,272
S	884
Ca	400
K	380
Br	65
C (Inorganic)	28
Sr	13
Si	0.02-4.0
B	4.6
C (Organic)	1.2-3.0
Al	0.16-1.9
F	1.4
N (as NO_3)	0.001-0.7
N (as organic N)	0.03-0.2
Li	0.1
P (as phosphate)	0.001-0.1
Ba	0.05
I	0.05
N (as nitrite)	0.0001-0.05
N (as ammonia)	0.005-0.05
As (as arsenite)	0.003-0.024
Fe	0.002-0.02
P (as organic P)	0-0.016
Zn	0.005-0.014
Cu	0.001-0.09
Mn	0.001-0.01
Pb	0.004-0.005
Se	0.004
Sn	0.003
Mo	0.0003-0.002
Ni	0.0001-0.0005
V	0.0003
Hg	0.0003
Ag	0.00015-0.0003
Co	0.0001
Cd	Present in Marine Organisms
Cr	Present in Marine Organisms

TABLE VI-5

MINERAL PICKUP FROM DOMESTIC WATER USAGE

(Adapted from Metcalf and Eddy, 1972)

	RANGE, mg/l
ANIONS	
Chloride (Cl)	20-50
Sulfate (SO_4)	15-30
Phosphate (PO_4-P)	7-15
Bicarbonate (HCO_3)	50-250
CATIONS	
Sodium (Na)	40-70
Potassium (K)	7-15
Calcium (Ca)	6-16
Magnesium (Mg)	4-10
OTHER DATA	
Silica (SiO_2)	6-15
Fluoride (F)	1-4
Manganese (Mn)	0
Iron (Fe)	0-0.1
Aluminum (Al)	0.1-<3.0
Boron (B)	0.1-0.4
Total Dissolved Solids (TDS)	100-300
Total Alkalinity ($CaCO_3$)	100-150
Total Nitrogen (as N)	20-40

TABLE VI-6

MEAN POSITIVE TRACE ELEMENT CONCENTRATIONS

IN US.S RIVER BASINS

(Data from Kopp and Kroner, 1970)

ELEMENT	VALUES, mg/l ALL U.S.	NORTHEAST	LAKE ERIE	ALASKA
Zn	0.064	0.096	0.205	0.028
As	0.064	0.034	0.308	0.034
B	0.101	0.032	0.210	0.028
Cu	0.015	0.015	0.011	0.009
Ni	0.019	0.008	0.056	0.005
Pb	0.023	0.017	0.039	0.012
V	0.040	0.009	0.054	0.032

TABLE VI-7

A COMPARISON OF INCIDENCE AND CONCENTRATION OF SEVERAL SUSPENDED AND DISSOLVED TRACE ELEMENTS IN U.S. SURFACE WATERS

(Data from Kopp and Kroner, 1970)

ELEMENT	SUSPENDED		DISSOLVED	
	FREQUENCY FOUND (%)	MEAN (mg/l)	FREQUENCY FOUND (%)	MEAN (mg/l)
Zn	64	0.062	77	0.064
Al	97	3.86	31	0.076
Pb	2	0.12	19	0.023
Ba	95	0.038	99	0.043
Sr	10	0.058	100	0.217

Table VI-3 gives ranges of values of trace elements characteristic of soils and also reflects natural sources. Table VI-4 presents the average composition of sea water, which acts as a source of materials for the estuary. Table VI-5 lists approximate contributions of materials from domestic water use. Finally, Tables VI-6 and VI-7 present the incidence of several materials in U.S. surface waters. Table VI-6 implies a difference between waters subject to heavy use and pollution (Lake Erie) and waters subject to little use or pollution (Alaska).

With the above discussions in mind, brief discussions are given below for certain parameters of interest to the present study. These discussions are intended to give some insight into the basic importance of the various constituents, rather than the specific importance to the present study.

1. Color and Turbidity

Color and turbidity are discussed together because both determine light transmission in natural waters and consequently regulate biological processes within bodies of water.

Color in natural waters is attributable to suspended materials of varying size and composition and also to the nature and quantity of dissolved materials.

Turbidity is primarily due to the suspended particles, from natural soil erosion, industrial and municipal wastes, products of corrosion and growth of algae and other plankton organisms.

The major common effect of these factors is the reduction of light intensity and consequent limitation of photosynthesis and green plants. Of course, turbidity causing materials are often nutrients to aquatic life and may even be aquatic life, in the form of plankton.

2. pH, Alkalinity and Carbon Dioxide

pH is a factor that must be considered in most of the beneficial uses to which water is put. Many important chemical and biochemical reactions only take place at a certain pH value or within a narrow pH range.

The pH is a convenient way of expressing hydrogen ion activity of a water, or more precisely, it is the logarithm of the reciprocal of the hydrogen ion concentration in moles/liter. pH of natural waters is determined by substances in solution, particularly carbonates, carbon dioxide, various salts, and organic substances which collectively constitute a poor to fair buffer system so that water more acid than pH 6.7 or more alkaline than pH 8.6 is generally not found in inland streams unless there are unusual factors present.

pH values are necessary to evaluate the significance of other water quality parameters.

Alkalinity of water is usually imparted by bicarbonates, carbonates, and hydroxide components of a natural water and it is expressed as mg/l $CaCO_3$. According to Huet (1948), waters with alkalinity of 25 mg/l $CaCO_3$ or less are not considered advantageous to fish due to their low buffering action.

Carbon dioxide is more uniformly distributed in flowing waters than in ponds or lakes because of current movements that facilitate constant reaeration. Reaeration tends to release carbon dioxide to the air, and with the presence of calcium and magnesium salts, tends to keep river waters more alkaline than lakes and ponds.

From the equations:

$$CO_2 + H_2O \rightleftarrows H_2CO_3^- \rightleftarrows HCO_3^- + H^+$$

$$MCO_3 \rightleftarrows M^{++} + 2CO_3^=$$

$$HCO_3^- \rightleftarrows CO_2^= + H^+$$

$$CO_3^= + H_2O \rightleftarrows HCO_3^- + OH^-$$

it is obvious that CO_2 and alkalinity are all part of one system that tends toward equilibrium, since all equations involve HCO_3^-. A change in concentration of any one member of the system will cause a shift in the equilibrium, alter the concentration of the other ions, and result in a change of pH. Conversely, a change in pH will shift the relationships.

3. Specific Conductance

This test gives a rapid estimation of the dissolved solids content of a body of water. In most natural waters, it has been found that when specific conductance (in micromhos/cm at 25°C) is multiplied by a factor,which ordinarily lies in the range 0.55-0.7, the product is roughly equal to mg/l dissolved solids.

Specific conductance, therefore, offers a rapid method of determining the extent of downstream or upstream movement of the salt front in an estuary. Ellis (1967) reported that the specific conductance of inland fresh waters and rivers in general lies between 150 and 500 μmhos/cm at 25°C.

4. Dissolved Solids

Dissolved solids include the anions chlorides, sulfates, nitrates, bicarbonates and phosphates and the cations sodium, potassium, calcium, magnesium, iron and manganese.

In estuaries, variations in relative proportions of the minerals can be expected due to the variable nature of fresh water over a considerable distance (tidal reach). Estuaries may also contain greater concentrations of salts and certain nutrients due to introduction of substances from terrestrial sources (seasonal runoffs). All these substances in river water collectively exert osmotic pressure on the aquatic organisms living in the water so that fresh water fishes and other animals living in these areas have become adapted to the physical, physiological, and chemical actions of this salt complex.

5. Chlorides

Chloride values in estuarial waters may be used to calculate the proportion of sea water in the estuary at a given location. Waters containing chloride have been classified by Krul and Liefrink (1946) according to the following range:

(1) Fresh water does not exceed 100 mg/l Cl;

(2) Brackish water contains 100-1,000 mg/l Cl; and

(3) Salt water would have a Cl content greater than 10,000 mg/l.

6. Oil and Grease

Oil is most objectionable in a stream, not only from an aesthetic standpoint due to the visible pollution it causes, but also because it spreads to form a thin film on the surface and so tends to prevent diffusion of oxygen into the water. Oil in any considerable amount also tends to coat the gills of fish, thus making the utilization of dissolved oxygen difficult or even impossible.

7. Hardness

Hardness is caused by divalent metallic cations. Such ions are capable of reacting with soap to form precipitates and with certain anions present in the water to form scale. The principle hardness-causing cations are Ca, Mg, Sr, Fe, and Mn. Hardness is usually expressed in terms of mg/l $CaCO_3$.

The hardness of water reflects the nature of the geological formations with which it has been in contact. Hardness stems from minerals which are carbonates of calcium and magnesium. Other hardness-producing metallic ions are included when they are present in significant amounts.

8. Total Suspended Solids

Light penetration, and therefore, photosynthesis are much diminished by suspended matters in rivers. Accordingly, light penetration can be reduced by about 50% in muddy water and by about 75% in a very turbid, shallow water (Hoak, 1959). Suspended solids containing much organic matter tend, especially in warm weather, to be degraded, which may result in a decrease in dissolved oxygen in the water body.

Suspended solids consist normally of erosion silt, organic detritus, bacteria, and plankton. Each component of this mixture may be augmented by man's activities, as quantities of powdered rock, cellulose pulp, sawdust, semi-solid sewage, and other debris are added to natural waters.

9. Dissolved Oxygen

The amount of oxygen dissolved in water from the atmosphere is dependent upon the temperature, the baromentric pressure, and the amount of dissolved ions in the water. Solubility of oxygen falls markedly with rises in temperature and increases with rises in pressure, and is less in water containing chloride than in fresh water; thus, the amount of oxygen dissolved by sea water (containing ~20,000 mg/l chloride) in equilibrium with air is only about 80 per cent of that taken up by fresh water.

Air contains only 20.9% O_2, the rest being mainly nitrogen (N_2). When air is dissolved in water, the amounts of O_2 and N_2 dissolved depend upon the partial pressure and solubility of each gas (O_2 is about twice as soluble in water as N_2). At 14°C, water saturated with air contains about 10 mg/l O_2 but the solubility of pure O_2 at that temperature is about 48 mg/l, or nearly five times as much. It is, therefore, not surprising that figures exceeding 100% saturation are sometimes obtained in river waters particularly when photosynthesis is proceeding, that is, when plant life (algae and macrophytes) produce O_2.

In a river where the organic pollution load is small and the dilution by well-oxygenated stream water is high, sufficient dissolved O_2 may be present to enable certain bacteria - aerobic bacteria which require free O_2 - to break down the organic matter completely to relatively harmless, stable and odorless end products. The river thus recovers naturally from the effects of pollution and is said to have undergone "self-purification".

Self-purification of a stream is dependent upon the presence of a sufficient quantity of dissolved oxygen. In extreme cases, when all the dissolved oxygen has become exhausted, self-purification will cease and septic conditions will prevail.

Determination of dissolved oxygen at various points in the river is necessary to assess the extent to which self-purification has proceeded.

10. Chemical Oxygen Demand (COD)

This parameter provides measurement of organic compounds in water in terms of the total quantity of oxygen required for oxidation of the organic material by a strong chemical oxidant. It is based upon the fact that all organic compounds, with a few exceptions, can be oxidized by the action of strong oxidizing agents under acid conditions. During the determination of COD, organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. As a result, COD values are greater than BOD values and may be much greater when significant amounts of biologically resistant organic matter are present.

11. Biochemical Oxygen Demand (BOD)

This test is widely used to determine the pollutional strength of domestic and industrial wastes in terms of the oxygen that they will require if discharged into natural water courses in which aerobic conditions exist.

This test is of prime importance in regulatory work and in studies designed to evaluate the purification capacity of receiving bodies of water.

The test is essentially a bioassay procedure involving the measurement of oxygen consumed by living organisms (mainly bacteria) while utilizing the organic matter present in a waste. In some cases, the test reflects oxygen use for oxidation of nitrogen compounds (nitrification).

12. Phosphorus

Phosphorus is believed to be a key element in determining the biological activity in a body of water. It is a critical nutrient for algae, whose growth into blooms is a major manifestation of the eutrophication process. It is an essential element for living organisms, and invariably occurs in natural waters in various organic forms as well as inorganic condensed and orthophosphates.

Inorganic phosphates are formed by the hydrolysis of organic phosphorus compounds. Bacterias are known, however, that can reduce phosphates to phosphite, hypophosphite, and eventually under anaerobic conditions to phosphine (PH_3).

Although the critical levels of organic phosphorus and inorganic phosphorus are not yet well established, it is noted that most of the lakes producing nuisance blooms have average concentrations in excess of 0.10 ppm for organic phosphorus and 0.01 ppm for inorganic phosphorus.

13. Ammonia Nitrogen

Natural unpolluted waters generally contain extremely small amounts of ammonia nitrogen which primarily come from aerobic decomposition of plants and animals in streams or adjacent areas, together with such organic matter that is brought about by surface runoff waters. The maximal amount of dissolved ammonia considered in unpolluted rivers or streams not suggestive of any specific organic pollution is 1.5 mg/l as N (Ellis, 1967).

14. Organic Nitrogen

The organic nitrogen of a water is determined to indicate the presence of metabolic processes of living organisms as well as decomposition of dead organisms in a body of water. Some 60-80% of this organic nitrogen is composed of amino compounds as free amino acids, polypeptides, proteins, and also albuminoid nitrogen -- all products of biologic processes.

15. Nitrate Nitrogen

Nitrate nitrogen usually occurs in fresh waters as a by-product of bacterial nitrification or as a result of runoff from fertilized land.

As described by McElory, et. al. (1956), the oxidation of ammonia by aerobic bacteria, a process usually referred to as nitrification, produces first nitrites and then nitrates and two distinct groups of bacteria are concerned with these reactions:

(1) Nitrosococcus and Nitrosomomas convert only ammonia to nitrite:

$$2NH_3 + 3O_2 = 2HNO_2 + 2H_2O$$

(2) Nitrobacter oxidizes nitrites to nitrates:

$$2HNO_2 + O_2 = 2HNO_3$$

This nitrification is expected to rise at higher temperatures of the summer months when bacterial activity is greater than in the cold months. Also, they are generally high in estuarine areas due to land runoffs, organic releases, etc.

C. THE HUDSON RIVER ESTUARY - HISTORICAL WATER QUALITY

The Hudson River has played a very important role in industrial and economic development of its neighboring region. Since the last decade, the growing public interest in water pollution control and ecology of the nation's water resources has forced government and, in turn, private industries to provide funds for pollution abatement. This concern has encouraged the cooperative efforts by the New York State University Institute of Environmental Medicine and the Departments of Geology and Biology to study the ecology of the Hudson River.

In the recent past, the New York State Health Department and the U.S. Public Health Service and, as has been described previously, Consolidated Edison, Central Hudson Gas & Electric, and Orange & Rockland Utilities have been the sponsors of many ecological studies.

The water quality of the Hudson River has been examined at various locations by agencies such as the New York State Health Department (NYSHD) and U.S. Public Health Service. These agencies have examined the waters of the Hudson River mainly for public health reasons with the primary emphasis being on total coliform and fecal coliform measurements along with dissolved oxygen (DO) and five-day biochemical oxygen demand (BOD_5).

Salinity, followed by dissolved oxygen, have been the most measured parameters in the Hudson River. The current and salinity data measured since 1919 have been summarized by Quirk, Lawler & Matusky (QL&M) (1971). The water quality work performed prior to 1960 by NYSHD and other agencies is summarized in Table VI-8.

The water quality surveillance network established since legislation in 1962 (New York State Health Department Article 12 Section 1210, item 4 of Public Health Law) is a program organized to acquire, develop, and disseminate water quality information collected by various agencies. The New York State Department of Environmental Conservation has published two reports of the water quality surveillance network for 1960 through 1964 and 1965 through 1967 water years. The report for 1968 through 1970 is in the process of publication.

Prior to the formation of the above agency, the U.S. Department of Health, Education and Welfare published five national water quality network annual reports for the period 1957 through 1962. United States Geological Survey (USGS) also gathers water quality data at some of its gaging stations for New York State and the results are reported in the Surface Resources Data, Part II, New York State.

Water quality studies performed on the Hudson River are summarized as follows:

(1) During the summer and fall of 1964, Hydroscience Inc. performed a study: "Pollution analysis of the Upper Hudson River, from Federal Lock at Troy to Saugerties." Temperature, dissolved

TABLE VI-8

SUMMARY OF WATER QUALITY DATA PRIOR TO 1960

Date	Sampling Location	Parameters
1929		
May - September	Choes plus Mechanicsville (MP 160 - 170)	Flow
August 29, - September 14	MP 0 - 80	Salinity
1929, 1936, 1957 and 1964	MP 0 - 80	Salinity
1949 - 1951	Bear Mountain Bridge to Troy Lock (MP 47 - 155)	Temperature, pH, CO_2 DO, BOD, Hardness, Chlorides, Alkalinity and MPN
1951	MP 25.3 - 53.5	Chlorides
1952		
June	MP 46.4 - 89.5	Color, Odor, Turbidity, Temperature, pH, CO_2, Suspended Matter, BOD, Hardness, Chlorides, Alkalinity, MPN and Saturation
1957		
February - April and July - December	Danskammer (MP 66)	Chlorides
1956 - 1965	Danskammer (MP 66)	Chlorides (Daily Averages)
1958 - 1963	Indian Point (MP 43)	Salinity
1959		
May and June	MP 153.8 - 297.4	Color, Odor, Turbidity, Suspended Matter, pH DO, CO_2, BOD, Hardness, Chlorides, Alkalinity, MPN
April - July	Green Island	Flow
August 5 - September 2	MP 0 - 60	Salinity
1960		
May	MP 153.8 - 297.4	Color, Odor, Turbidity, Suspended Solids, pH, DO, CO , BOD, Hardness, Chlorides, Alkalinity, MPN

during November 1966, March through June 1967, and April through December 1968. A considerable variation in the concentrations of these trace metals at different locations and with seasonal change is attributed to the changes in the fresh water flow and the degree of turbulence.

4. Kneip, et. al., (1970) have reported their studies on radionuclides and pesticides residue in the Hudson River for 1964 - 1967. They report that the concentration of artificial radionuclides is at least 250,000 times less than the levels permitted by the existing regulations and the concentration of radium and other naturally occuring nuclides was 250 times less than the permitted concentrations. Occasionally, in a localized area, they found the concentration of the trace metals exceeding the allowable limits permitted for drinking water. The concentration of pesticides in the water sample was negligible but the build-up of its concentration in fish through the biological food chain may render some fish unfit for commercial use.

5. Duram et. al. (1970) have published the concentrations of As, Cd, Co, Pb, Hg, and Zn found in the major water resources in the United States for October 1970.

6. During September 1969 to October 1970, Raytheon (1972) did a study of the ecology of the Hudson River at Indian Point and surveyed the dissolved oxygen, temperature, and salinity of this area. They

found a distinct drop in dissolved oxygen concentrations across the power plant. However, no marked increase or decrease in dissolved oxygen was observed in relation to river mile. Tidal-induced salinity fluctuations were very apparent, and tidal variations of about 1.0 to 1.5 parts per thousand (ppt) approximately every six hours were observed during October 13 through 14, 1969. Seasonal variations in salinity were also observed.

Dissolved oxygen ranged from 3.0 mg/l during the summer to over 11.0 mg/l during the winter. Seasonally, a distinct correlation was observed between dissolved oxygen and temperature.

7. The Interstate Sanitation Commission (ISC) (1971) performed an extensive survey of the lower Hudson River from Upper New York Bay to Bear Mountain Bridge from August 2 to August 12, 1971. The dissolved oxygen values observed - 2.3 to 5.7 mg/l - during this period from Upper Bay area to Hastings were lower than the requirements of the ISC. This report concluded that an improvement in DO and fecal coliform densities would be expected after the completion of new and upgraded treatment facilites and improved combined sewer system.

8. Feldman (1971) has investigated a microfaunal and microfloral population of Hudson River in the vicinity of Roseton between June 29 and August 10, 1971. To find the correlation between key organisms and chemical parameters, water samples were collected and analyzed for temperature, pH, color, turbidity, salinity,

alkalinity, DO, nitrite, nitrate, and phosphates. The productivity decreased for four sample sites in the following order: Howland, (Control Station), Roseton, Danskammer effluent, and Danskammer influent.

9. Rehwoldt (1971), during the summer of 1971, studied the effect of increasing water temperature on the toxicity of metal ions present in the Hudson River water to various indigenous species of fishes. The investigators chose the metal ions Cu, Zn, Ni, Cd, Mg, and Cr, and temperature values of 15°C and 28°C. The temperature of 28°C was chosen on the basis of the thermal plume at the Danskammer Point Generating Station. Tolerance Lethal Median (TLM) data at 28°C and 15°C were not significantly different for the ions studied

10. Quirk, Lawler & Matusky Engineers have conducted many ecological studies to investigate the effects of waste heat load discharged by power plants along the river. The reports of these investigations are reported as follows.

    (1) January 1968 — "Hudson River Water Quality and Assimilative Capacity Study", Status Report

    (2) December 1970 — "Hudson River Water Quality and Assimilative Capacity Study," Final Report.

(3) December 1969 "Effects of Bowline Cooling Water Discharge on Hudson River Temperature Distribution and Ecology"

(4) December 1969 "Effects of Roseton Plant Cooling Water Discharge on Hudson River Temperature Distribution and Ecology."

(5) March 1971 "Environmental Effects of Bowline Generating Station on Hudson River,"

(6) March 1971 "Environmental Effects on Hudson River Lovett Plant Unit No. 5 Submerged Discharge,"

11. Texas Instruments, Inc.

(1) July 1972 "Hudson River Ecological Study in the Area of Indian Point."

D. MATERIALS AND METHODS

1. Sampling Programs

(a) 1971

In May of 1971, a preliminary water quality study was initiated in the vicinity of the Roseton and Danskammer Generating Stations. The sampling sites are shown in Figure VI-1 and were designated as follows:

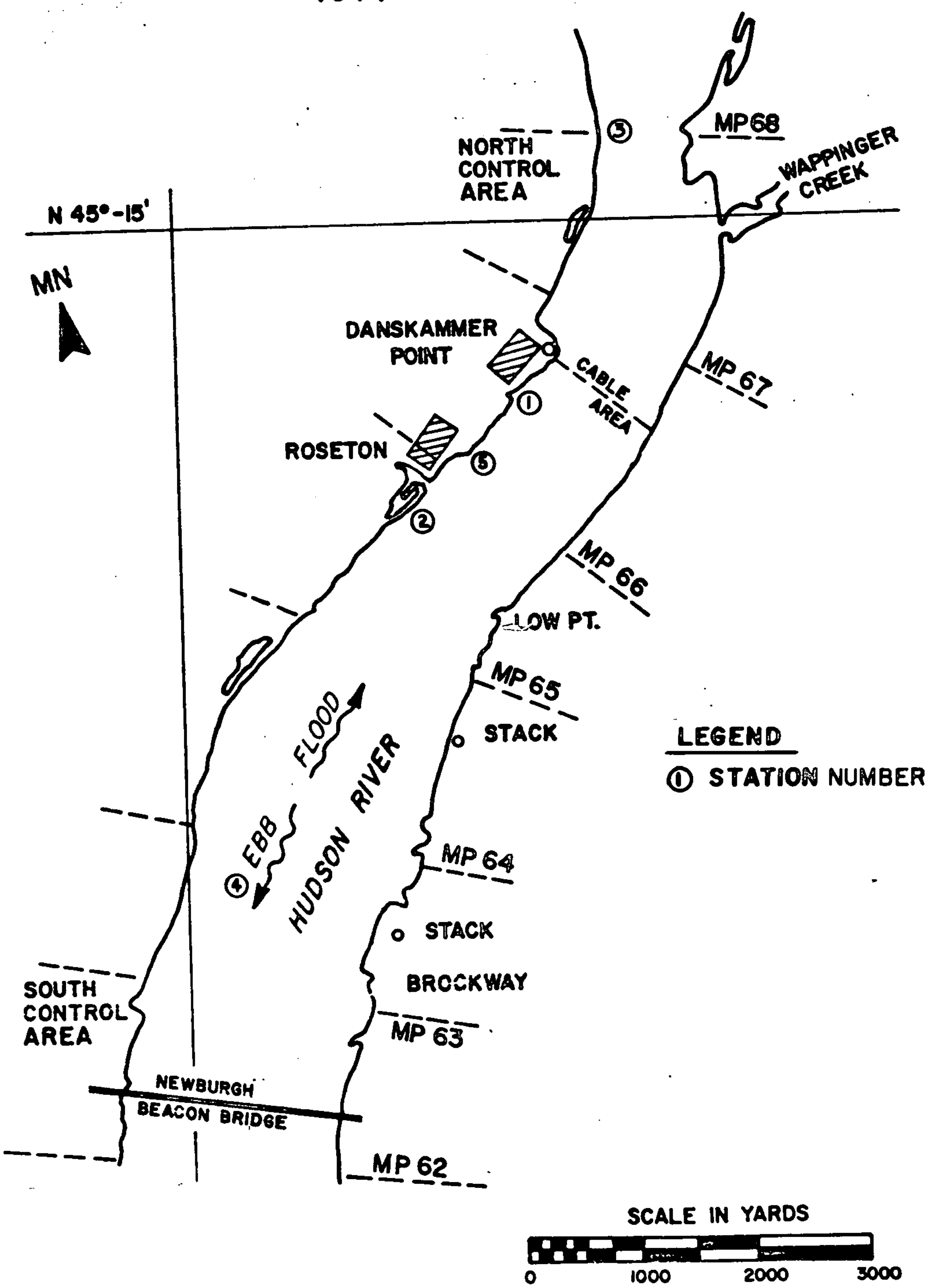
Station 1 - Danskammer discharge

Station 2 - Hess fuel storage

Station 3 - North control

FIGURE VI-1

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
WATER QUALITY SAMPLING STATIONS
1971



Two additional stations were added in December 1971, to include Station 4 - South Control and Station 5 - Roseton Intake. These stations were generally sampled at the surface and bottom.

As with the sampling stations, the number of parameters was increased during the study period. In the early months of the survey, samples were analyzed for temperature, pH, and dissolved oxygen (D.O.). As the survey continued, the number of parameters analyzed was expanded to include those presented in Section E, Results and Discussion.

(b) 1972

A more intensive water quality program was initiated in 1972. Sampling commenced in May 1972, and continued through December 1972. Surface, mid-depth, and bottom grab samples were collected monthly from the locations as shown in Figure VI-2. The sampling stations were:

RMC - Roseton mid-channel

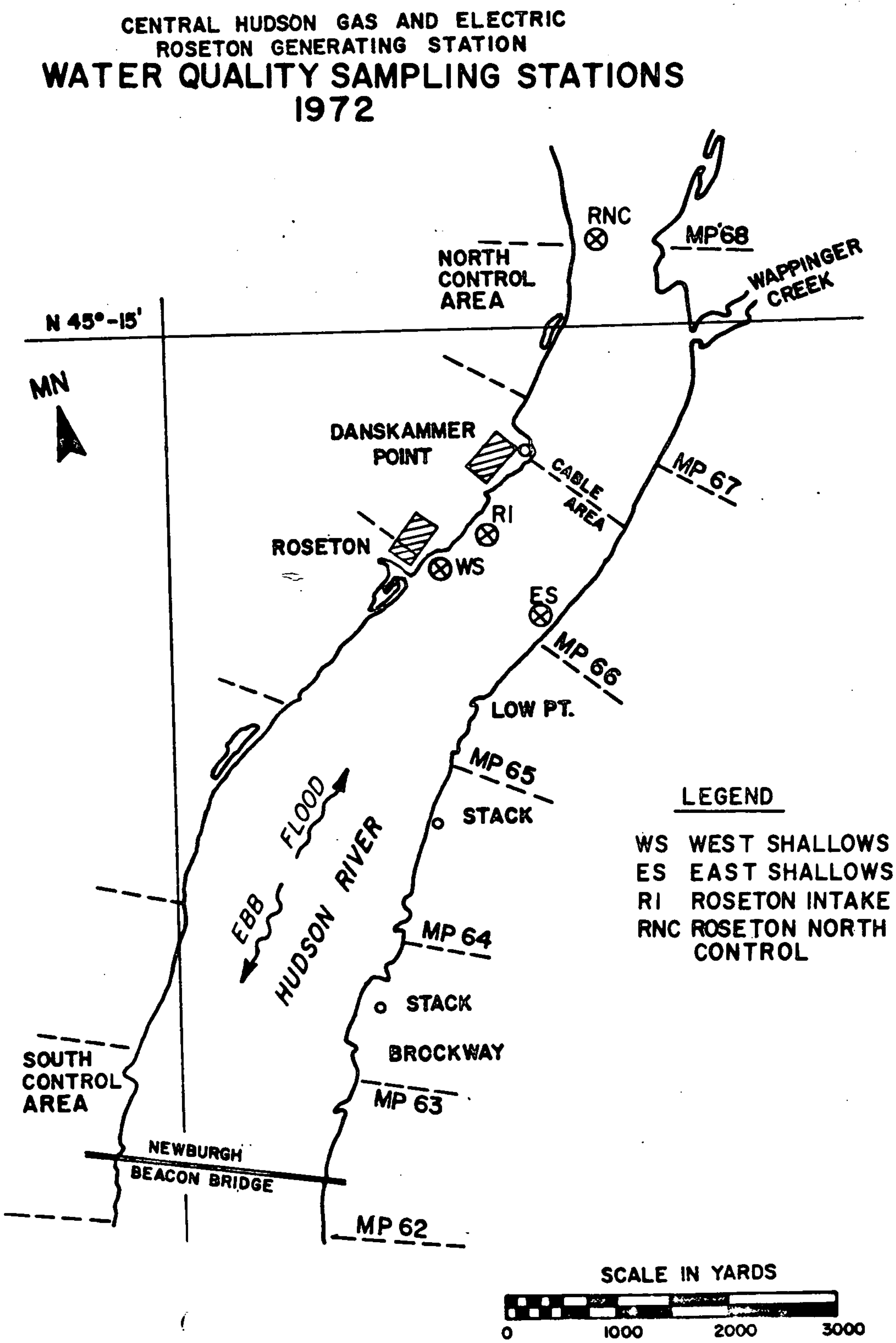
RNC - Roseton North control

RIF - Roseton intake face

RES - Roseton East shallows

RWS - Roseton West shallows

In May and July 1972, water samples were collected hourly over a twelve hour period at the RMC station at mid-depth and surface,


CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
WATER QUALITY SAMPLING STATIONS
1972
RNC
MP 68
NORTH CONTROL AREA
WAPPINGER CREEK
N 45°-15'
MN
DANSKAMMER POINT
CABLE AREA
MP 67
RI
ROSETON
WS
ES
MP 66
LOW PT.
MP 65
STACK
FLOOD
EBB
HUDSON RIVER
MP 64
STACK
BROCKWAY
SOUTH CONTROL AREA
MP 63
NEWBURGH BEACON BRIDGE
MP 62
LEGEND
WS WEST SHALLOWS
ES EAST SHALLOWS
RI ROSETON INTAKE
RNC ROSETON NORTH CONTROL
SCALE IN YARDS
0
1000
2000
3000

respectively. These surveys were conducted to determine the variations of water quality parameters over a tidal cycle.

2. <u>Field Sampling Procedures</u>

Water samples were collected with a Kemmerer water sampler. The samples were placed in plastic bottles, stored in ice chests for transportation to the laboratory for chemical analysis.

Temperature measurements were made using a Montedore-Whitney Thermistor Model TF-20.

Samples for dissolved oxygen were prepared in the field, to be analyzed in the laboratory. In some cases, dissolved oxygen was measured in the field with a YSI Model 51A oxygen meter.

3. <u>Laboratory Procedures</u>

Water quality samples were treated and analyzed based upon procedures derived from <u>Standard Methods for the Examination of Water and Wastewater</u>, 13th Edition 1971. These methods are summarized in Appendix F.

E. RESULTS AND DISCUSSION

1. Introduction

Two opposing current systems exist in an estuary. The unidirectional current system of river water flowing seaward and the oscillating tidal currents of the ocean meet and exert considerable and complicated effects upon sedimentation, water mixing, and other physical and chemical features. The velocity and magnitude of tidal currents depend upon the morphology of stream channel and estuary basin.

Before examining water quality data for any particular area of an estuary, one has to determine the background concentrations for that area. In an estuary, beyond the salt water intrusion, the observed values of the water quality parameters will be that of the natural waters plus the man-made inputs along the length of the river and will depend upon the morphology of the channel bed, atmospheric inputs, overland runoff, and the extent of resuspension of the bottom material - such as silt and detritus. In the areas of salt water intrusion, higher variations in water quality parameters would be expected due to the salt water mixing. The extent of variations in these parameters at a particular location will depend upon the degree of salt water intrusion and the degree of mixing at that location.

An additional factor to be considered is that the mouth of the Hudson River is surrounded by a highly urbanized area. This fact does not make the Hudson River Estuary unique, but it is an important consideration when examining water quality data for an area influenced by salt water intrusion. As ocean water moves upstream, material, discharged at points within the salt water intrusion, is transported upstream also. These man-made inputs to the Hudson River cause variations in water quality parameters beyond what would be expected from salt water intrusion alone.

In the vicinity of the Roseton and Danskammer Point Generating Stations, water quality parameters will vary with time and space due to natural inputs. Increases in the variability of these parameters is caused by man-made inputs such as the municipal and industrial discharges upstream of the Roseton - Danskammer area. During periods of low fresh water flow, salt water intrusion with its associated man-made inputs from downstream will increase the variability of water quality parameters.

2. Flow Characteristics, 1971 - 1972

From flow measurements for the Hudson River at Green Island, 1971 and 1972 have been high water years with mean annual flows exceeding 14,800 cfs and minimum mean monthly flows exceeding 6,200 cfs. The extreme flow conditions for the last 10 years, 1963 through 1972, have been summarized in Table VI-9. Figure VI-3 represents the mean daily and mean monthly flow for 1972 and the mean monthly flow for the last 25 years (1948 through 1972). Figure VI-4 shows the mean monthly flow for 1971 and 1972.

The calendar year 1971 had the highest mean annual flow for the years 1963 through 1971. As shown in Figures VI-3 and VI-4, the mean monthly

TABLE VI-9

EXTREME FLOW CONDITIONS OF THE HUDSON RIVER

AT GREEN ISLAND, 1963-1968

Year	Minimum Daily Flow cfs	Maximum Daily Flow cfs	Minimum Mean Monthly Flow cfs	Maximum Mean Monthly Flow cfs	Mean Annual Flow cfs
1972	3,740	94,500	6,309	40,520	18,670
1971	2,160	59,700	6,233	37,270	14,830
1970	2,030	83,200	3,923	39,350	11,930
1969	1,990	77,900	4,133	40,730	13,310
1968	882	80,000	4,440	24,860	12,470
1967	2,460	54,100	4,934	30,940	11,150
1966	1,640	45,400	3,674	23,090	10,060
1965	1,590	35,200	2,912	19,280	7,750
1964	1,010	96,000	2,875	26,948	8,714
1963	1,660	79,700	3,630	31,350	9,399

CENTRAL HUDSON GAS AND ELECTRIC

HUDSON RIVER FRESH WATER FLOW AT GREEN ISLAND - 1972

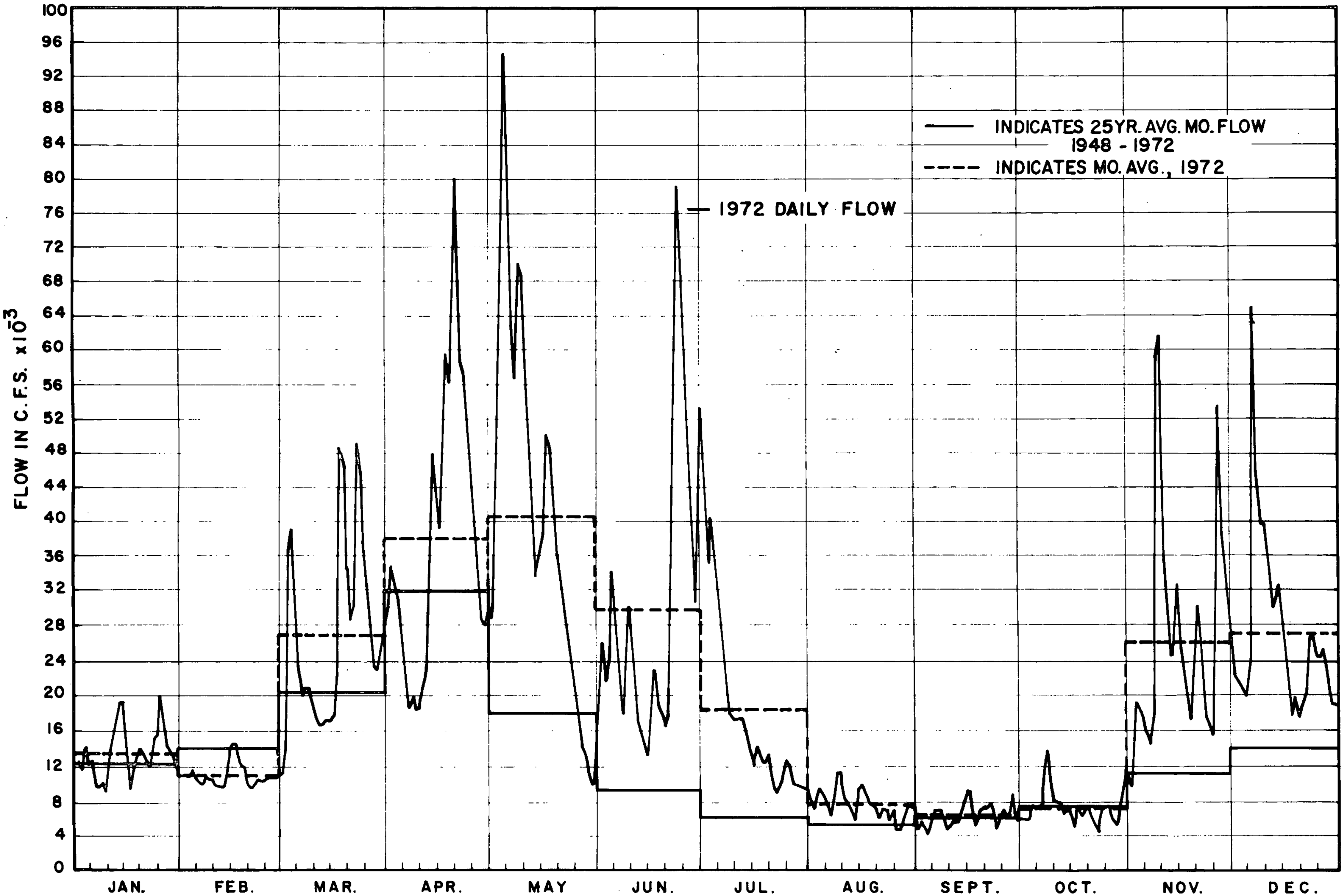


FIGURE VI-3

CENTRAL HUDSON GAS AND ELECTRIC

MEAN MONTHLY HUDSON RIVER FLOW AT GREEN ISLAND 1971 - 1972

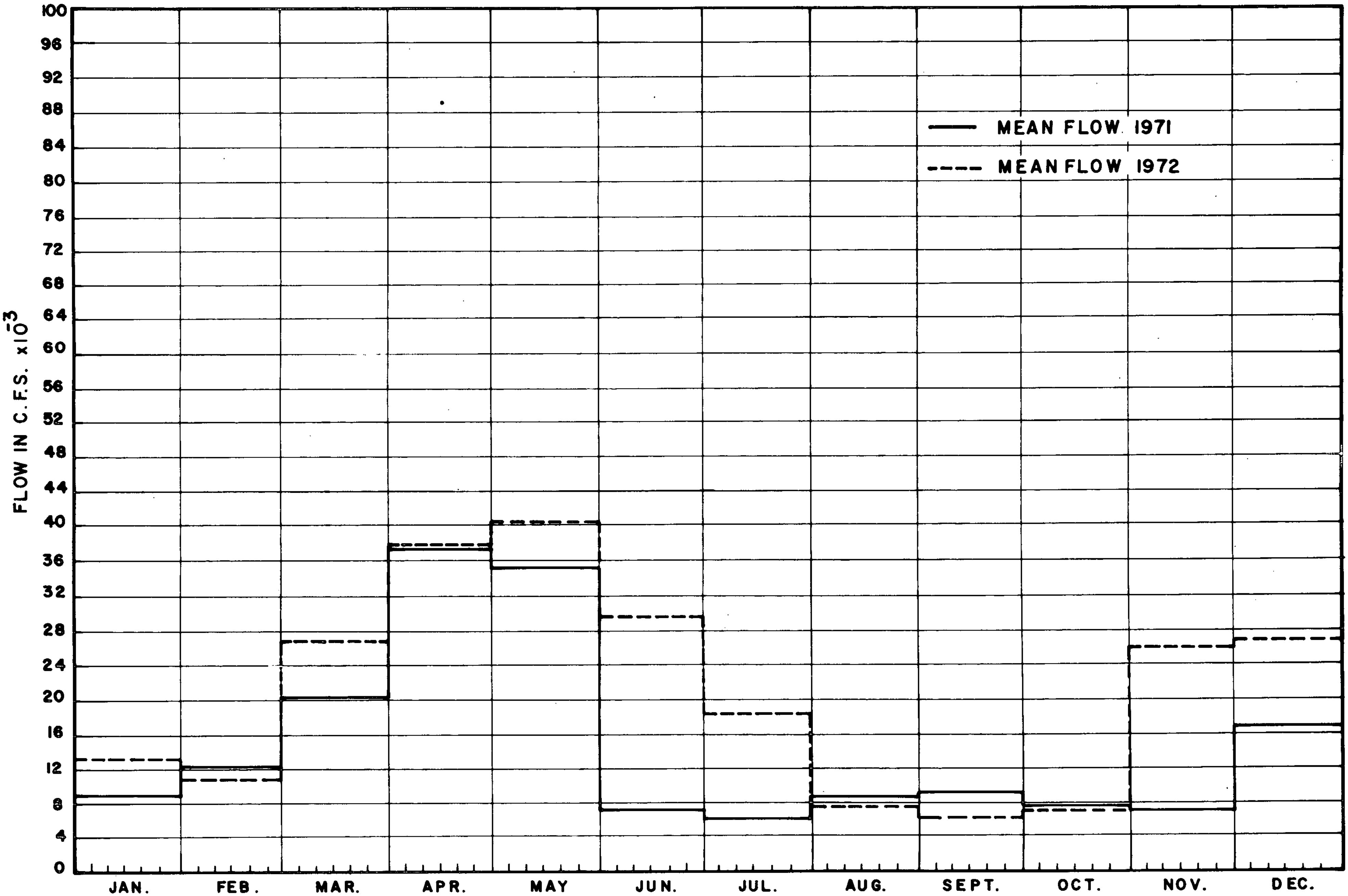


FIGURE VI - 4

flows in 1971 were equal to or greater than the mean monthly flows for the years 1948 through 1972.

All data indicate that the calendar year 1972 represented a high fresh water flow year. For the ten year period 1963 through 1972, the mean annual flow in 1972 represented a 26% increase over the next highest value which was observed in 1971. As can be seen in Figure VI-3, the mean monthly flows in 1972 exceeded the twenty-five year average with the exception of February and October. It should be noted that, for 1971 and 1972, during the low flow months of August, September and October, the mean monthly flow for those months approached the twenty-five year averages.

The magnitude of fresh water flow tidal currents are important considerations for any water quality survey of the Hudson River. The extent of salt water intrusion is dependent upon these water movements.

During periods of high runoff, the salt front (defined here as chloride ion concentrations of approximately 100 mg/l) is pushed as far south as the George Washington Bridge (approximately 13 miles north of the Battery) while during extreme low flow, such as the drought of 1964 and 1965, the salt front has been reported by Buckley (1971) as far north as Kingston (approximately 105 miles from the Battery).

From previous surveys (QLM, 1971), means of predicting the extent of salt water intrusion based on steady state conditions have been developed. Figure VI-5 presents the lower Hudson River fresh water flow versus mean

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

HUDSON RIVER GENERALIZED MEAN SALINITY PROFILES
STEADY STATE CONDITIONS

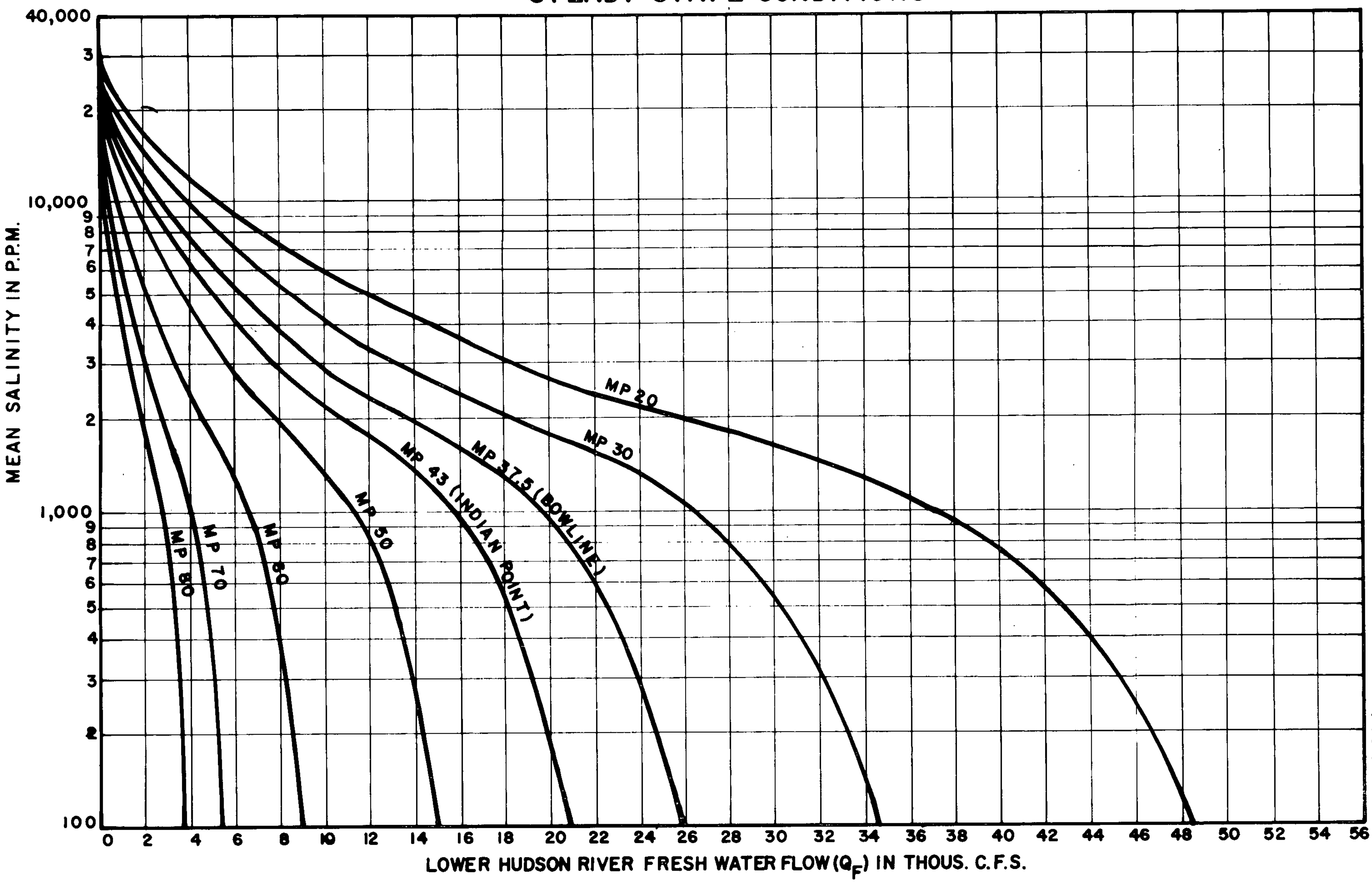


FIGURE XI-5

salinity for various locations along the river. For a steady state summer low flow condition, of approximately 6,000 to 8,000 cfs, the salt front would be predicted to be between Mile Point 60 and Mile Point 70 (Newburgh Bay and Wappingers Falls) which is in the vicinity of the Roseton and Danskammer Generating Stations.

3. Current and Chloride Study

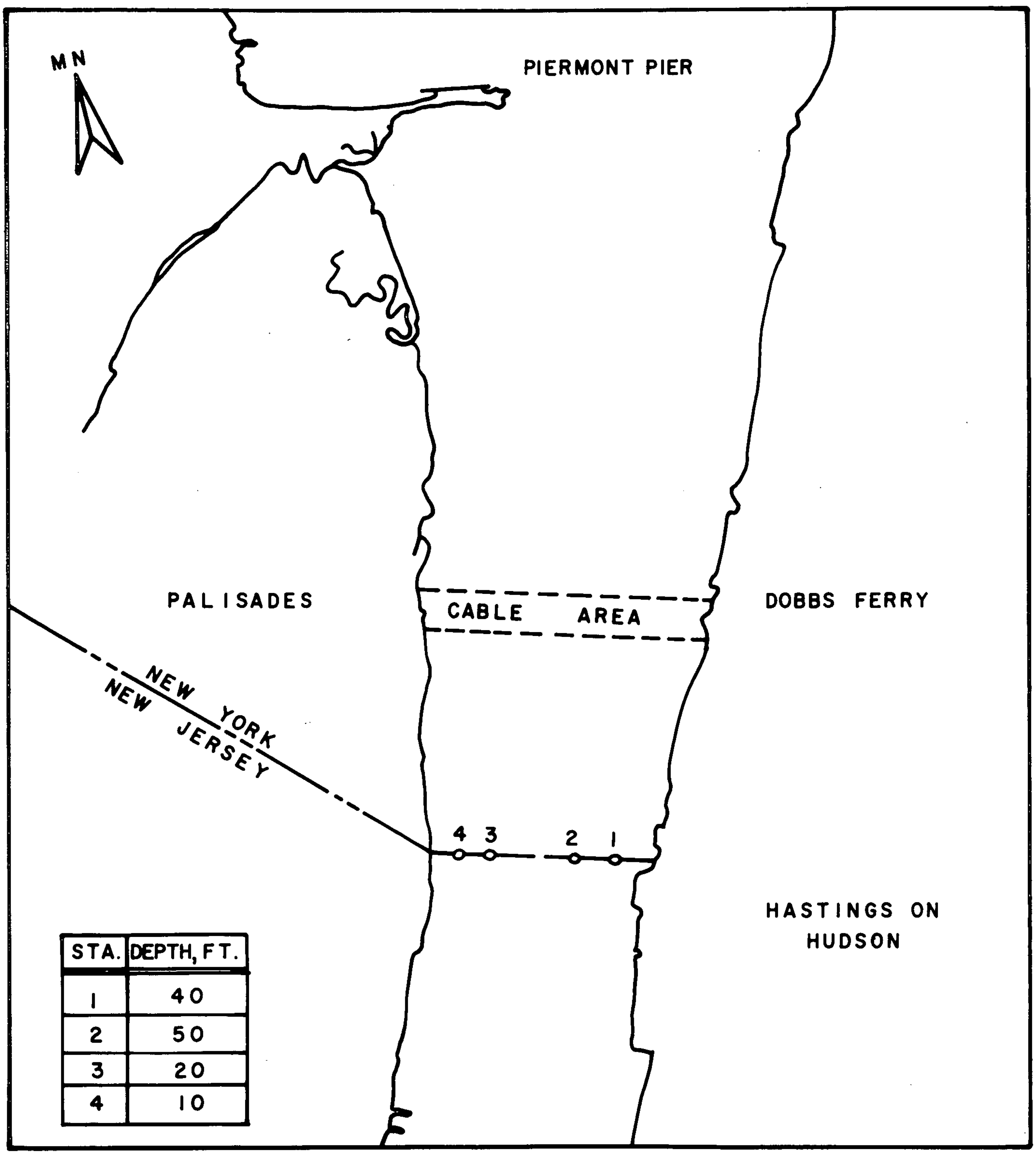
A study was performed in the vicinity of Hastings-on-Hudson (Mile Point 22), December 2, 1972, to measure the chloride stratification and current variation during a tidal cycle. The sampling locations are shown in Figure VI-6.

This survey was conducted in order to monitor variations of physical and chemical parameters (specifically current and chloride values) in the immediate vicinity of the salt front over a portion of the tidal cycle. The survey was conducted in the Tappan Zee as this was the location of the salt front at the time of the decision to perform the study. The information obtained is applicable to the present study, as similar variations would occur when the salt front is in the Roseton/ Danskammer area. As discussed in the previous section, the salt water intrusion extends to the area of the present study, and in extreme low water years, will extend even further upstream.

Figures VI-7 through VI-10 represent the current velocity and chloride data with depth at the four sampling locations. The current data show the difference in the duration of ebb tide for upper and bottom layer

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

SAMPLING LOCATIONS
CURRENT & CHLORIDE MEASUREMENTS
DEC. 2, 1972

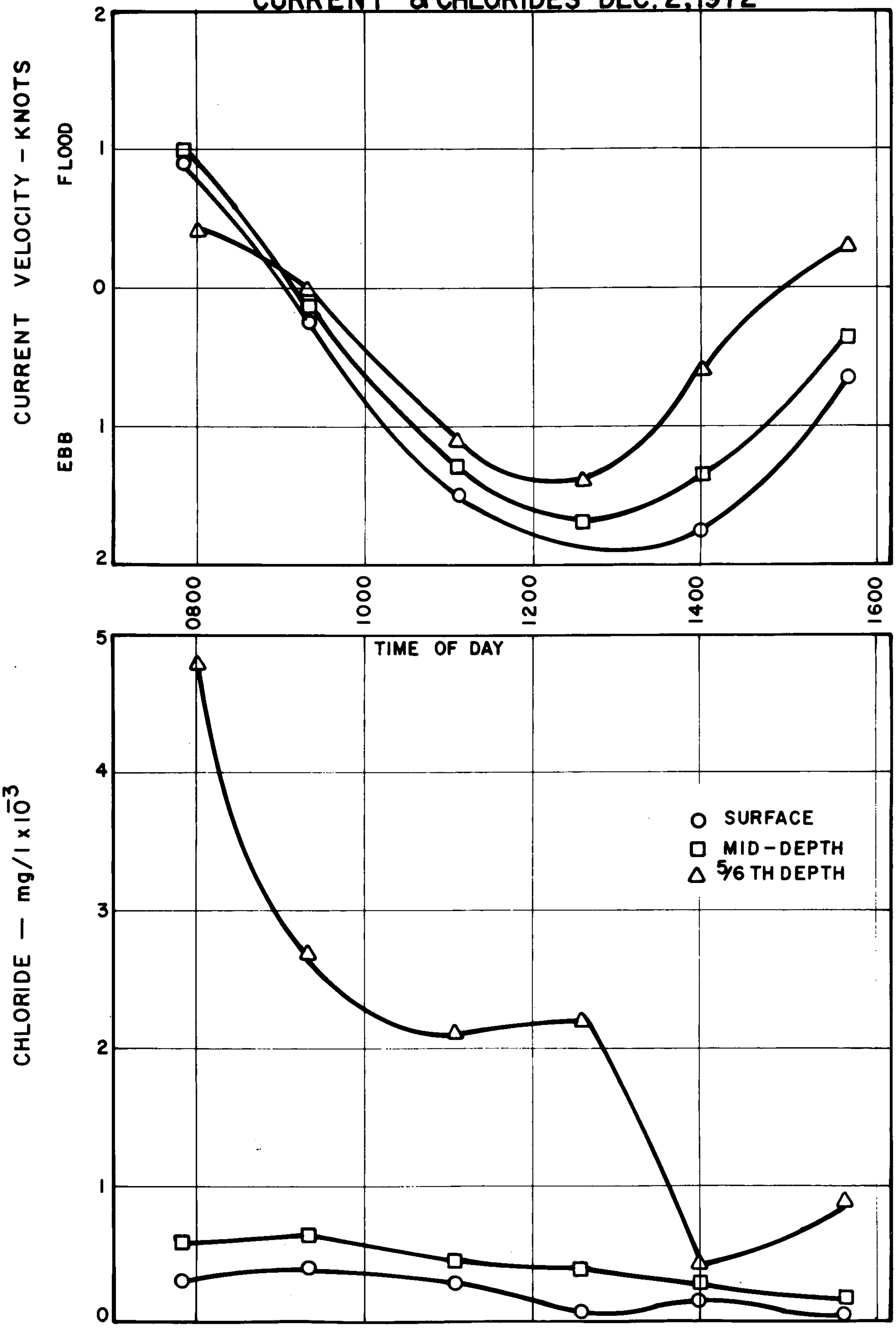


STA.	DEPTH, FT.
1	40
2	50
3	20
4	10

CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

FIGURE VI-7

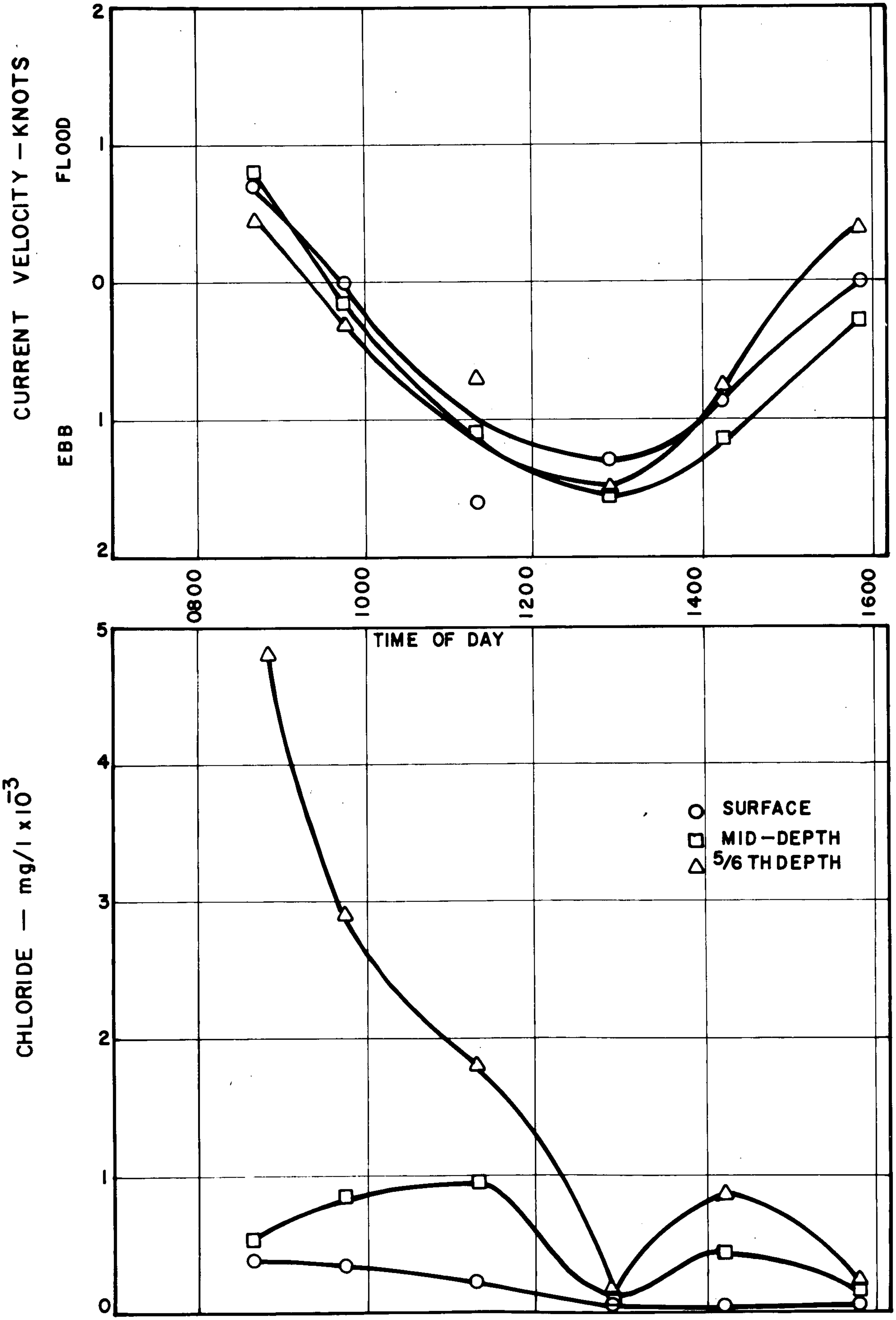
HUDSON RIVER CROSS SECTION AT NEW YORK-NEW JERSEY BORDER STA. NO. 1 CURRENT & CHLORIDES DEC. 2, 1972



CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

FIGURE VI-8

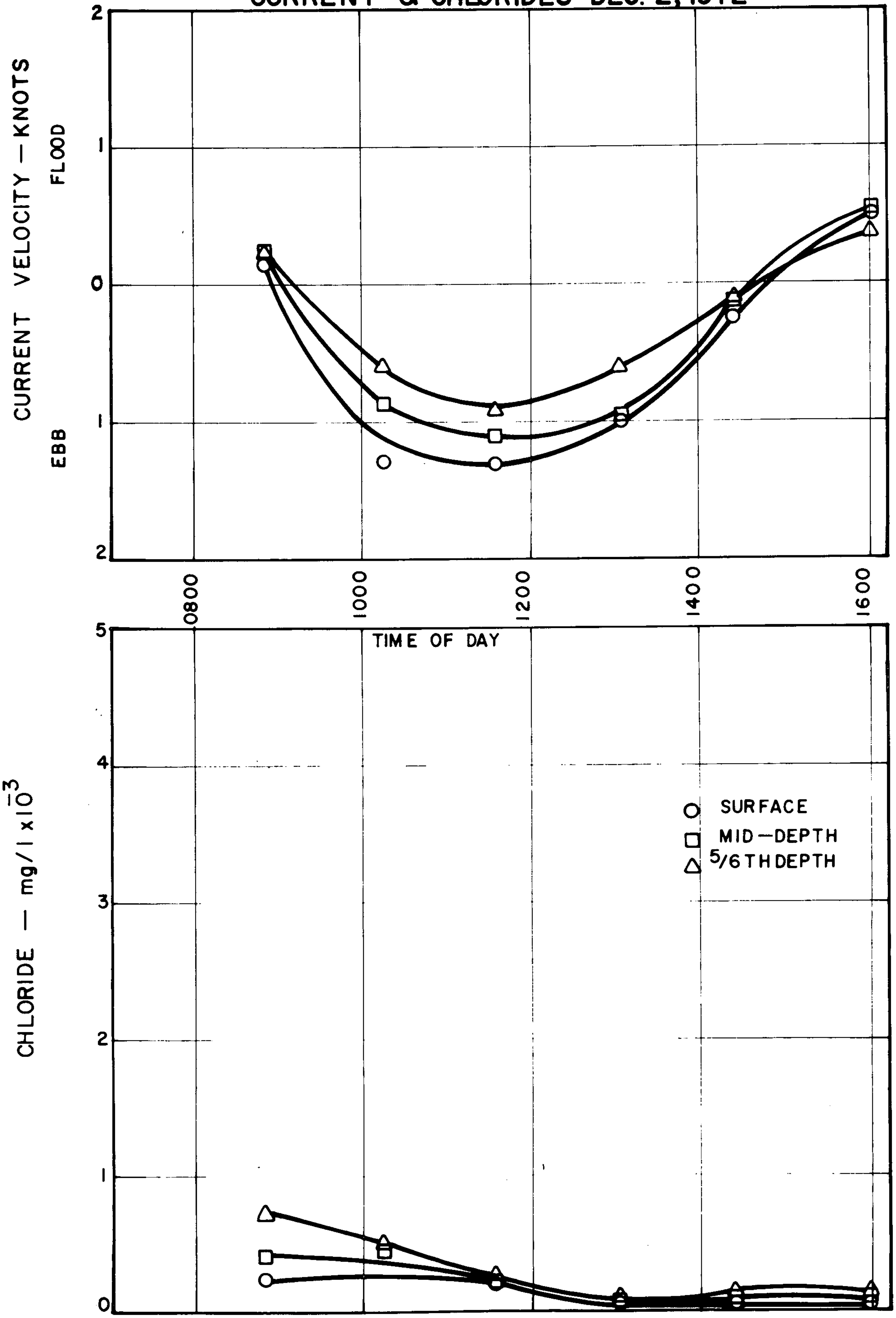
HUDSON RIVER CROSS SECTION AT NEW YORK-NEW JERSEY BORDER STA. NO.2 CURRENT & CHLORIDES DEC. 2, 1972



CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

FIGURE VI-9

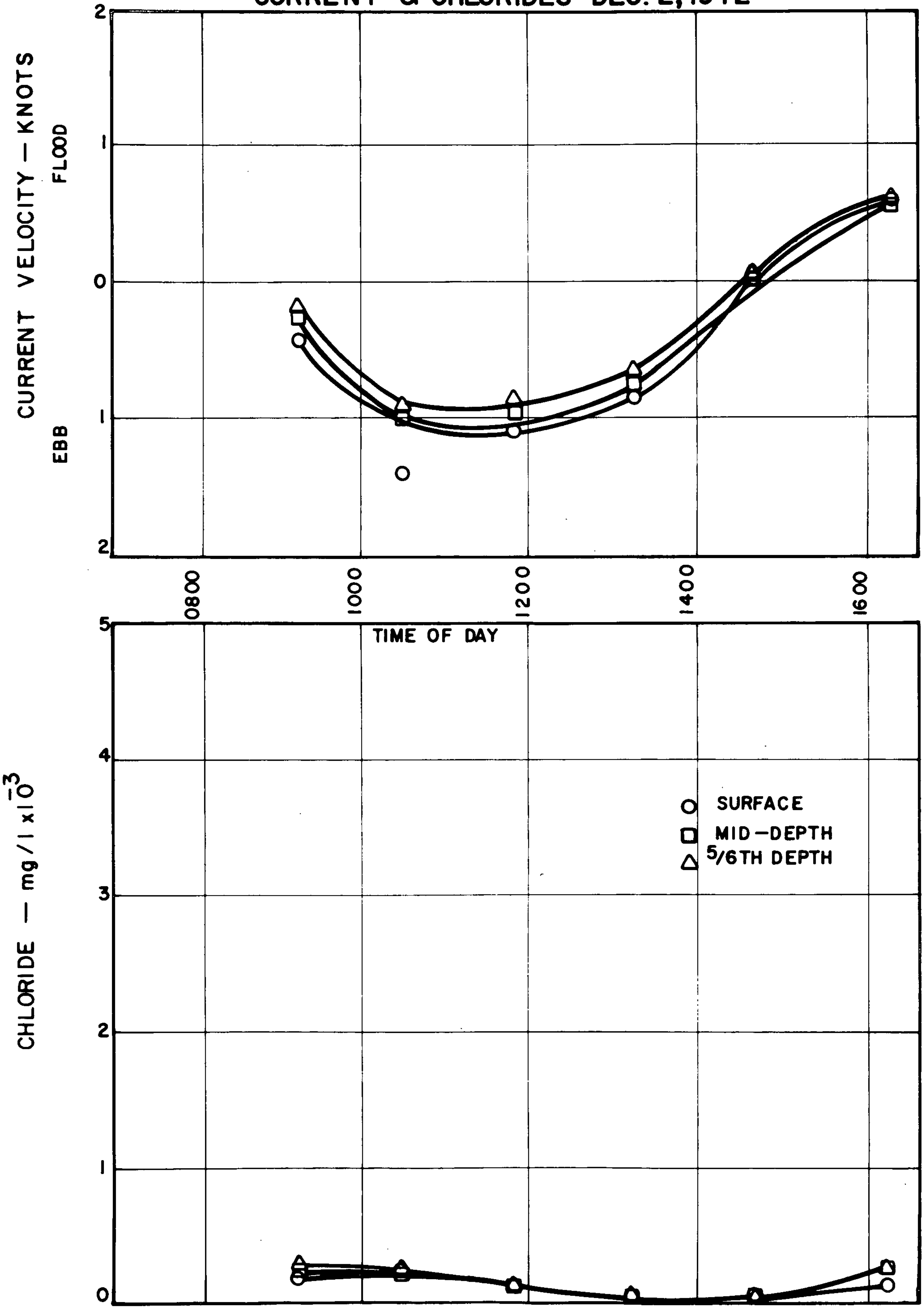
HUDSON RIVER CROSS SECTION AT NEW YORK-NEW JERSEY BORDER STA. NO. 3 CURRENT & CHLORIDES DEC. 2, 1972



CENTRAL HUDSON GAS AND ELECTRIC
AT ROSETON

FIGURE VI-10

HUDSON RIVER CROSS SECTION AT NEW YORK-NEW JERSEY BORDER STA. NO. 4 CURRENT & CHLORIDES DEC. 2, 1972



for stations 1, 3 and 4. The degree of stratification varies with the depth at particular location and in an east-west direction across the river. The drop in bottom chloride values with time at sample site 1 and 2 might be due to the sampling error. Due to high velocity, the sampling device was deflected and the sample collected was not actually at 5/6 depth but closer to the mid-depth.

The current velocity data show the difference in the velocity distribution across the river. The velocity distribution at any particular location is dependent on the depth of the water column and its distance from the shoreline. Stations 3 and 4 were in shallow water compared to stations 1 and 2. The current velocities recorded at stations 1 and 2 were slightly higher than those recorded at stations 3 and 4. Due to the variations in current velocities at different sites across the river, the effects of maximum ebb at different sites were observed in different times. The chloride data at different sites across the river support the above mentioned differential velocity distribution across the river. The chloride values measured at sites 3 and 4 were considerably lower, ranging from 20 to 50 mg/l. These different values of chloride across the river and with the depth indicate the channelization of fresh water flow in the upper layer and along the west bank of the river. During ebb tide the observed chloride values of around 100 mg/l indicate that the salt wedge was oscillating near the site of this study. The estimated mean daily flow for Green Island, based on five days previous to December 2, exceeded 35,900 cfs. Because of this high flow, the salt front was observed near Hastings-on-Hudson (MP 22). As mentioned earlier, the high variations in the parameter values could be expected in the area of the salt wedge, and during this study, the high variation in chloride values, ranging from 18 to 4,800 mg/l, i.e., 250-fold increase, supports that. The high value of 4,800 mg/l of chloride indicates approximately 25% seawater mixing with fresh water, assuming the chloride concentration of sea water at 19,400 mg/l.

The results from this survey point out the wide variations in chloride concentrations in the vicinity of the salt front. Previous discussions have shown that wide variations in chloride concentrations are representative of similar variations in other water quality parameters. The major effect on power plants would be the variability of intake water quality. These variations have the potential for causing misinformation. As an example, if a power plant cooling water discharge water quality were to be monitored by daily grab samples and the salt front was in the area, significant changes in water quality of the discharge would be observed. This result might lead the investigator to conclude that materials were being discharged by the facility, when in fact the discharge was representative of the intake water.

Errors like those described above can be eliminated by the proper selection of the sampling program. If sampling of the intake occurs some time period prior to sampling of the discharge, where the time period is the time of travel of the water through the plant, a closer representation of actual water quality will be observed. It is important to recognize that in any sampling and measurement testing, variations will occur. This fact makes it important to obtain a sufficient number of samples and analyze the results statistically before drawing conclusions.

4. Water Quality Surveys

(a) Tidal Cycle Variations

The purpose of these studies was to determine the variation of water quality parameters over a tidal cycle in the area of the Roseton-Danskammer Point Generating Stations. The tidal cycle surveys were conducted in May and July, 1972. The results of these surveys are presented in Figures VI-11 through VI-16. The tidal velocites for the sampling dates were computed from the predicted values based on the Tidal Current Tables 1972, and are presented in Figures VI-12 and VI-16.

The water quality parameters measured May 24, 1973 indicate that the salt water intrusion did not extend into the area. The fresh water flow was approximately 30,000 cfs during the survey. The calcium, sulfate and chloride concentrations are good indicators of the lack of salt water intrusion.

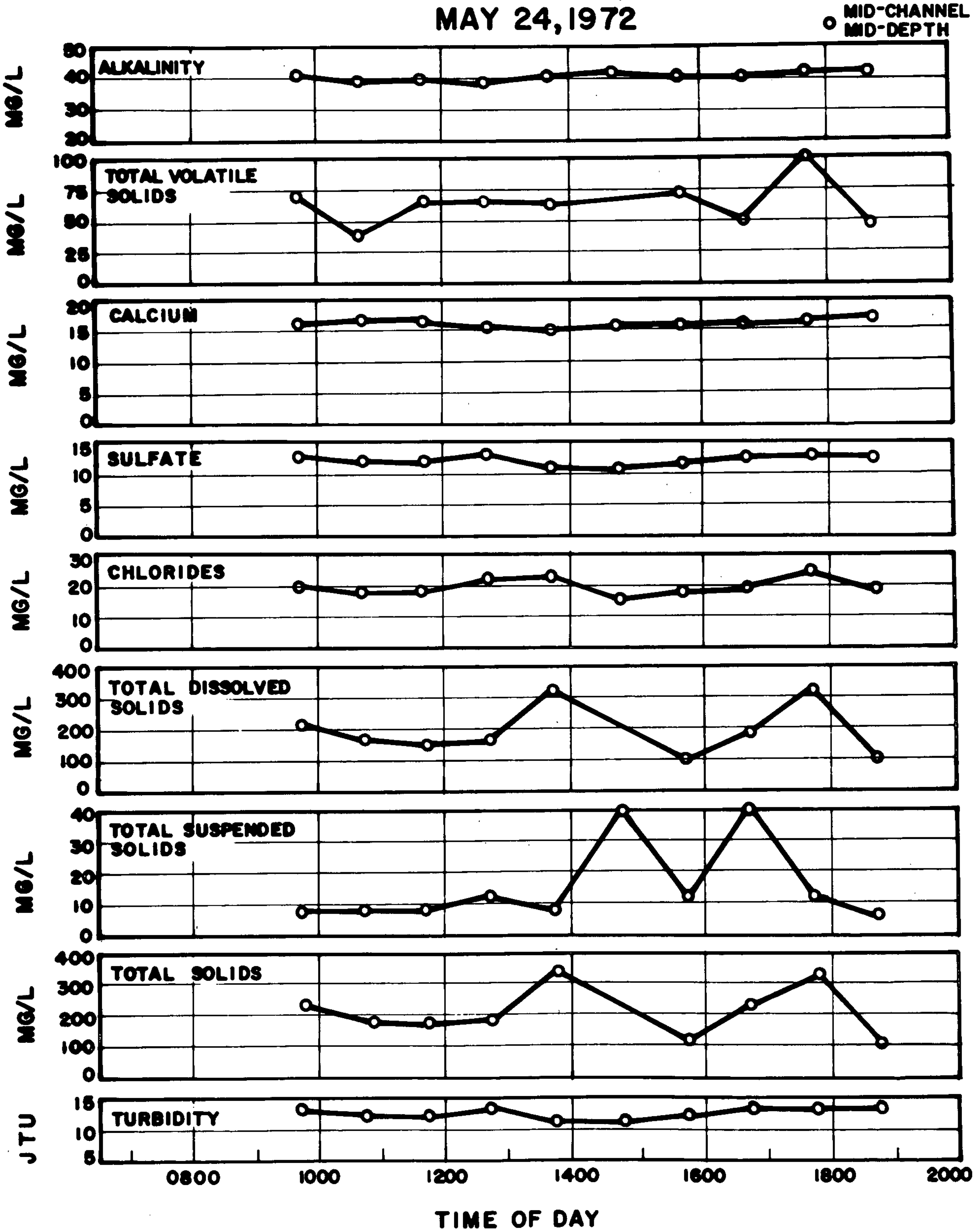
These values were essentially constant. The chloride concentration of approximately 20 mg/l represented fresh water values. Figure IV-12 is presented to compare the tidal velocities with chloride concentrations. As can be seen, it is difficult to discern the effect of tidal fluctuations on chemical parameters when salt water intrusion is not present.

On July 9, 1972, a second tidal cycle survey was conducted. The fresh water flow was approximately 25,000 cfs. The high

FIGURE VI-11

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION

SUMMARY OF WATER QUALITY DATA
HUDSON RIVER (MP-65)
MAY 24, 1972



CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
SUMMARY OF TIDAL CYCLE STUDY
HUDSON RIVER (MP-65)
MAY 24, 1972

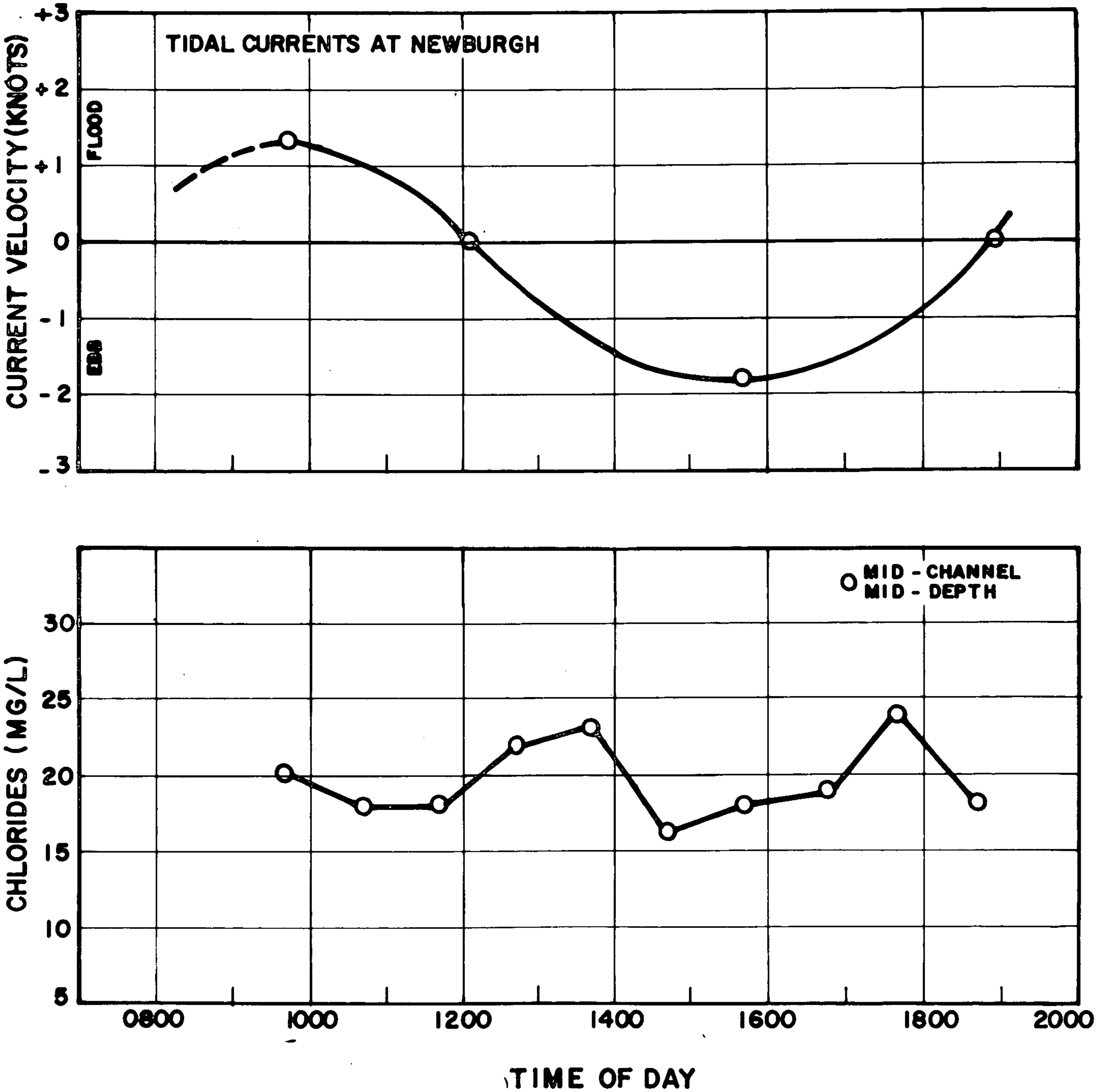
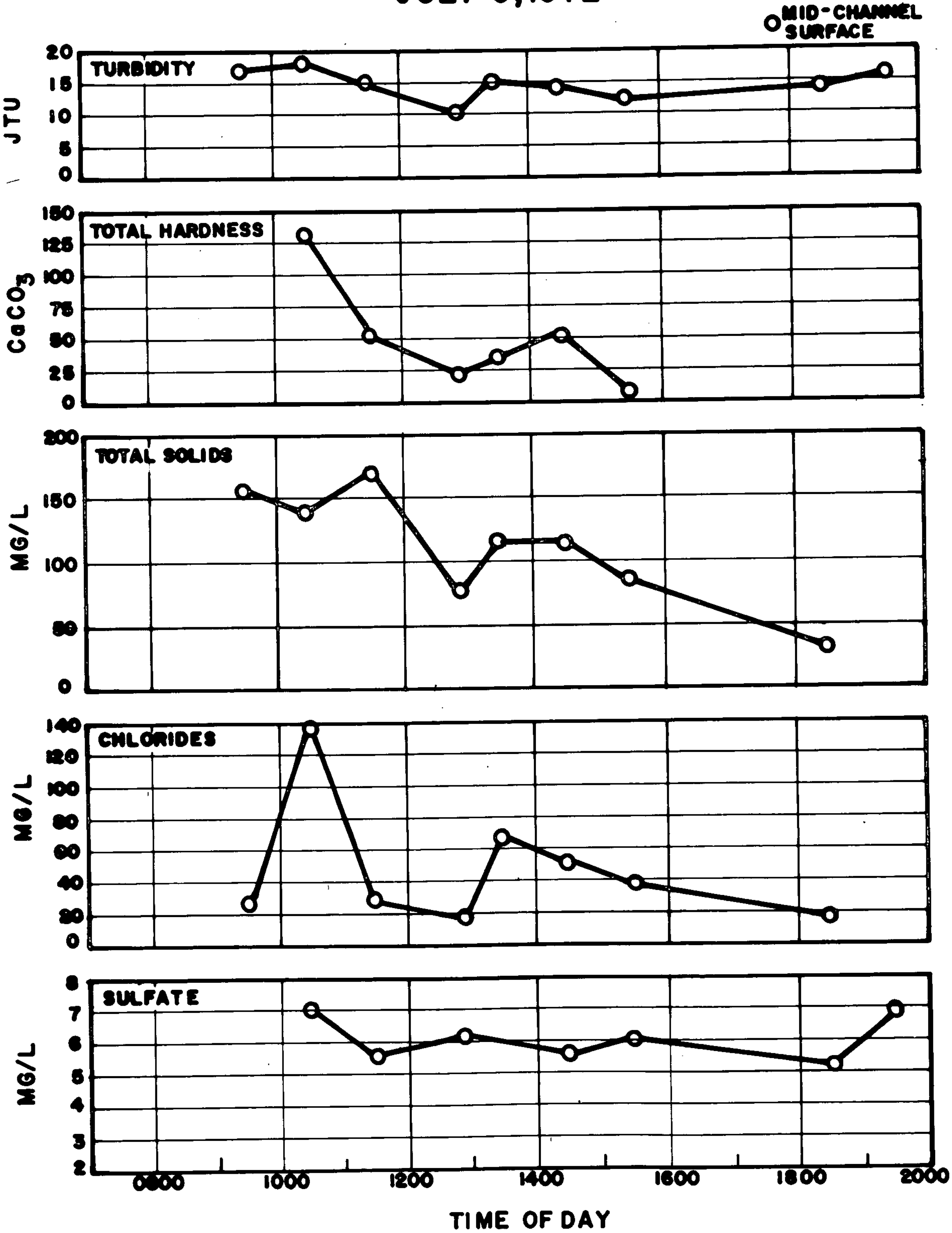
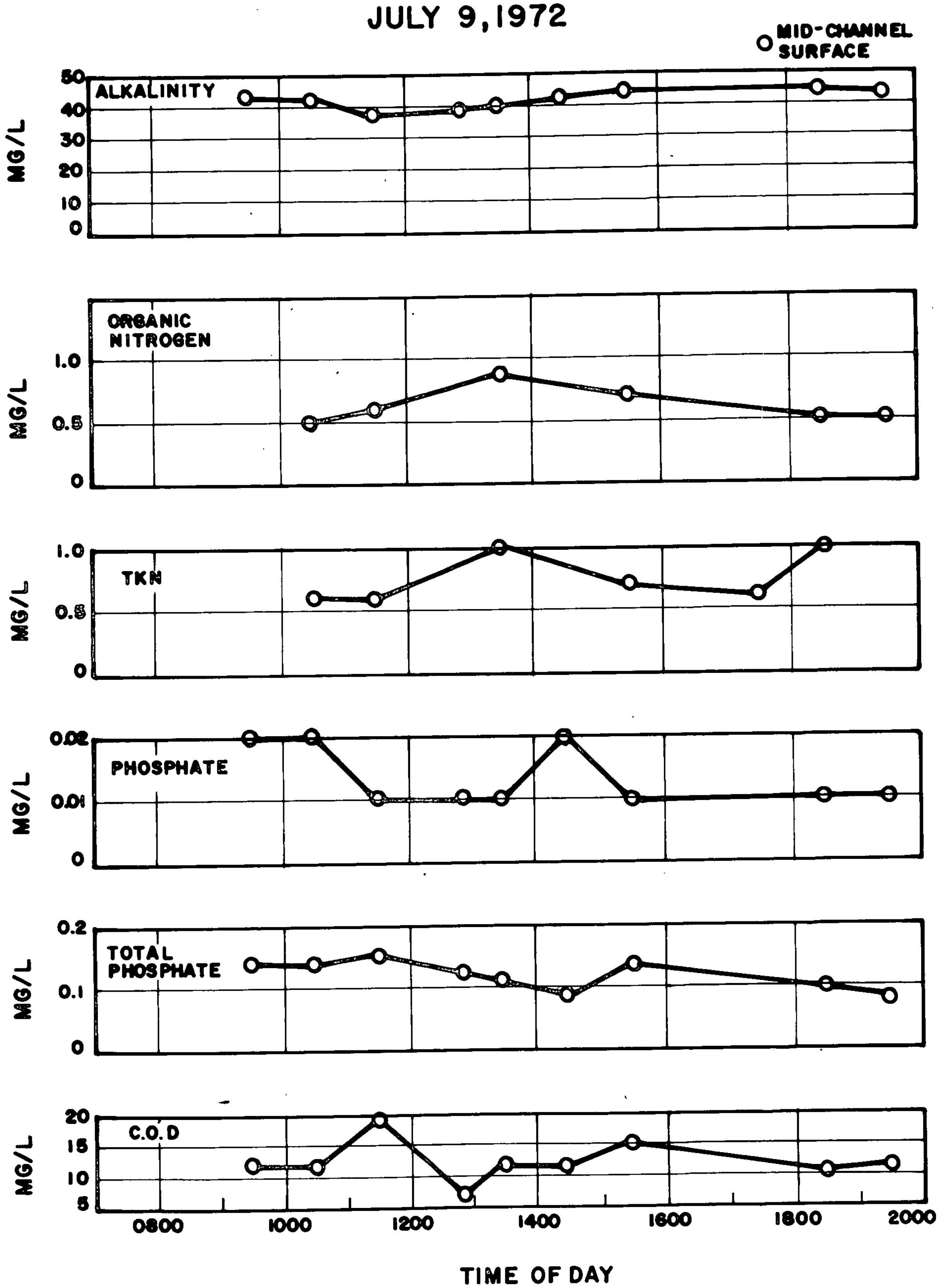


FIGURE VI-13

CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
SUMMARY OF WATER QUALITY DATA
HUDSON RIVER (MP-65)
JULY 9, 1972



CENTRAL HUDSON GAS AND ELECTRIC
ROSETON GENERATING STATION
SUMMARY OF WATER QUALITY DATA
HUDSON RIVER (MP - 65)
JULY 9, 1972



CENTRAL HUDSON GAS & ELECTRIC FIGURE VI-15

HUDSON RIVER AT ROSETON (MP. 65)
SUMMARY OF WATER QUALITY DATA, JULY 9, 1972

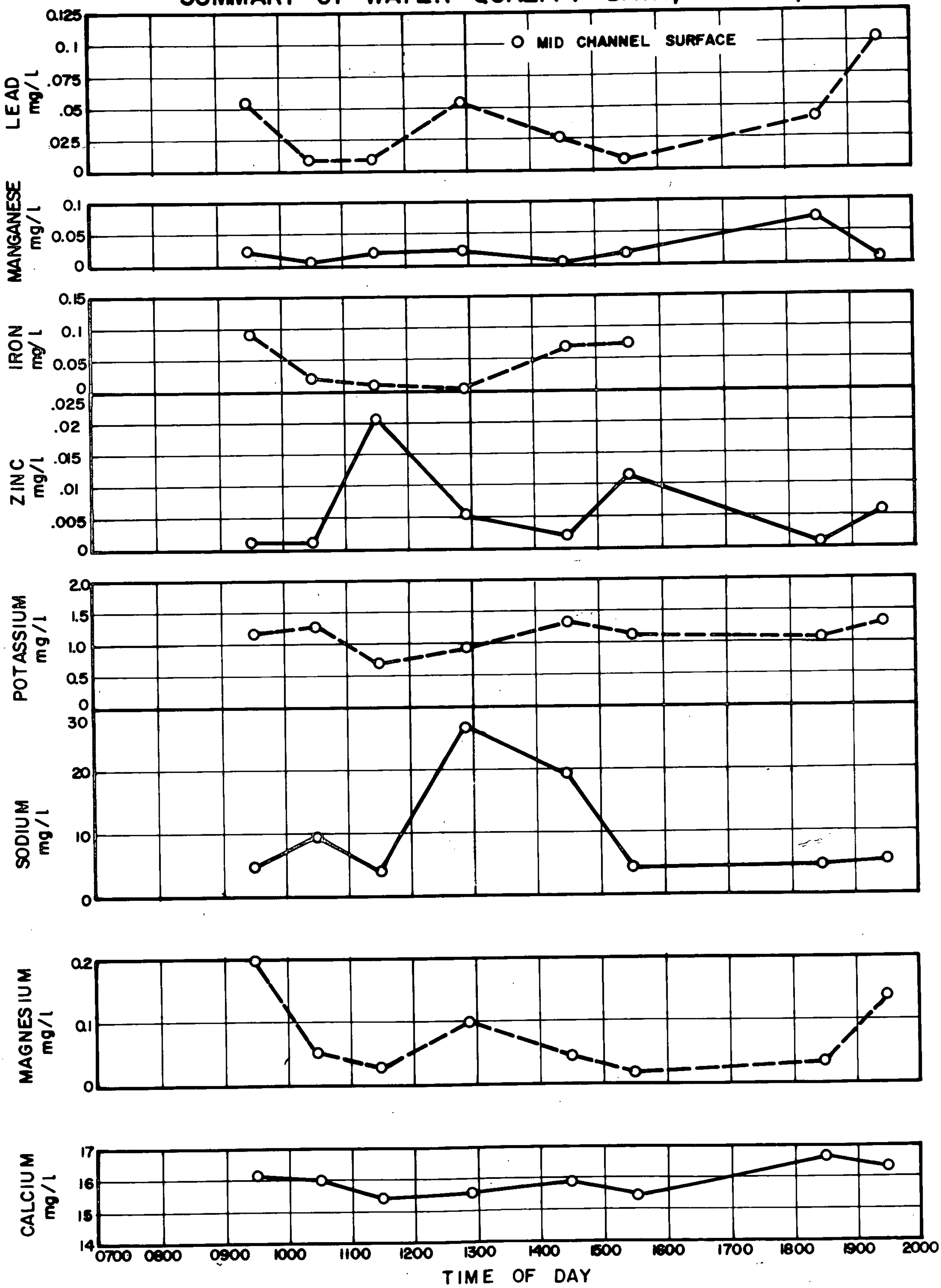
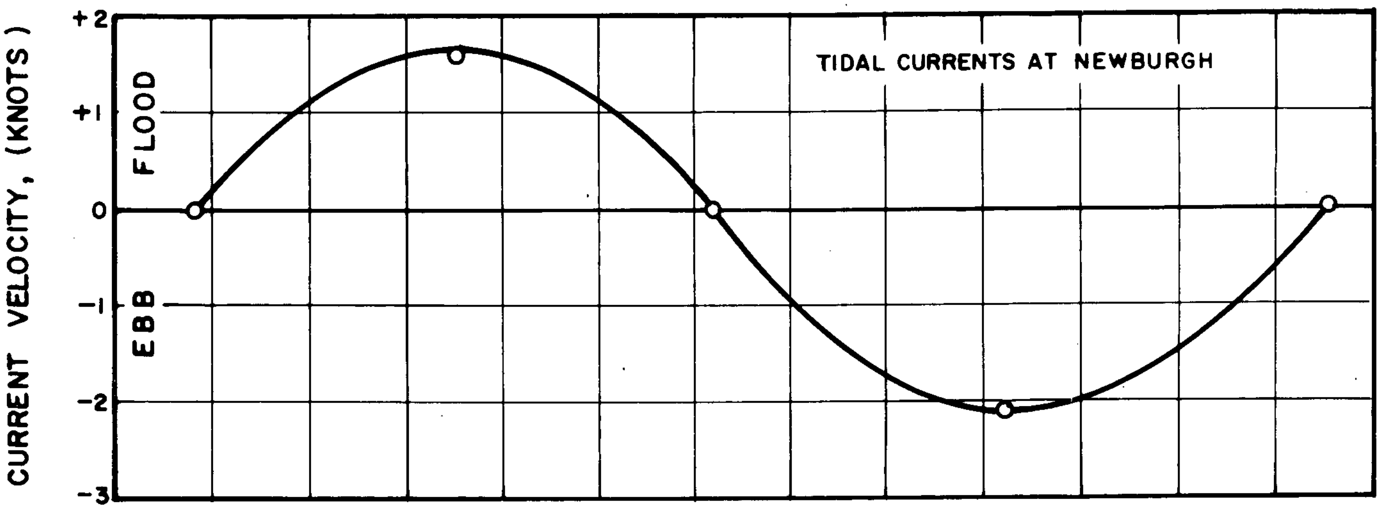


FIGURE VI-16

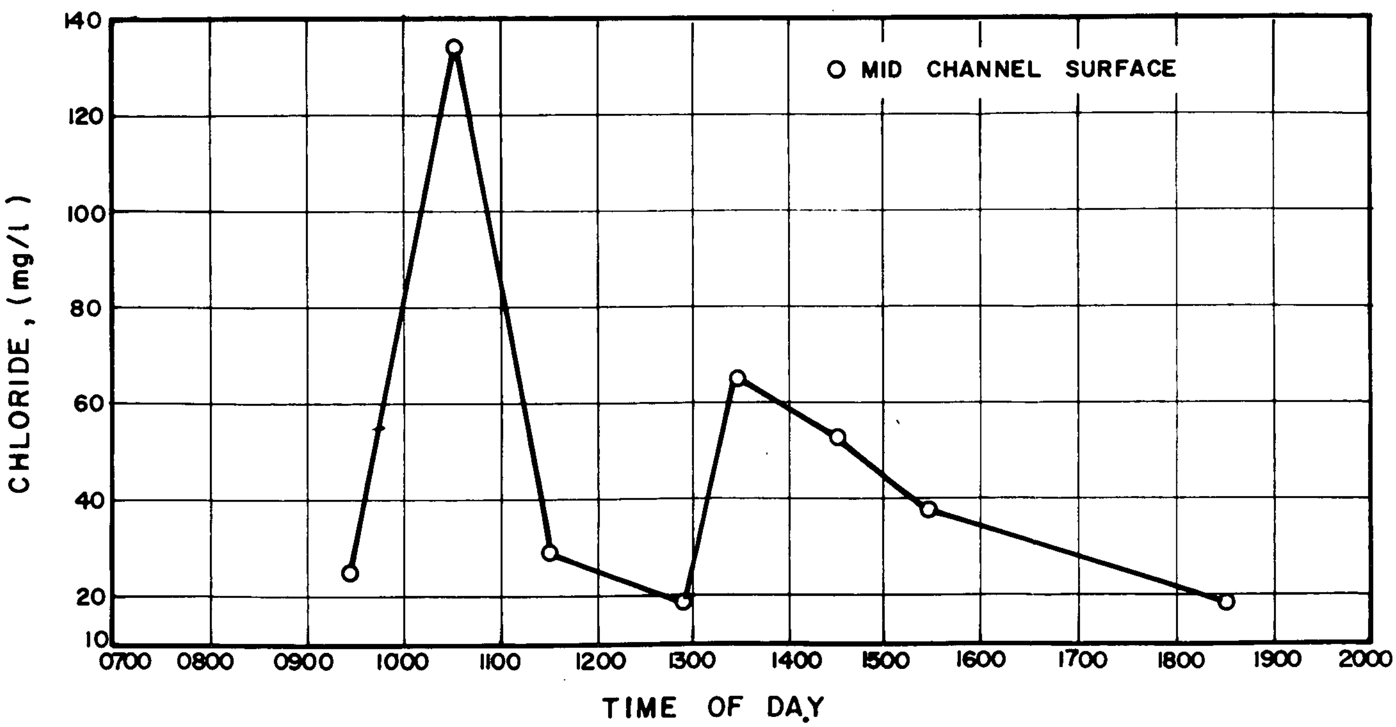
CENTRAL HUDSON GAS & ELECTRIC

HUDSON RIVER AT ROSETON (MP. 65)
JULY 9, 1972

SUMMARY OF TIDAL CYCLE STUDY



SUMMARY OF WATER QUALITY DATA



fresh water flow coupled with the predominantly low chloride, total solids, sulfate, calcium and sodium concentrations suggests the absence of salt water intrusion. It is interesting to note the apparent decrease with time of hardness, total solids, and chloride as the tidal cycle changed from flood to ebb. The decrease in these parameters would suggest that the material originated at some point down stream of the sampling location. Even though the data indicate the absence of salt water intrusion, there was considerable variation with time for most of the measured parameters. During this survey, a composite was made consisting of an equal volume of each sample taken. This test was performed to determine if compositing was a reliable technique for measuring water quality parameters during a tidal cycle. The results of this procedure are presented in Table VI-10. In most cases the composite sample proved to be representative of the average of the samples.

The conclusion drawn was that composite sampling would be sufficient to provide representation of average water quality conditions over a tidal cycle. It should be pointed out that composite sampling will not provide information relating to the variability of water quality parameters over a tidal cycle.

TABLE VI-10

COMPARISON OF COMPOSITE AND

AVERAGE VALUES - JULY 9, 1972

PARAMETER		COMPOSITE VALUE	AVERAGE
Turbidity	TU	22	18
Alkalinity as $CaCO_3$	mg/l	43	42
Hardness as $CaCO_3$	mg/l	40	40
BOD	mg/l	1	1
COD	mg/l	21	13
Total Solids	mg/l	135	133
Total Volatile Solids	mg/l	50	56
Ortho PO_4-P	mg/l	.02	.02
Phosphorus	mg/l	.16	.14
Chloride	mg/l	19	45
Sulfate	mg/l	5.8	5.8
Calcium	mg/l	15.8	17.3
Lead	mg/l	.027	.058
Magnesium	mg/l	.04	.08
Manganese	mg/l	.012	.025
Potassium	mg/l	1.12	1.11
Sodium	mg/l	5.05	9.04

(b) Water Quality 1971

The results of the 1971 QLM water quality survey in the vicinity of the Roseton/Danskammer Generating Stations are presented in Table VI-11. As the 1971 survey progressed, more parameters were added. Several parameters were measured during the entire period. These were pH, alkalinity, COD, nitrate - nitrogen and chlorides. The measured values of these parameters were used as indicators of differences in stations or depths.

Comparing sampling stations within each sampling date, it should be possible to establish the existence of trends if any, among stations. On July 14, 1971, no apparent differences existed between the North control and the Danskammer discharge stations for the indicator parameters. On August 1971, no discernable differences existed between stations, but a slight increase of alkalinity and chloride concentrations over the July 14, 1971 measurements occurred. Both July and August 1971, were relatively low fresh water flow months, but the data provide no indication of salt water intrusion. In August, BOD and COD measurements were conducted. The average BOD concentration of 2 mg/l and COD concentration of 14 mg/l provide an interesting insight into the relationship of BOD and COD. The BOD concentrations were low, possibly even in the non-measureable range, while the COD concentrations were relatively high. These values are consistent with previous data, as shall be pointed out later. The existence of a low BOD/COD

TABLE VI-11

SUMMARY OF 1971 WATER QUALITY DATA

FOR THE ROSETON AREA

PARAMETERS		JULY 14 Station			AUGUST 17 Station					
		1↑	1↓	3↓	1↑	1↓	2↑	2↓	3↑	3↓
time										
pH		7.6	7.6	7.6	7.45	7.45	7.6	7.6	7.45	7.5
Temperature, °F										
Alkalinity ($CaCO_3$ mg/l)		48	48	47	53	52.5	53.5	53.5	53	53.5
BOD	mg/l				2	2	2	2	1	3
COD	mg/l				13.6	13.3	15.1	16	13.1	13
TOC	mg/l									
TIC	mg/l									
T.S.	mg/l									
T.D.S.	mg/l									
T.V.S.	mg/l									
T.S.S	mg/l									
NH_3-N	mg/l									
TKN	mg/l									
NO_3-N	mg/l	0.51	0.78	0.64	0.65	0.47	0.12	0.63	0.59	0.30
Ortho PO_4-P	mg/l	0.5.	0.106	0.124	0.076	0.078	0.080	0.076	0.076	0.083
Total Phosphorus-P	mg/l									
Phenol	mg/l									
Chloride	mg/l	6.7	6.7	5.7	13.3	15.2	13.3	14.3	14.3	14.3
Sulfate	mg/l									
Chromium	mg/l									
Zinc	mg/l									

PARAMETERS		NOVEMBER 2 Station					NOVEMBER 24 Station				DECEMBER 8 Station				
		1↑	1↓	1*	3↑	3↓	1↑	1↓	3↑	3↓	1↑	3↑	3↑	4*	5*
time		1200	1200	1630	1000	1000		-		-	0945	1245	1050		
pH					-		7.2	7.3	7.2	7.2	7.3	7.3	7.3	7.3	7.3
Temperature, °F				66.5	63	62.3			47.4	47.3	40.5	38.5	39.5		41
Alkalinity ($CaCO_3$ mg/l)		49.5	50	48.4	47	48.3	49.9	49.6	49.4	49.9	47.5	47.5	46.0	[illegible]	48
BOD	mg/l	0	1	0	1	0					2	2	2	2	2
COD	mg/l	3.6	1.8	2.9	1.8		11	15.20	11.30	21.70	18.00	18.22	15.58	13.83	[illegible]
TOC	mg/l						5.6	5.4	6.0	7.9					
TIC	mg/l						12.3	12.4	11.9	12.0					
T.S.	mg/l	170	200	189	187.0	307.4	198.5	188.3	193.6	283	164.6	164	163.8	166	167
T.D.S.	mg/l	154	173	161	173	144					148.7	151.7	153.6	156.0	156.2
T.V.S.	mg/l	84	95	127	87	110	110	88	105	83	64.4	66.6	70.0	71.8	67.2
T.S.S	mg/l	16	27	28	14	164	8.6	13	29.7	115.0	15.9	12.3	10.2	10.0	10.8
NH_3-N	mg/l					0	0	0	0	0	0	0	0	0	0
TKN	mg/l					1.1	0.4	0.6	0.5	0.4	0.6	0.4	0	0	0
NO_3-N	mg/l	0.58	0.63	0.60	0.41	0.78	0.44	0.44	0.42	3.57	0.34	0.29	0.29	0.42	[illegible]
Ortho PO_4-P	mg/l						0.11	0.14	0.09	0.21					
Total Phosphorus-P	mg/l	0.09	0.13	0.13	0.09	0.42	0.12	0.14	0.10	0.22	0.04	0.04	0.03	0.05	0.03
Phenol	mg/l										0	0	0	0	0
Chloride	mg/l	10.48	11.4	9.95	9.95	11.5	13.3	12.2	12.2	14.4	13.3	13.3	12.2	13.9	13.2
Sulfate	mg/l	23	25	25		34	18.4	16.7	17.8	16.3	21.8	21.6	21.3	21.3	19.0
Chromium	mg/l	0,060	0.081	0.072	0.06	0.068	0.04	0.08	0	0	0	0	0	0	-
Zinc	mg/l	0,035	0.042	0.031	0.035	0.024	0	0	0	0	0	0	0	0	0

Surface
Bottom
Mid-depth

Station #1 Danskammer Discharge
Station #2 Hess Fuel Storage Area
Station #3 North Control
Station #4 South Control
Station #5 Roseton Intake

ratio (0.14) suggests that even though no immediate oxygen demand is being exerted, there exists a substantial residual and refractory organic source in the Hudson River.

The November 2, 1971 data again suggest no difference between stations, at least at the surface. The observed values were similar to the previous months with the exception of BOD, COD in the North Control bottom sample. The COD values were low while the BOD values were essentially zero. The North Control bottom sample exhibited an increase in total solids (TS), total suspended solids (TSS) and total phosphorus concentrations. The increase in TS concentration from ~190 mg/l to ~300 mg/l appears to have been caused by suspended material, as evidenced by the increase in TSS concentrations from ~20 mg/l to ~160 mg/l. The total phosphorus values increased from ~0.1 mg/l to ~0.4 mg/l. These data should be compared to the values observed from the November 24, 1971 samples where similar differences were observed. The November 24 samples showed increases in COD (15 mg/l to ~20 mg/l), TS (~200 mg/l to ~280 mg/l), TSS (~30 mg/l to ~115 mg/l), nitrate and nitrogen (~0.4 mg/l to ~3.6 mg/l) and total phosphorus (~0.1 mg/l to ~0.2 mg/l).

A possible explanation for the increases in the above parameters might be provided by examining the sampling technique. As the water sampling device was lowered to the bottom, the bottom sediments might have been disturbed. This explanation has merit, but one, if not two, factors contradict it. Normally, benthic materials contain higher total volatile solids (TVS) concentrations and metals concentrations than the overlying water. As the samples in question have increased suspended material, but no associated increase in TVS, the chromium or zinc concentrations, it is doubtful that the differences were due to resuspension of bottom material. The data suggest that stratification did exist at the North control station during the November sampling dates, but it is difficult to provide an explanation for the occurence.

The December 8, 1971 data consists of surface values only. It is not possible to determine if the stratification continued to exist. The data indicate that there was no differentiation from station to the station at least at the surface. The data were consistent with that reported for the previous sampling dates.

Data obtained from the New York State Department of Environmental Conservation (NYSDEC) are presented in Table VI-12. The data are from water quality samples taken near Beacon (MP 60-Wappinger Falls), Danskammer Point (MP 65.3 - Wappinger Falls) and Poughkeepsie (MP 71.6) from October 1967 to September 30, 1970. These data are presented to provide comparisons of 1971

TABLE VI-12

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

WATER QUALITY DATA FOR 1967-1970

PARAMETERS		WAPPINGER FALLS MP-60.0 Median 50%	Range 10%-90%	WAPPINGER FALLS MP-65.3 Median 50%	Range 10%-90%	POUGHKEEPSIE MP-71.6 Median 50%	Range 10%-90%
pH		7.4	7.0-7.6	7.5	7.3-7.7	7.3	7.1-7.5
Color	Cu	30.0	19.0-31.0	-	-	20	15-20
Sp. Conductance	μmho/cm	230.5	148.0-1192.0	200.0	160.0-280.0	-	-
Temperature	°F	72.5	43.7-77.9	-	-	50.0	35.8 -68.0
Turbidity	TU	10.0	5.0-20.0	13.0	8.0-22.0	25.0	25.0-42.0
Carbon Dioxide	mg/l	-	-	-	-	-	-
Alkalinity as $CaCO_3$	mg/l	52.0	42.0-59.0	57.0	47.0-65.0	45.0	40.0-55.0
Total Hardness as $CaCO_3$	mg/l	79.0	62.0-167.0	78.0	62.0-94.0	72.0	60.0-90.0
D.O.	mg/l	7.4	6.2-11.0	-	-	9.3	5.7-11.5
BOD	mg/l	1.7	.8-2.3	-	-	4.3	1.0-5.6
COD	mg/l	10.0	7.0-14.5	10.0	4.0-17.1	16.0	5.2-24.0
TOC	mg/l						
TIC	mg/l						
T.S.	mg/l	149	108-710	191	118-274		
T.D.S.	mg/l						
T.V.S.	mg/l	18	10-76	57	15-130		
T.S.S.	mg/l	20	15-32	38	15-95		
V.S.S.	mg/l	6	2-9	13	3-36		
NH_3-N	mg/l	0.111	0.035-0.252	.328	.180-.607	-	
Organic-N	Mg/l	.22	.09-.39	.28	.08-.76	-	
TKN	mg/l						
NO_3-N	mg/l	0.63	0.50-0.80	0.60	0.33-0.84	-	
NO_2-N	mg/l						
Ortho PO_4-P	mg/l						
Total P hosphorus-P	mg/l	.11	.7-.18	.11	.06-.15	-	
Oil and Grease	mg/l						
Phenol	mg/l						
Chloride	mg/l	16.0	8.2-298.0	19.2	12.0-39.8	18.0	6.6-26.0
Sulfate	mg/l	25.5	17.5-65.0	25.8	18.6-30.5	29.5	21.3-50.8
Beryllium Be	mg/l						
Cadmium Cd	mg/l						
Calcium Ca	mg/l	25.0	19.0-32.0	25.0	20.2-28.8	-	
Chromium Cr	mg/l						
Copper Cu	mg/l						
Iron Fe	mg/l	.04	.02-.11	.16	.03-.50	-	
Lead Pb	mg/l						
Magnesium Mg	mg/l	4.2	3.4-21.0	4.3	2.7-6.0	-	
Manganese Mn	mg/l	.00	.00-04	.03	.00-.12	-	
Mercury Hg	mg/l						
Nickel Ni	mg/l						
Potassium K	mg/l	1.2	.9-7.3	1.2	.7-1.9	-	
Silica Si	mg/l						
Sodium Na	mg/l	10.8	5.2-165.5	8.5	4.8-18.0	-	
Vanadium V	mg/l						
Zinc Zn	mg/l						

QLM survey results with data collected in previous years. The NYSDEC data are presented in percentiles, for example, for the fifty percentile, 50% of the total values observed were equal to or less than the value reported. The ten and ninety percentile values are presented as an indicator of the range of the observed values. The values observed by QLM in 1971 correspond closely to those observed by the various surveys from 1967 to 1970.

When the NYSDEC water quality data at the ninety percentile was compared in terms of increasing river mile location, a decrease was observed for chloride concentrations. A substantial decrease (298 mg/1 to 39.8) mg/1 was observed from MP 60 to MP 65, suggesting the absence of salt water intrusion much beyond MP 60 during this time period.

The discussion of the 1971 water quality data has been oriented toward providing insight into the interactions and relationships of the various water quality parameters. These results should be considered to be representative of the water quality in the absence of salt water intrusion.

During extreme low flow conditions such as drought periods, the salt water intrusion will extend upstream of the study area, thus increasing the variability and changing of the character of the area.

(c) Water Quality 1972

The water quality program was essentially a continuation of of the 1971 program. The survey was expanded in September 1972, to include the Roseton intake sampling station as well as metals analyses. The results of the 1972 water quality survey are presented in Table VI-13. In 1972, the water quality trends were essentially the same as those observed in 1971. Few differences were observed from station to station and minor variations from sampling date to sampling date.

The variations that did occur appear to be related to decreased fresh water flow. During the course of the survey, the chloride concentrations increased from approximately 15 mg/l to approximately 35 mg/l in September and October. These values were below the previously defined limit of 100 mg/l for salt water intrusion but slightly above background concentrations of 15 - 20 mg/l. This result might suggest that the choice of a chloride ion concentration of 100 mg/l might not be adequate as an indicator of salt water intrusion. In an absolute sense, the choice of 100 mg/l chloride ion concentration would be inadequate. Any increase above background concentration might have been a better choice. For the purposes of a general water quality survey of the Hudson River such as the present study, guidelines must be selected for defining the extent of salt water intrusion. The selection of this guideline was based on two criteria. The 100 mg/l chloride concentration is a substantial increase above ambient condtions and, therefore,

TABLE VI-13

SUMMARY OF 1972 WATER QUALITY DATA FOR THE ROSETON AREA

SAMPLE PARAMETERS

PARAMETERS		MAY 2 RMC ↑	MAY 2 RMC ↓	JUNE 27 RNC ↑	JUNE 27 RNC ↓	JULY 20 RMC ↑	JULY 20 RES →	JULY 20 RWS →	AUGUST 8 RNC →	AUGUST 8 RMC →	AUGUST 23 RNC →	AUGUST 23 RMC →	AUGUST 23 RMC →
Time		1520	1520	1600	1600	1140	1450	-	1330	1355	1205	1610	1720
pH		-	-	-	-	-	-	-	7.2	7.3	7.4	7.5	7.4
Color	Cu	40-50	40-60	30-40	-	-	40-50	50-60	50-60	40-50	50	50	50
Sp. Conductance	μmho/cm												
Temperature	°F	49	49	70	68	76	76	-	78	78	76	77	77
Turbidity	TU	13	22	8	10	-	7	12	14	11	6	6	6
Alkalinity	$CaCO_3$ mg/l	41	44	51	52	-	45	44	48	48	58	56	56
Total Hardness	$CaCO_3$ mg/l	64	64	-	-	-	-	-	-	-	-	-	-
D.O.	mg/l	-	-	6.7	6.5	5.5	5.3	-	6.4	7.1	5.9	6.4	6.3
BOD	mg/l	-	-	2.0	2.0	-	-	-	2.2	2.0	-	-	-
COD	mg/l	7	11	8	11	12	9	-	-	12	15	19	17
T.S.	mg/l	115	135	-	-	-			170	150	-	-	-
T.D.S.	mg/l	105	100	-	-	-			155	140	-	-	-
T.V.S.	mg/l	50	50	-	-	-			77	70	-	-	-
T.S.S.	mg/l	10	35	-	-	-			16	13	-	-	-
V.S.S.	mg/l												
NH_3-N	mg/l	-	-	0	<0	-	-	-	1.40	0.60	0.30	0.50	0.20
Organic-N	mg/l	-	-	0.60	0.80	-	-	-	0.80	1.95	1.25	0.85	1.15
TKN	mg/l	-	-	0.60	-	-	-	-	2.20	2.55	1.55	1.35	1.35
NO_3-N	mg/l	0.95	0.95	-	-								
Ortho PO_4-P	mg/l	-	-	0.05	0.05	-	0.05	0.15	0.05	0.19	0.09	0.06	0.10
Total Phosphorus	mg/l	0.06	0.09	0.13	0.14	-	0.07	0.3[illegible]	0.17	0.19	0.20	0.25	0.31
Phenol	mg/l	-	-	-	-	-	-	-	-	-	[illegible]	0.005	0.006
Chloride	mg/l	13	14	3	3	-	16	19	7	8	11	9	10
Sulfate	mg/l	9.2	10.2	-	-	-	9	12	9.5	9.0	16.5	18	16
Cadmium Cd	mg/l	0.02	0.02	-	-	-	-	-	-	-	-	-	-
Calcium Ca	mg/l	19.7	19.4	-	-	-	-	-	-	-	-	-	-
Chromium Cr	mg/l	0.01	0.01	-	-	-	-	-	-	-	-	-	-
Copper Cu	mg/l	<0.002	<0.002	-	-	-	-	-	-	-	-	-	-
Iron Fe	mg/l	0.45	1.43	-	-	-	-	-	-	-	-	-	-
Lead Pb	mg/l	0.03	0.02	-	-	-	-	-	-	-	-	-	-
Magnesium Mg	mg/l	3.6	3.7	-	-	-	-	-	-	-	-	-	-
Manganese Mn	mg/l	0.05	0.04	-	-	-	-	-	-	-	-	-	-
Mercury Hg	mg/l	<0.01	-	-	-	-	-	-	-	-	-	-	-
Nickel Ni	mg/l	-	<0.01	-	-	-	-	-	-	-	-	-	-
Potassium K	mg/l	0.90	1.17	-	-	-	-	-	-	-	-	-	-
Sodium Na	mg/l	5.49	5.69	-	-	-	-	-	-	-	-	-	-
Zinc Zn	mg/l	0.012	0.025	-	-	-	-	-	-	-	-	-	-

PARAMETERS		SEPTEMBER 10 RMC ↑	SEPTEMBER 10 RMC ↓	SEPTEMBER 10 RNC ↑	SEPTEMBER 10 RNC ↓	SEPTEMBER 10 RIF ↑	SEPTEMBER 10 RIF ↓
Time		1450	1500	1420	1420	1515	1520
pH		7.5	7.3	7.3	7.2	7.3	7.2
Color	Cu	40-50	30-40	30-40	30-40	40-50	50-60
Sp. Conductance	μmho/cm						
Temperature	°F	71	71	71	71	71	71
Turbidity	TU	-	-	-	-	-	-
Alkalinity	$CaCO_3$ mg/l	55	51	54	53	54	54
Total Hardness	$CaCO_3$ mg/l	76	70	68	72	70	72
D.O.	mg/l	7.3	7.3	6.9	6.9	7.6	7.3
BOD	mg/l	1.0	1.0	1.0	1.0	1.0	1.0
COD	mg/l	18	17	15	17	11	16
T.S.	mg/l	205	200	220	215	190	220
T.D.S.	mg/l	-	-	-	-	-	-
T.V.S.	mg/l	-	-	-	-	-	-
T.S.S.	mg/l	-	-	-	-	-	-
V.S.S.	mg/l						
NH_3-N	mg/l	0	0	0	0	0	0
Organic-N	mg/l	0.35	0.80	0.40	0.35	[illegible]	0.40
TKN	mg/l	-	-	0.40	0.35	-	0.40
NO_3-N	mg/l	0.72					
Ortho PO_4-P	mg/l	-	-	-	-	-	-
Total Phosphorus	mg/l	0.20	0.20	0.10	0.20	0.10	0.20
Phenol	mg/l	-	-	-	-	-	-
Chloride	mg/l	28	32	22	28	30	36
Sulfate	mg/l	14	15	14	16	11	14
Cadmium Cd	mg/l	0.006	0.007	0.004	<0.001	<0.001	<0.001
Calcium Ca	mg/l	20.5	20.4	20.4	21	20.5	21.0
Chromium Cr	mg/l	<0.003	<0.003	<0.062	<0.003	<0.003	<0.025
Copper Cu	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Iron Fe	mg/l	<0.01	0.10	0.10	<0.01	<0.01	<0.01
Lead Pb	mg/l	<0.02	<0.02	0.06	0.04	<0.02	<0.02
Magnesium Mg	mg/l	6.15	4.61	4.20	4.60	4.60	5.20
Manganese Mn	mg/l	0.062	<0.032	<0.002	0.027	0.013	<0.002
Mercury Hg	mg/l	<0.01	-	-	-	-	-
Nickel Ni	mg/l	-	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium K	mg/l	1.6	2.1	1.4	2.2	2.0	2.2
Sodium Na	mg/l	13.00	15.20	22.50	10.20	15.00	10.00
Zinc Zn	mg/l	0.004	0.002	0.007	0.007	0.007	0.004

PARAMETERS		OCTOBER 26 RMC ↑	OCTOBER 26 RMC ↓	OCTOBER 26 RNC ↑	OCTOBER 26 RNC ↓	OCTOBER 26 RIF ↑	OCTOBER 26 RIF ↓	DECEMBER 6 RMC ↑	DECEMBER 6 RMC ↓	DECEMBER 6 RNC ↑	DECEMBER 6 RNC ↓	DECEMBER 6 RIF ↑	DECEMBER 6 RIF ↓
Time		1325	1325	1155	1155	1300	1300						
pH		7.7	7.6	7.7	6.9	7.9	7.9	7.5	7.5	7.5	7.5	7.4	7.4
Color	Cu	30-40	40-50	40-50	40-50	40-50	40-50	30-40	50	30.40	40-50	60-70	60-70
Sp. Conductance	μmho/cm	203	211	204	207	202	192						
Temperature	°F	59	58	57	57	58	58	38	38	38	38	41	41
Turbidity	TU	6	3	5	6	4	18	17	47	19	24	24	21
Alkalinity	$CaCO_3$ mg/l	62	52	52	36	51	49	49	49	51	49	49	49
Total Hardness	$CaCO_3$ mg/l	69	70	71	69	70	71	77	84	84	80	80	77
D.O.	mg/l	-	-	-	-	-	-						
BOD	mg/l	1.0	1.0	0.4	0.7	0.2	0.9	2.0	2.0	2.0	1.0	2.0	2.0
COD	mg/l	11	15	14	15	16	10	18	22	14	16	14	16
T.S.	mg/l	115	130	125	130	145	160	130	180	140	170	195	165
T.D.S.	mg/l	110	110	115	120	115	125	-	100	130	105	170	130
T.V.S.	mg/l	42	25	45	61	53	55						
T.S.S.	mg/l	5	20	9	10	30	36	14	80	13	65	26	33
V.S.S.	mg/l												
NH_3-N	mg/l	-	-	-	-	-	-	0.27	0.23	0.26	0.28	0.26	0.31
Organic-N	mg/l	-	-	-	-	-	-						
TKN	mg/l	-	-	-	-	-	-						
NO_3-N	mg/l							0.72	1.17	0.83	1.00	0.83	1.00
Ortho PO_4-P	mg/l	0.06	0.06	0.05	0.06	0.06	0.06	0.10	0.19	0.10	0.14	0.10	0.10
Total Phosphorus	mg/l	0.09	0.08	0.09	0.10	0.11	0.11	0.10	0.30	0.10	0.20	0.20	0.10
Phenol	mg/l	0	0	0	0	0.007	0	0	0.033	0	0	0	0.020
Chloride	mg/l	36	32	26	29	27	25	13	11	12	12	12	12
Sulfate	mg/l	11	11	11	39	32	26	22	20	17	17	19	20
Cadmium Cd	mg/l	<0.001	<0.001	<0.008	0.007	0.006	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium Ca	mg/l	19.8	20.7	20.5	19.8	20.0	20.5	23.0	25.0	24.0	24.0	24.0	23.0
Chromium Cr	mg/l	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.004	<0.027	<0.054	<0.003	<0.002	<0.022
Copper Cu	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.035	<0.014	<0.002	<0.002
Iron Fe	mg/l	0.04	<0.01	0.32	0.14	0.18	0.21	0.70	2.25	1.05	1.85	1.05	1.05
Lead Pb	mg/l	<0.02	<0.02	0.07	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Magnesium Mg	mg/l	4.78	4.49	4.90	4.84	4.80	4.90	4.70	5.34	5.20	4.90	4.89	4.80
Manganese Mn	mg/l	0.023	0.017	0.066	0.066	0.017	0.060	0.010	0.100	0.010	0.060	0.010	0.010
Mercury Hg	mg/l	-	-	-	-	-	-	-	-	-	-	-	-
Nickel Ni	mg/l	0.05	0.04	0.11	<0.01	0.05	0.04	<0.01	<0.10	<0.01	<0.10	<0.01	<0.01
Potassium K	mg/l	1.1	1.3	1.1	1.1	1.2	1.3	1.6	2.4	1.8	2.4	1.6	1.5
Sodium Na	mg/l	10.00	9.80	9.70	10.00	10.00	10.60	6.50	7.00	9.25	7.50	8.20	7.50
Zinc Zn	mg/l	0.026	0.025	0.024	0.014	0.007	0.007	0.003	0.022	0.016	0.22	0.026	0.009

↑ Surface
↓ Bottom
→ Mid-depth

RMC Roseton Mid-Channel
RNC Roseton North Control
RES Roseton East Shallows
RWS Roseton West Shallows
RIF Roseton Intake Face

not likely to be confused with ambient conditions. Also, at or near this value a discernable concentration gradient with depth exists. The selection of any water criteria or guidelines should not be viewed as absolute or inflexible limits but as guidelines whereby judgements are made possible.

Based on the above discussion, it is possible to state that some degree of salt water mixing did occur in the Roseton-Danskammer area in September and October 1972. The primary effect of even a minor degree of salt water mixing was the resultant increase in the variability of the observed parameters.

Water quality data made available from the United States Environmental Protection Agency (EPA) "STORET" data retrieval system are presented in Table VI-14. These data were collected for stations at Beacon (MP 60), Chelsea (MP 65.3) and Poughkeepsie (MP 71.6), March 1970 through December 1972. These were the same stations as those reported for the 1967 through 1970 data in Table VI-12. When the data collected by QLM in 1971 and 1972 was compared with the NYSDEC data for 1967 - 1970, and the EPA data for 1970 - 1972, it was clear that the values correspond closely with the major differences occuring at the Beacon (MP 60) station.

As in 1967 through 1970, a noticable difference was observed for water quality parameters for MP 60 and MP 65.3. These differences were primarily associated with salt water intrusion. The maximum

TABLE VI-14

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WATER QUALITY DATA - 1970-1972

PARAMETERS		BEACON MP 60		CHELSEA MP 65.3		POUGHKEEPSIE MP 71.6	
		Mean	Range	Mean	Range	Mean	Range
pH		7.5	7.0-8.0	7.39	6.70-7.70	7.0	6.1-8.7
Color	Cu	18.5	10.0-24.0	18.85	7.0-38.0	22.33	20.0-27.0
Sp. Conductance	μmho/cm	308.0	137.0-1690.0	203.43	128.0-334.0	240.66	105.0-910.0
Turbidity	Tu					10.55	.50-55.0
Carbon Dioxide	mg/l	6.4	1.9-11.0	5.10	2.30-6.40		
Alkalinity as $CaCo_3$	mg/l	53.7	37.0-72.0	51.64	34.0-66.0	52.75	47.0-61.0
Total Hardness as $CaCo_3$	mg/l	87.3	53.12-219.0	77.2	50.0-93.0	83.33	72.0-90.0
D.O.	mg/l					8.88	1.90-13.80
BOD	mg/l					1.50	1.30-1.70
COD	mg/l	11.3	6.0-19.0	10.71	.00-21.0	14.20	9.0-22.0
T.S.	mg/l	180	90-333	146	113-247		
T.V.S.	mg/l	22	13-76	18	3-79		
NH_3-N	mg/l	.126	.000-.275	.121	.00-.370	.080	.010-.180
Organic-N	mg/l	.601	.000-2.49	.397	.00-.440	.585	.450-.720
NO_3-N	mg/l	.695	.340-1.020	.731	.100-1.10	.678	.080-1.10
NO_2-N	mg/l	.031	.002-.090	.017	.00-.071	.020	.00-.040
Ortho PO_4-P	mg/l	.160	.160-.160	.156	.140-.170		
Total Phosphorus-P	mg/l	.137	.030-.390	.115	.00-.520	.114	.050-.240
Oil and Grease	mg/l					60.50	1.00-120.0
Phenol	mg/l					0.002	0.0-0.005
Chloride	mg/l	39.6	7.60420.0	14.03	4.00-43.0	19.0	17.0-21.0
Sulfate	mg/l	28.0	15.0-103.0	24.04	13.0-35.0	29.33	27.0-33.0
Beryllium Be	mg/l						
Cadmium Cd	mg/l					0.013	0.001-0.025
Calcium Ca	mg/l	24.8	16.0-35.0	23.74	16.0-29.0	25.50	23.0-28.0
Chromium Cr	mg/l					0.003	0.001-0.004
Copper Cu	mg/l	0.023	0.0-0.040	.00	.00-.00	0.005	0-0.010
Iron Fe	mg/l	0.080	0.080-0.080	0.130	0.130-0.130	0.173	0.06-0.290
Lead Pb	mg/l	.00	.00-.00	0.005	.005-.005	0.010	.003-.027
Magnesium Mg	mg/l	6.11	2.8-32.0	4.36	2.60-6.20	4.35	3.70-5.0
Manganese Mn	mg/l	0.020	.00-0.09	0.007	.00-0.06	0.022	.00-0.047
Potassium K	mg/l	1.79	.700-9.00	1.23	.600-2.20	1.55	1.5-1.6
Silica Si	mg/l	2.98	.100-6.00	3.35	.20-5.80	1.10	.70-1.50
Sodium Na	mg/l	23.7	4.5-240.0	9.024	3.80-26.0	11.5	10.5-13.0
Vanadium V	mg/l						
Zinc Zn	mg/l						

values for TS, chloride, sulfate, magnesium, potassium and sodium at Beacon (MP 60) were consistently higher than those observed at Chelsea (MP 65.3) and Poughkeepsie (MP 71.6). These values point to a distinct difference for an average low flow condition in the survey area between MP 60 and MP 65.

F. SUMMARY OF RESULTS

1. The Hudson River fresh water flow increased from 1967 until the present survey period of 1971 and 1972. 1971 and 1972 were consistently high water years with the majority of the high flows occurring in the Spring months with the low flow months of August, September and October approximating low flow average conditions. This result made possible the observation of average low flow conditions in the survey area, as well as extreme high flow periods.

2. During periods of flow greater than approximately 7,000 cfs, the water quality in the Roseton/Danskammer area (MP 65) will be determined by upstream conditions. During the average low flow conditions of approximately 6,000 cfs, during the Summer and Fall months, the survey area should be considered a transition zone; the point where the water quality changes from predominantly fresh water (and constant) to estuarine (and variable). During extreme low flow conditions, this area would be subject to much greater degrees of salt water intrusion and its associated change in water quality.

3. The ability to provide a label (good, bad, acceptable, unacceptable) for the water quality of a given body of water, is dependent upon at

least two factors:

(1) Type (e. g. lake, river estuary).

(2) The use for which the waterbody is intended.

As an example, if at a given location along an estuary, the water was to be used for public drinking water supplies, the water quality might be labelled acceptable during periods of high fresh water flow, but unacceptable during periods of drought. This example applies to the Hudson River near Poughkeepsie, and during the majority of an average year, it would apply to the study area (MP 63 to MP 67).

4. During average low flow conditions, the water quality in the Roseton/ Danskammer area might become unacceptable for drinking purposes, but remain acceptable for the majority of uses. The Danskammer Point Generating Station uses Hudson River water as process water and during an average year, the water quality should be acceptable for process water. During lower than average summer conditions, the water quality might become unacceptable for continuous use as process water and modifications to the process water treatment system could become necessary.

5. During the majority of an average year, the aquatic community is subject to fresh water conditions, while in portions of the summer and fall (August, September and October), the community is subject to variable and unstable conditions. This result would be especially true during periods of lower than average water flow such as drought conditions. In these periods, the aquatic community would be subject to much in-

creased saline conditions, and, in fact, the character of the aquatic community might change significantly.

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