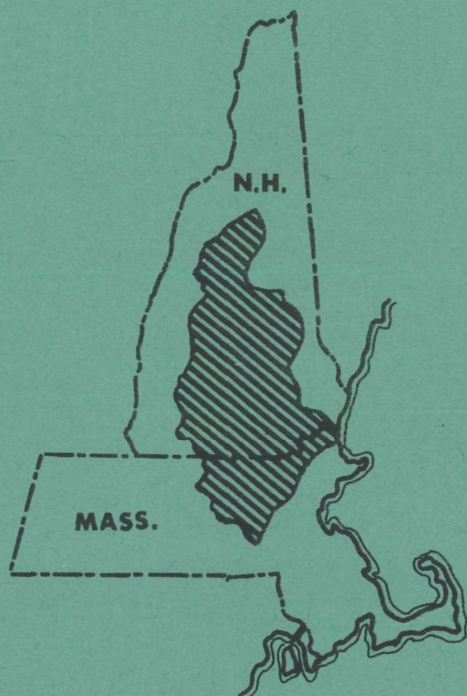
REPORT ON POLLUTION OF THE MERRIMACK RIVER AND CERTAIN TRIBUTARIES —

part III - Stream Studies Biological



U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

Merrimack River Project - Northeast Region
Lawrence, Massachusetts

August 1966

REPORT ON

POLLUTION OF THE MERRIMACK RIVER

AND CERTAIN TRIBUTARIES

PART III - STREAM STUDIES - BIOLOGICAL

by

Warren H. Oldaker

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
Merrimack River Project
Lawrence, Massachusetts

August 1966

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

In February 1964, the U. S. Department of Health, Education, and Welfare established the Merrimack River Project to carry out a study in the Merrimack River Basin (Figure 1). The basic objectives of the project were twofold:

1. Evaluation of the adequacy of the pollution abatement measures proposed for the Merrimack River within Massachusetts.
2. Development of adequate data on the water quality of the Merrimack River and its tributaries. Waters in both New Hampshire and Massachusetts were to be studied.

As part of the study of water quality, a detailed biological survey of the Merrimack River, extending from Franklin, New Hampshire, to the mouth at Newburyport, Massachusetts, was conducted during the summer months of 1964 and 1965. Biological surveys were also carried out on several tributaries, including the Souhegan River and the Nashua River[1]. The primary goal of these surveys was to evaluate the effects of municipal and industrial wastes on the benthic fauna.

GENERAL OBSERVATIONS

GRADIENT

Where the general nature of the stream community was considered, an estimate of the gradient or longitudinal slope was obtained from topographic maps. This estimate did not assess "microstratification."

The Merrimack River drops 263 feet in the 116 miles between Franklin, New Hampshire, and the mouth at Newburyport, Massachusetts. However, much of the decrease in elevation occurs at points where dams have been constructed, resulting in a relatively gentle slope for most of the length of the river. Gradient alone then was considered insignificant in determining the distribution of benthic fauna except below dams or in the specific areas mentioned for each reach.

RIVER BOTTOM

The physical characteristics of the benthic sediments were based on macroscopic examination during field biological sampling operations with the Petersen dredge. The river bed may be conveniently divided into six zones based on these observations. River miles are the distances upstream of the U. S. Coast Guard light at Newburyport, Massachusetts. A list of sampling stations and key points along the Merrimack River and their associated river miles is presented in Table 1 in the Appendix.

1. River miles 116 to 90. This zone extends from Franklin

to Concord, New Hampshire. The benthic sediments were primarily composed of rock, gravel and coarse sand.

2. River miles 90 to 65. This zone extends from Concord to Goff's Falls below Manchester, New Hampshire, and has sediments consisting mainly of fine sand and silty loam.

3. River miles 65 to 55. The benthic sediments from Goff's Falls to Nashua, New Hampshire, were primarily coarse sand and gravel.

4. River miles 55 to 45. This zone extends from Nashua, New Hampshire, to Tyngs Island, upstream of Lowell, Massachusetts. The benthic sediments were primarily coarse sand and silt with some sludge build-up.

5. River miles 45 to 2. The benthic sediments from Tyngs Island to Newburyport, Massachusetts, were primarily sludge and silt with some sand.

6. River miles 2 to 0. This portion of the estuary had sediments composed of coarse sand with some silt and sludge.

OBSERVATIONS FOR SPECIFIC REACHES

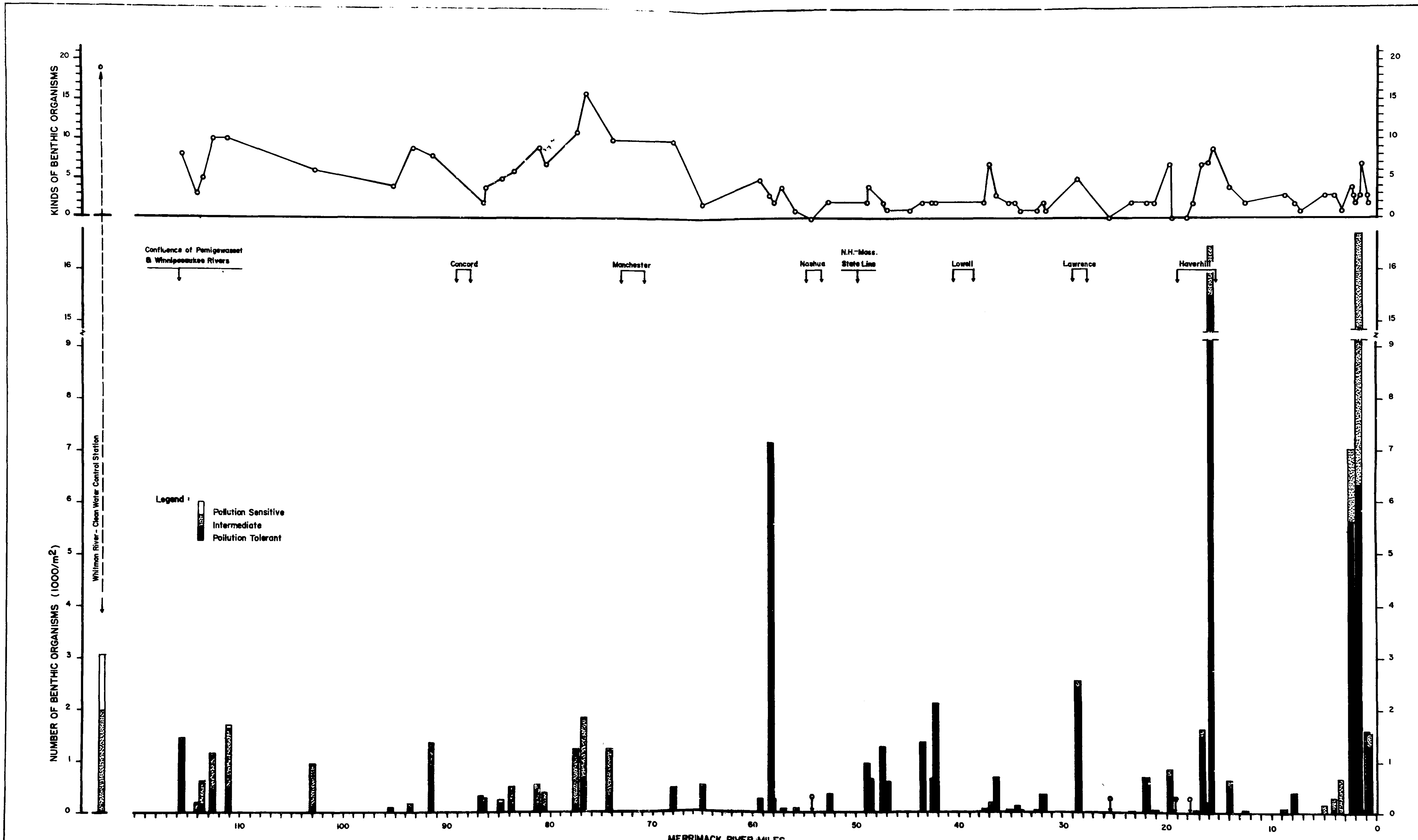
Data obtained in the biological survey were grouped and discussed, as nearly as possible, for reaches having similar physical characteristics. Eleven reaches between Franklin, New Hampshire, and the mouth of the river were selected, plus an additional station on each of the Winnipesaukee and Pemigewasset Rivers. Information for a control station above any significant waste discharge is presented in Table 2 to show the type of relatively clean-water associated bottom fauna that may be expected in non-polluted waters.

The number of bottom organisms per square meter and the various kinds of organisms found in the Merrimack River and significant tributaries near their confluence with the Merrimack are presented in Table 3. This information is illustrated in Figure 2 for the Merrimack River and in Figure 3 for the tributaries. The biological condition of the Merrimack River is shown in Figure 4.

CLEAN WATER CONTROL

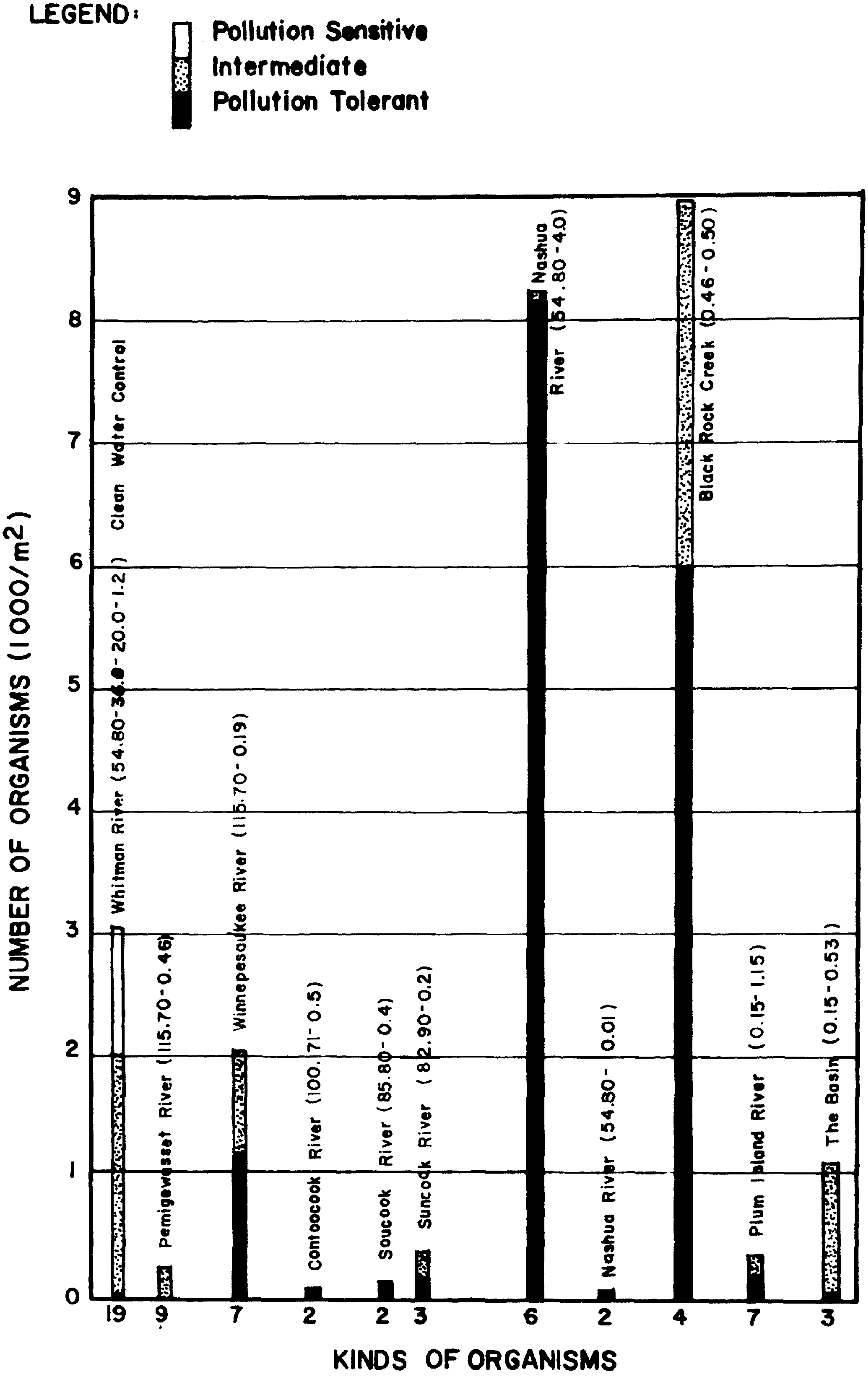
An assemblage of bottom organisms commonly found in clean water stream beds (mayflies, stoneflies, caddisflies, beetles and certain midgeflies) was difficult to find in the Merrimack River Basin. No such area was found in the Merrimack River itself.

The principle streams and smaller tributaries were found to



NUMBERS AND KINDS OF BENTHIC ORGANISMS - 1964-65
MERRIMACK RIVER

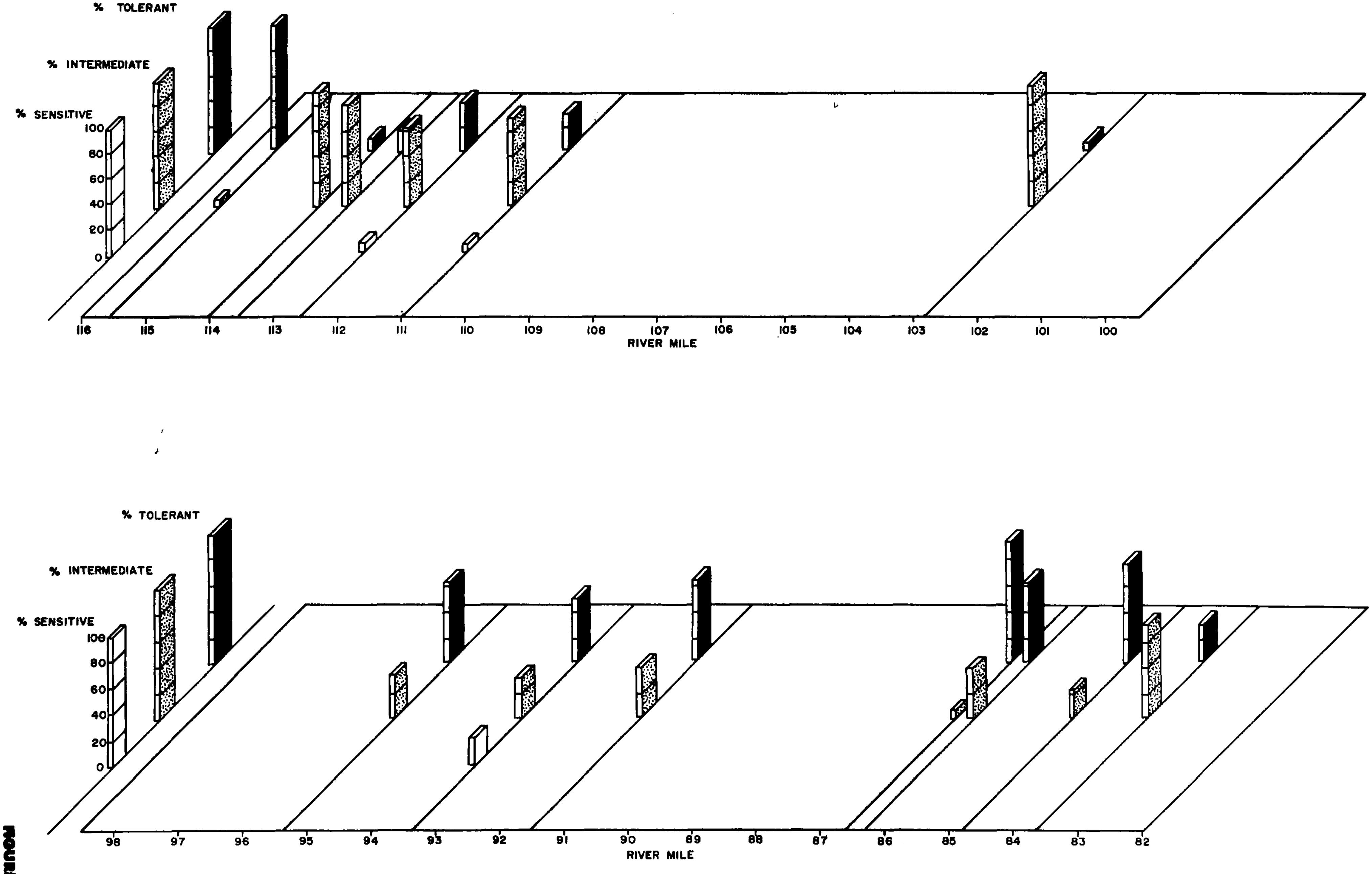
FIGURE 2



MERRIMACK RIVER TRIBUTARIES

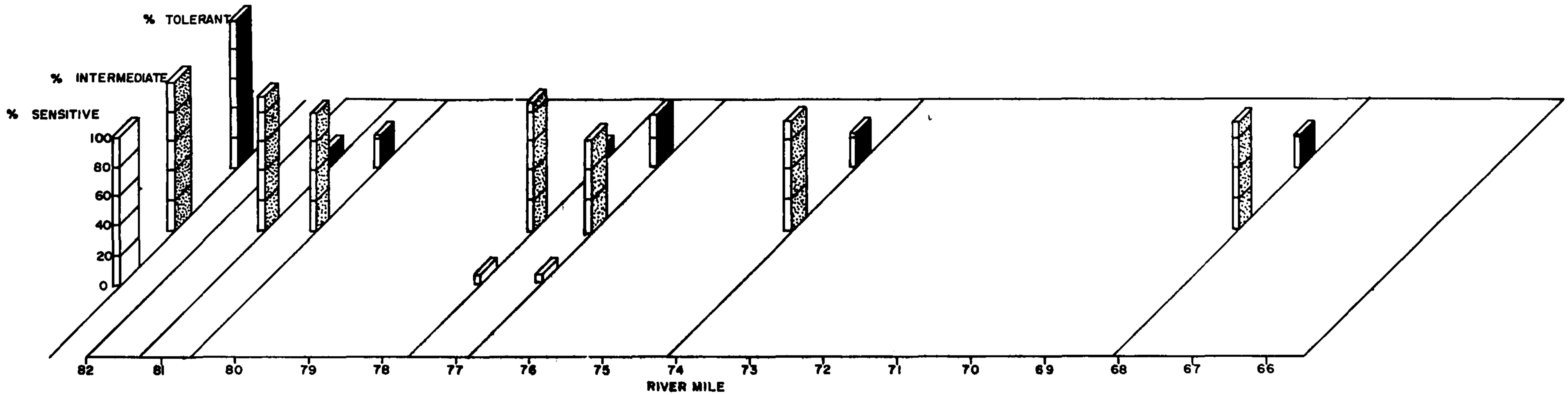
NUMBERS AND KINDS OF BENTHIC ORGANISMS-1964

FIGURE 3



DISTRIBUTION OF BENTHIC ORGANISMS
IN MERRIMACK RIVER

FIGURE 4



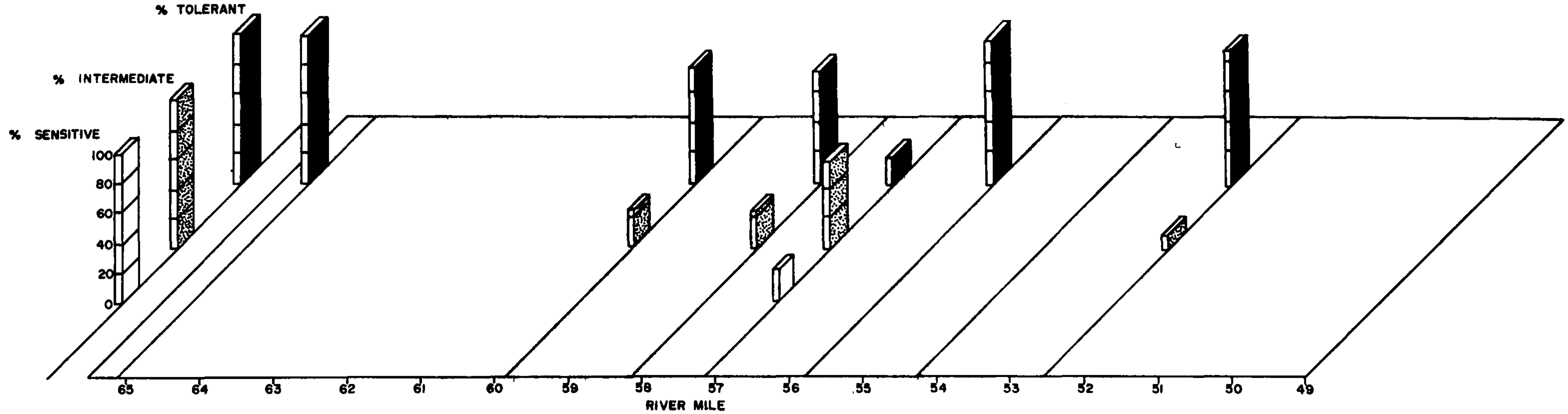
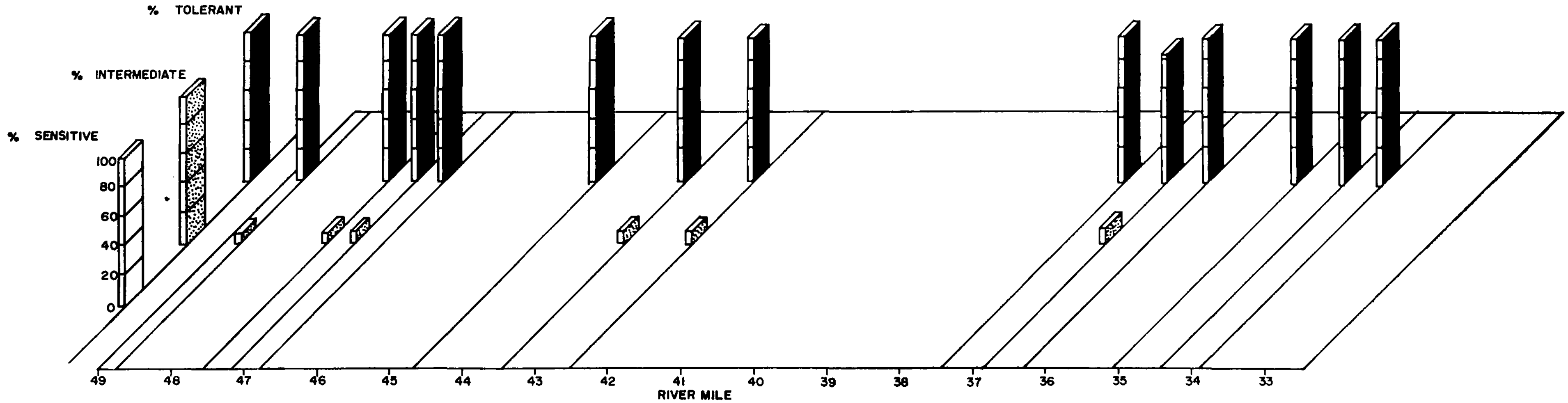
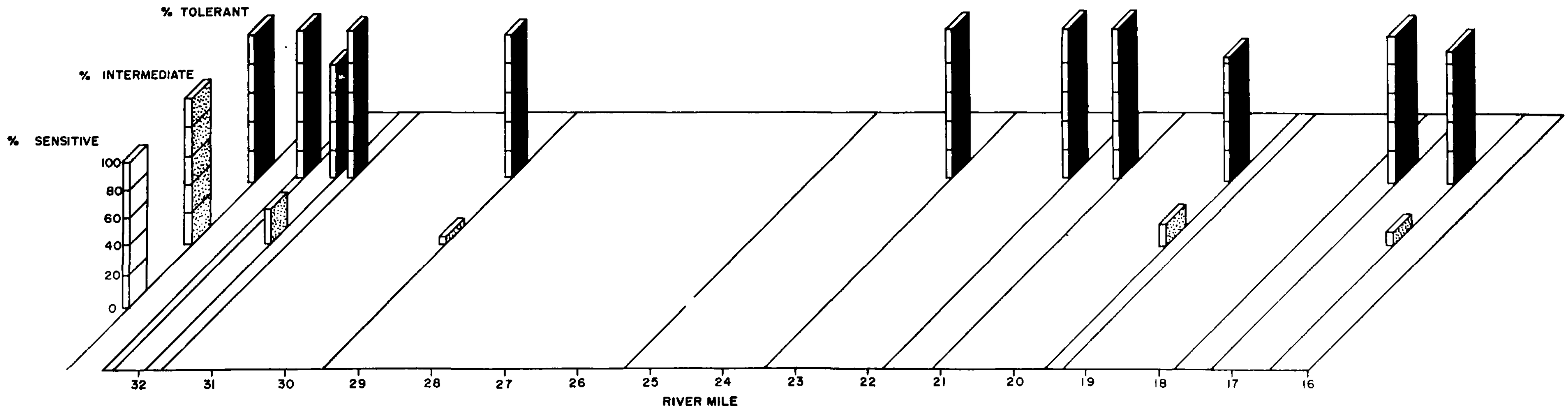


FIGURE 4 (CONT.)

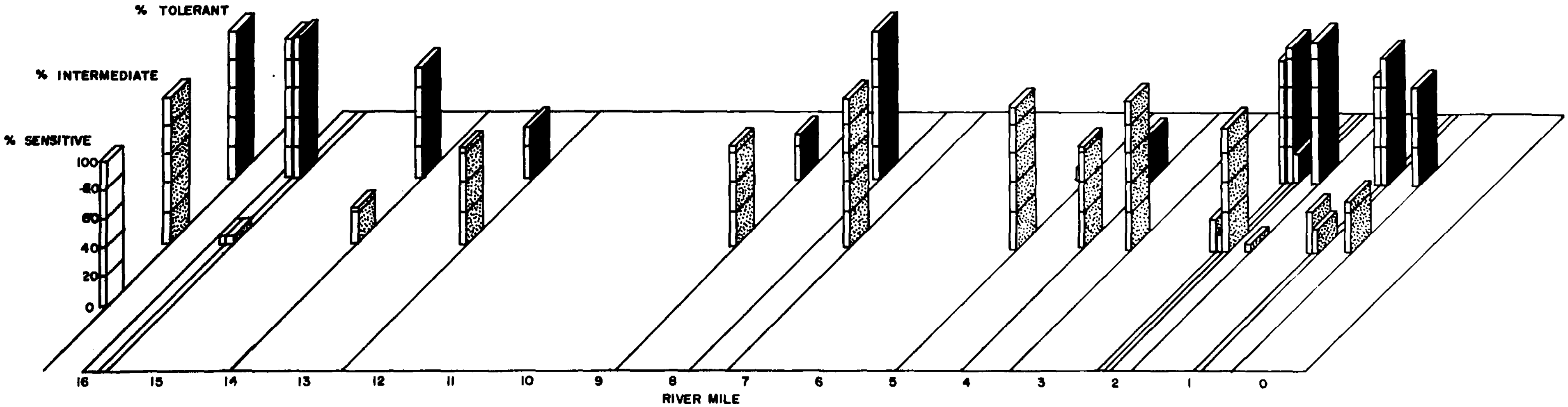
DISTRIBUTION OF BENTHIC ORGANISMS
IN MERRIMACK RIVER





DISTRIBUTION OF BENTHIC ORGANISMS
IN MERRIMACK RIVER

FIGURE 4 (CONT.)



DISTRIBUTION OF BENTHIC ORGANISMS
IN MERRIMACK RIVER

FIGURE 4 (CONT.)

be polluted not only in the general vicinity of the confluence with the Merrimack River but also for many miles upstream. Municipal sewage and wastes from pulping and tanning operations were discharged to the Pemigewasset River. Raw sewage from Franklin, New Hampshire, was discharged to the Winnipesaukee River. The Contoocook River received raw sewage, paperboard and tannery wastes. The Piscataquog River was mostly raw sewage from Manchester, New Hampshire, at the time of sampling. The Nashua River received the wastes from paper manufacturers and from raw and treated sewages. Municipal wastes from the City of Lowell, Massachusetts, were discharged to the Concord River. Industrial and municipal wastes were discharged to the Spicket and Shawsheen Rivers.

A relatively clean stream bed was found in the Whitman River just upstream of the Route 2A bridge, west of Fitchburg, Massachusetts. The Whitman River is a tributary to the North Nashua River.

Samples of bottom sediments taken from the Whitman River revealed a well-rounded population, with nineteen different kinds of bottom organisms. Organisms sensitive in their tolerance of pollution included caddisflies, beetles, mayflies and stoneflies. Six kinds of organisms intermediate in their tolerance of pollution were found. Kinds of benthic fauna considered intermediate in their tolerance of pollution are those commonly occurring in naturally enriched organic substrata. These included beetles, mothflies, midgeflies and clams. Pollution tolerant sludgeworms were also found. These data are presented in Table 2.

PEMIGEWASSET AND WINNIPESAUKEE RIVERS

The Merrimack River is formed by the confluence of the Pemigewasset River, draining the northern mountainous region of New Hampshire and the Winnipesaukee River which drains a large lake system in the central portion of the state.

A biological sampling site was established in the Pemigewasset River 0.46 miles upstream of its confluence with the Winnipesaukee River. Raw and partially treated sewage was discharged to the stream by most of the towns bordering the banks of the Pemigewasset. These wastes supported a lush growth of algae found covering the rocks and rubble in the stream bed.

In an unpolluted stream, a rocky stream bed such as this one with its coating of algae and organic debris, potentially provides abundant cover and nourishment to a large and varied population of benthic fauna. However, the actual numbers and types of fauna found here consisted of only 254 individuals per square meter with just nine kinds of bottom life, mostly herbivorous midgefly larvae. In comparison to a relatively unpolluted stream, such as the Whitman River, a tributary to the North Nashua River in Massachusetts, a total of 3,047 individuals per square meter and nineteen different kinds of benthic fauna were found in the bottom sediments (Table 2).

Especially noteworthy in these sediments from the Pemigewasset River was the total absence of pollution sensitive insect predator species, such as the mayflies.

The meager diversity and paucity of species found here indicates that the benthic community was affected by recent upstream organic pollution.

A biological sampling site was located in the Winnipesaukee River, 0.19 miles upstream of its confluence with the Pemigewasset River. At this location the water was grey-green, very turbid and sluggish. The stream bed was quite rocky. The bottom sediments contained brown fibrous matter in abundance and smelled like decomposing sewage sludge. Raw sewage discharged at Franklin produced septic conditions in the stream bed and overlying waters. Gases of anaerobic decomposition bubbled up from the stream bed during dredging of the bottom sediments. Insect predator species, such as stoneflies, which cannot tolerate poisonous gases resulting from the breakdown of sewage[2], were not found. Mayflies[3], stoneflies, caddisflies and certain bettles cannot withstand the low oxygen levels that occur here. Other more tolerant species, including the snails, leeches and certain midgefly larvae, were found in large numbers. A total of 2,033 individuals and seven kinds of bottom fauna, mostly leeches, were found per square meter of stream bed. This large number of a few tolerant species of bottom fauna, gases of anaerobic decomposition rising from the bottom sediments, and the abundance of raw sewage discharged to the stream from Franklin, New Hampshire, indicate that these headwaters were grossly polluted.

REACH 1, FRANKLIN TO BOSCAWEN, (115.70 to 114.04)

At a biological sampling site, located 0.53 miles downstream of the confluence, the stream bed was rocky and contained some sludge in which there were many fine, grey fibers. These fibers blanketed the benthic community and contributed to the reduction of the midgefly and snail populations. Respiratory body surfaces and gill structures may have been clogged by these fibers, resulting in suffocation. A total of 1,467 individuals and eight different kinds of bottom fauna were found per square meter of stream bed. Most of these were leeches, with a total of 1,120 individuals and four kinds per square meter. This large leech population, tolerant of the pollution of the river and the septic conditions, preyed upon the snail population and further depleted its number. Any of the kinds of benthic fauna such as the scuds, sowbugs, scavenger beetles and certain herbivorous midgeflies found upstream which may have been carried downstream to this site were either suffocated or unable to withstand the septic conditions. Further evidence of gross pollution of this area was the huge numbers of rotifers found clinging to the body surfaces of the midgefly larvae and leeches. These rotifers (Conochiloides sp.) feed on the bacteria and microcrustacea in waters where active bacterial decomposition of organic sludge is occurring.

The stream was rapid, shallow and passed over a stream bed primarily composed of sand with some rock 1.66 miles downstream of the confluence. This same stream bed under unpolluted conditions would be suitable for the development of many different kinds of bottom fauna, especially certain mayflies, caddisflies and waterpennies. However, only 216 individuals and three kinds of benthic fauna were found per square meter of this stream bed. Only certain midgeflies, a few leeches and sludgeworms could tolerate the grossly polluted environment.

The Merrimack River from the confluence of the Pemigewasset and Winnipesaukee Rivers to the end of this reach was grossly polluted and represented a zone of active decomposition.

REACH 2, BOSCAWEN TO PENACOOK, (113.53 to 102.84)

Dense growths of aquatic plants (Potomogeton sp.) covered the stream bed 2.17 miles downstream of the Winnipesaukee and Pemigewasset Rivers. In relatively unpolluted streams, prolific numbers of herbivores such as certain midgeflies and mayflies may be found feeding on the tissues of these plants. Innumerable snails browse on the debris near the roots, and predatory carnivores such as dragonflies and leeches search for sludgeworms and insects burrowing into the substrate for food or shelter.

However, such a community of bottom life did not exist at this site. The assemblage of bottom life found was impoverished both in kind and number. Only 615 individuals, mostly snails and sowbugs, and five kinds of fauna were found per square meter of stream bed. Sewage discharges taking place at upstream locations contributed an abundance of fertilizer, such as nitrogen and phosphorus, causing a prodigeous growth of aquatic plants. Neither midgefly larvae nor pollution sensitive insect species such as mayflies were found. The sparse population and paucity of species further characterized this area as one of moderate pollution.

Pollution sensitive caddisflies were found in the Merrimack River 3.10 and 4.52 miles downstream of the confluence. Herbivorous midgeflies were also found at these locations. Snails and snail-leeches were plentiful. Death and decay of aquatic plants at upstream areas apparently recycled additional fertilizer to this site, supplementing that not used by the upstream plants and causing another abundant plant growth (*Potomogeton sp.*). The Merrimack River showed signs of recovery at these two locations.

At 5.10 miles upstream of the Sewalls Falls Dam, there were a few clams (*Pisidium sp.*), leeches, sludgeworms and many snails. Midgefly larvae and the pollution sensitive caddisflies were not found. Although aquatic plants grew in abundance, providing food, cover and concealment for the bottom life, only 970 individuals and six different kinds of benthic fauna were found. The few kinds and numbers of bottom life and the prolific aquatic plant growth indicated that moderate pollution still existed in the stream.

The stream in this entire section may be characterized as one of moderate pollution but showing signs of recovery. Most of this river bed was covered with a dense plant growth nourished and sustained by the fertilizer from sewage discharged upstream.

REACH 3, PENACOOK TO CONCORD, (100.71 to 86.80)

As a result of the raw discharge of the Brezner Tanning Corporation, Boscawen, New Hampshire, massive organic pollution occurred in the Contoocook River one-half mile upstream of the confluence. The stream was clogged with rafts of decomposing sludges four to six inches in dimension, floating downstream to the Merrimack River. When the stream bed was disturbed, large volumes of decomposition gases and grey fibrous matter rose to the surface. The only benthic fauna found in the bottom sediments were leeches. Even these numbered only ninety-four individuals per square meter of stream bed. Other kinds of fauna which may have been carried downstream from areas in the Contoocook faced suffocation by clogging of respiratory surfaces with the fibrous matter discharged from the tannery, as well as death by the septic environment.

The Merrimack River was still in a zone of moderate pollution 5.41 miles downstream of the Contoocook River, although most of the organic sludges originating in the Contoocook had settled out behind Sewalls Falls Dam. Only four kinds of benthic fauna and 127 individuals, mostly sludgeworms, were found per square meter of stream bed. There were also a few leeches, snails and midgefly larvae in these bottom sediments. Pollution sensitive fauna were not found.

Farther downstream of Sewalls Falls Dam, the river recovered somewhat from the organic pollution very evident in upstream locations. Nine kinds of bottom fauna and 173 individuals were found per square meter of stream bed. Sediments removed from this area contained a few midgefly larvae, scuds, snails, leeches and sludgeworms. Even a few pollution sensitive caddisflies and riffle beetles were found in these sediments.

Five hundred feet downstream of the Route 4 bridge in Concord, New Hampshire, floating sludge masses with a septic sewage odor occurred. Bottom sediments dredged here were foul-smelling and were chiefly sewage sludges discharged from Concord. Large numbers of benthic fauna tolerant of the organic pollution were found in the sludge. Eight kinds of bottom life and 1,356 individuals, mostly sludgeworms, were found per square meter of stream bed. Benthic fauna found included clams, mussels, leeches, midgefly larvae and snails. Although the stream bed was gravel and potentially suitable for the case-making types of caddisflies found upstream of Concord, these nymphs could not have tolerated the septic environment.

In summary, this reach may best be described as one undergoing active decomposition of the organic pollutants discharged to the Merrimack River by the Contoocook River, moderate recovery shortly downstream of Sewalls Falls Dam, followed by another zone of gross organic pollution caused by the municipal wastes of Concord, New Hampshire.

REACH 4, CONCORD TO HOOKSETT, (86.80 to 81.05)

Dredging of the stream bed 0.20 and 0.50 miles, respectively, downstream of Garvins Falls Dam produced only an impoverished assemblage of bottom fauna, consisting of a few sludgeworms and midgefly larvae. At these locations, the river was still in a zone of moderate pollution even though most of the sewage sludges discharged at Concord had settled behind the dam.

In the Soucook River, 0.04 mile upstream of its confluence with the Merrimack River, and in the Merrimack River, one mile downstream of this confluence, only a few kinds and numbers of bottom fauna, mostly sludgeworms, were found in the bottom sediments. These sediments also contained snails, leeches and craneflies.

In a ponded section of the Merrimack River, 2.63 miles upstream of the Hooksett Dam, the sediments were composed mostly of silt and organic sludge. The small number of predatory leeches and the abundant food supply favored the development of a large number of omnivorous snails--348 per square meter were found.

Bottom sediments in the Suncook River, 0.2 miles upstream of its confluence with the Merrimack River, contained large numbers of snails and leeches, as well as a few clams and sludgeworms. These kinds of fauna flourish in quiescent, ponded areas enriched with dissolved nutrients, especially where rooted aquatic plants are available to supply food, cover and concealment. There was an extensive growth of pondweeds (Potomogeton sp.) throughout this sampling area. This location was in the backwater of the Merrimack River. Sewages supplied abundant nutrients and fertilizing elements to nourish both the flora and the fauna.

Bottom sediments dredged from the stream bed 0.19 miles upstream of the Hooksett Dam were black and had a septic odor, and consisted chiefly of sand, silt and organic sludges. A few midgefly larvae and dragonfly nymphs were found in these sediments. Other insect species, such as mayflies and certain caddisflies, could not tolerate the septic condition of the sediments and overlying waters. Although predatory leeches were found, they were few in number. Municipal discharges upstream contributed organic enrichment favoring development of the many snails and mussels found. A total of 352 snails and 120 mussels were found per square meter of stream bed.

Impoverished assemblages of benthic fauna in some areas, large numbers of a few species in other areas, and prolific growths of pond-weeds in backwater sections indicate that gross to moderate pollution existed in this section of the Merrimack River.

REACH 5, HOOKSETT TO MANCHESTER, (81.05 to 73.14)

This reach of the Merrimack River extends from the Hooksett Dam to the Amoskeag Dam in Manchester, New Hampshire.

Bottom sediments one-half mile downstream of the Hooksett Dam had a foul septic sewage odor. Anaerobic decomposition of the sewage, blood and paunch manure discharged to this area rendered the stream bed ineffectual as a habitat for most benthic fauna except for a few snails and leeches.

Bottom fauna in sediments dredged 3.45 miles downstream of the Hooksett Dam indicated that some improvement of the river had taken place. These fauna included many midgefly larvae, snails, leeches and even a few pollution sensitive caddisfly larvae. Eleven kinds of bottom fauna and 1,231 individuals were found per square meter of stream bed.

Conspicuous and favorable improvement of the benthic environment was found 4.26 miles downstream of the Hooksett Dam. Large numbers of individuals (1,845 per square meter) and sixteen kinds of caddisfly larvae, midgefly larvae, clams, snails, scuds, leeches and sludgeworms were found. The great diversity of benthic fauna found was not equalled or surpassed in any other location sampled in the Merrimack River.

Benthic sediments were black and had a septic odor near the end of this reach, located 1.03 miles upstream of the Amoskeag Dam. Municipal waste dumped into the river from northern Manchester contributed to the septic environment. Although certain species of caddisfly larvae can tolerate low dissolved oxygen concentrations[4], the septic environment would kill any of these larvae, such as those found upstream, which may have been dispersed to this area. Other kinds of benthic fauna, such as leeches and snails, apparently tolerated this type of environment as they were found in large numbers. Clams, midgefly larvae and mussels were also found, since organic food was abundant in these sediments.

Although there was some recovery evident in the central portion of this reach, both the first and last portions were grossly polluted.

REACH 6, MANCHESTER TO NASHUA, (73.14 to 55.75)

Massive organic pollution occurred in the first two miles of the Merrimack River downstream of the Amoskeag Dam. Sewage and industrial wastes from the city of Manchester were discharged to this section. The flow of the Piscataquog River consisted chiefly of the sewage from Manchester.

When the sediments were dredged from the stream bed 5.09 miles downstream of the Amoskeag Dam, few benthic fauna were found. There were only 453 individuals per square meter of stream bed. Although ten different kinds of bottom life were present, most of these were certain pollution tolerant midgefly larvae and leeches. A few mussels, snails and sludgeworms were also found. These few individual representatives of the several different kinds of benthic fauna found indicate that population depletion may have occurred not only as a result of the septic environment but also by suffocation brought about through settling of organic wastes discharged upstream. Scouring of the river bed occurred downstream of the Amoskeag Dam during peaking power operations at the dam. Scouring in this area led to mixing and resuspension of sewage and slaughterhouse and other industrial wastes, as well as settled organic sludges. The prolific growth of pondweeds (Potomogeton sp.) observed suggested the highly organic nature[5] of the soil, as well as attesting to the excessive fertilization of this stretch of the river. In addition, the body surfaces of the midgefly larvae and leeches taken from the sediments were covered with rotifers. These rotifers (Conochiloides sp.) were often found attached to benthic fauna found in areas of the Merrimack River known to receive gross organic pollution with sewage.

Resuspension of sediments occurred in the vicinity of Goffs Falls, New Hampshire. Deposition and decomposition of these sediments caused the sparse population of benthic fauna found at river mile 65.11. Only two kinds of bottom fauna, certain pollution tolerant midgefly larvae and sludgeworms, totaling 516 individuals, were found per square meter of stream bed.

Organic pollutants discharged into the Souhegan and Merrimack Rivers provide an ample food supply. However, 3.07 miles downstream of their confluence, only five kinds of benthic fauna and 269 individuals were found per square meter of stream bed. This fauna consisted of sludgeworms and a few midgefly larvae and leeches. The lethal action of the New England Pole and Wood Treating Corporations' discharge of phenols (2.32 miles upstream) caused the small size of the population.

The lethal action of phenol on fish has received considerable study. Wuhrmann and Woker, in a review[6] of the literature on the toxicity of phenol to fish, quote a number of limiting concentrations for various species ranging from 0.5 ppm to 20 ppm. The mussel fauna may very well have been eradicated from this section of the river because of their dependence in their life cycle on fish hosts. Concentrations of phenols in the river muds at river mile 61.18 were found to equal 8,000 ppm. Since phenols are also known to cause an intense irritant action on mucous membranes, mussels, clams and snails would suffer starvation and respiratory failure.

Benthic fauna found in sediments farther downstream were chiefly sludgeworms, with 7,092 worms found per square meter of stream bed. Except for a few midgefly larvae and these sludgeworms, no other form of benthic fauna was found in these sediments. Other forms of benthic fauna such as clams, mussels and snails may have been eradicated by phenolic substances or smothered by the large quantities of grease and oil found in the bottom sediments.

Bottom sediments at river miles 58.10 and 57.91 also contained only a few midgefly larvae and sludgeworms.

Some improvement in the stream bed took place 2.60 miles upstream of the confluence of the Nashua and Merrimack Rivers. Four different kinds of benthic fauna, including mussels, snails, sludgeworms and even caddisfly larvae, were found.

Reach 6 suffered gross organic and chemical pollution. There was some improvement at the end of the reach, however.

REACH 7, NASHUA TO NEW HAMPSHIRE-MASSACHUSETTS STATE LINE, (54.80 to 49.82)

Dredgings from the stream bed in the Nashua River were black and had a septic sewage odor. Discharges from upstream paper manufacturing operations and municipal sewage from Nashua, New Hampshire, contributed to the condition. Only two kinds of benthic fauna were found in these sediments—midgefly larvae and sludgeworms—and just sixty-four individuals per square meter of stream bed. Other benthic fauna such as snails and clams found upstream in the Nashua were not found here. These fauna either could not tolerate the septic environment or were smothered by the settling solids.

Upstream in the Nashua River Canal, the bottom sediments consisted chiefly of paper manufacturing sludges and contained a huge population of midgefly larvae, 6,856 larvae per square meter, and sludgeworms, 1,294 worms per square meter. The abundance of food and lack of predatory fauna favored development of pollution tolerant life.

No benthic fauna were found in sediments from the Merrimack River 0.55 miles downstream of the confluence with the Nashua. During dredging of the stream bed, nauseous gases of anaerobic decomposition bubbled to the surface. This portion of the Merrimack River was in a state of active decomposition. Benthic fauna dispersed to this area from upstream locations would face death by exposure to this septic environment or be smothered by fibrous matter found in abundance in these sediments.

Few benthic fauna except certain midgefly larvae and sludgeworms were found in bottom sediments dredged at three additional downstream locations at river miles 52.81, 52.72 and 52.53. In addition to the limiting or lethal septic environment in these areas, survival of these few benthic fauna was further endangered by oil and grease, especially noticeable in the sediments taken at river mile 52.72. Oil and grease coat the respiratory surfaces of bottom fauna, causing death by suffocation. Just as in other upstream locations receiving gross organic pollution, sediments dredged at river mile 52.53 contained certain midgefly larvae completely covered with rotifers. Whatever oxygen resource was still available to the larvae in this septic environment became even less available because of the decreased respiratory surface area used as points of attachment by these rotifers.

Throughout most of this reach, the Merrimack River was in a state of active decomposition. With the exception of a few midgefly larvae and sludgeworms, no other kinds of benthic fauna were found in sediments from the river bed.

REACH 8, NEW HAMPSHIRE-MASSACHUSETTS STATE LINE TO LOWELL, (49.82 to 40.60)

Septic conditions were especially noticeable during dredging of the bottom at river miles 48.57, 44.69 and 43.46, just downstream of the New Hampshire-Massachusetts state line. Nauseous gases bubbled out of the river bed and the sediments were black and odorous. Grease and oil were found in sediments at river mile 46.82. Fine grey fibers were found in dredgings from the river bottom at river miles 43.46 and 42.52, downstream of two wool-scouring plants.

Only one to four kinds of benthic fauna were found in this reach of the river. Sludgeworms ranged from 24-2,104 per square meter, midgefly larvae 0-8 per square meter, mussels 0-16 per square meter and snails 0-16 per square meter. No other benthic fauna were found in sediments dredged from the river bed. Septic conditions suppressed or killed most benthic fauna. Others faced death by suffocation brought about by clogging of respiratory surfaces with solids or by coating of these surfaces with grease and oil.

This reach showed very little improvement, continuing throughout most of its length in a zone of active decomposition.

REACH 9, LOWELL TO LAWRENCE, (40.60 to 28.99)

Reach 9 extends from the Pawtucketville Dam at Lowell, Massachusetts, to the Essex Dam at Lawrence. Except for a rapids area extending about three miles downstream of the Pawtucketville Dam, the remaining portion of this reach is in quiet water as a result of the backwater of the Essex Dam. The reach was found to be grossly polluted by the discharge of organic wastes.

Decomposition of bottom sediments was especially remarkable at two locations, river miles 36.36 and 36.30, downstream of the confluence of the Concord and Merrimack Rivers. Gas-lifted fecal matter and putrid sludges floated about the water surface. During dredging of the stream bed, decomposition gases bubbled to the surface.

An extensive and varied assemblage of benthic fauna such as certain burrowing mayflies, caddisflies, mussels and clams would under unpolluted conditions occupy a stream bed of this type. However, only sludgeworms (8-299 per square meter), midgefly larvae (0-347 per square meter) and, in one location, leeches (42 per square meter) were found. These few kinds and numbers were the only benthic fauna surviving in the polluted sediments. The septic sludge and overlying water markedly reduced available oxygen. A further hazard to survival of the midgefly larvae were the numerous rotifers found attached to their body surfaces, thereby reducing the available respiratory surface area. These rotifers were especially noticeable on the fauna found in the sediments at river miles 36.36, 35.11 and 31.92.

As in the reach upstream, this reach was in a zone of active decomposition throughout most of its length. Only a few pollution tolerant leeches, midgefly larvae and sludgeworms were found.

REACH 10, LAWRENCE TO HAVERHILL, (28.99 to 15.70)

The reach is broken down into three sections. Section 1 is that portion of the river between the cities of Lawrence and Haverhill. Section 2 is that portion through Haverhill and extending downstream to Buoy 61. Section 3 extends from Buoy 61 to the Groveland Bridge.

Gases of anaerobic decomposition bubbled up from the stream bed.

Gas-lifted fecal matter and islands of decomposing organic filth floated throughout the sampling area. Just prior to dredging, samples of water taken within a foot overlying the stream bed were found to be acid (pH 6.3-6.9) with concentrations of dissolved oxygen ranging from 1.2 to 4.1 mg/l ($T = 20^{o}C$). Stream bed sediments were primarily organic and had a strong sewage odor.

The only benthic fauna found in section 1 were midgefly larvae and sludgeworms, except for a few leeches found at river mile 28.50. No benthic fauna were found at river mile 25.35. In general, snails are uncommon in streams whose surface waters are more acid than pH 6.2 and require rather high concentrations of dissolved oxygen(7). The acid waters and septic conditions prevailing in this section would limit, if not prevent, the development of snail populations. Also, leeches which do not appear to be able to tolerate gases of anaerobic decomposition at low oxygen tensions(7) were not found, nor could they survive in this section of the river where decomposition gases as well as low concentrations of dissolved oxygen occurred. An abundance of dissolved oxygen also appears to be an environmental necessity(7) to scuds. Scuds were not found in this section of the river. Most of the midgefly larvae and all of the sludgeworms contained red blood pigments which enabled them to survive the low dissolved oxygen levels common to this section.

The second section resembled the first in that decomposition gases rapidly rose to the river surface during dredging. Gas-lifted islands of fecal matter and decomposing sludge up to four inches in dimension were abundant. Sludge formed accumulations up to six inches deep along the river banks at river mile 17.30 downstream of Haverhill. Dissolved oxygen concentrations in this section ranged from 1 to 2.5 mg/l (T = 20°C) in water immediately above the stream bed. The pH ranged from 6.4 to 6.7. Bottom sediments in this section were mostly organic, black and had the stench of septic sewage.

There were a few leeches, snails and even a few marine clams in the sediments dredged at river mile 19.62. Midgefly larvae and sludgeworms were the predominant benthic fauna found in this section. As had been observed in other areas of the Merrimack which were grossly polluted with organic matter, certain rotifers were attached in great numbers to the body surfaces, especially the gills, of the midgefly larvae, thereby reducing the respiratory surface area and making it even more difficult for these larvae to survive.

This section, subjected to tidal action, is a mixohaline region. Very few species can survive in this region; therefore, one would not expect to find either very many or much diversity. However, several kinds of marine fauna can adapt to salinities less than those found in the sea, such as certain sowbugs (Cyathura carinata) and scuds (Gammarus sp.)(5). Neither of these marine forms were found here, but they did appear at the next downstream stations. Although certain fresh-water animals will tolerate variations in salinity, such as sludgeworms and certain midgefly larvae, most find tidal waters uninhabitable because the organisms do not contain structures or mechanisms for maintaining a proper salt balance. It is important to note that at river miles 19.35 and 17.75, no benthic fauna of either fresh or marine origin were found. Without doubt, gross organic pollution in this section was responsible for the lack of either fresh or marine benthic fauna found here.

In section 3, bottom sediments were composed mostly of sand and rock with some organic sludge. Septic conditions existed at river mile 16.51 where the dissolved oxygen level a foot over the stream bed was 1.9 mg/l (T = 21°C). Some gas bubbled to the surface in this same area during dredging. Leeches, clams, midgefly larvae, scuds and sludgeworms were found. Rotifers, abundant on the body surfaces of the midgefly larvae and leeches, were nourished by the bacteria and microcrustacea supplied through decomposition of the bottom sediments. Low oxygen levels and septic conditions are known to favor certain kinds of benthic fauna, such as sludgeworms, resulting in great numbers of them. The sludgeworm population at river mile 15.68 was very large, with 14,972 worms per square meter. The stream bed did support greater numbers of both marine and fresh water fauna, but these were forms of bottom life that could tolerate the gross organic pollution in this section.

REACH 11, HAVERHILL TO ATLANTIC OCEAN, (15.70 to 0.00)

This reach is divided into two sections. Section 1 extends from the Groveland Bridge to the Route 1 Bridge, river mile 2.91. Section 2 extends from the Route 1 Bridge to the ocean.

Throughout the first section, the sediments were composed of silt and sand. Dissolved oxygen concentrations ranged from 2.1 to 3.6 mg/l in the water one foot above the stream bed. For the first 8.42

miles of this section the temperature one foot above the stream bed was 20°C. The remaining portion of 4.37 miles reflected tidal excursion upstream with temperatures dropping to 17.5°C at river mile 4.10. Throughout this section, decomposition gases bubbled to the surface during dredging.

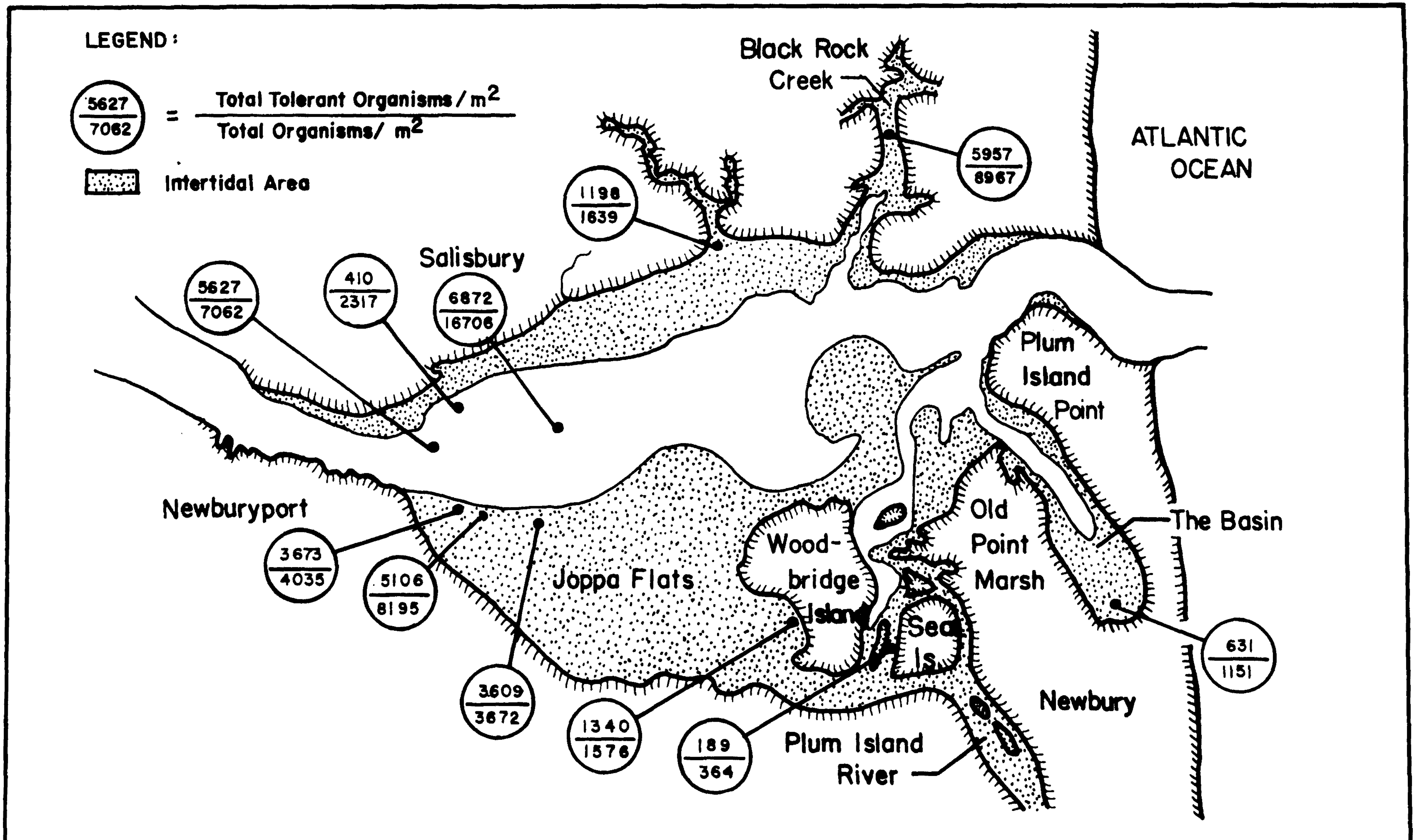
Benthic fauna of freshwater origin in the sediments from Section 1 consisted of midgefly larvae and sludgeworms. Marine fauna in these sediments included scuds, sowbugs and marine worms. Downstream of river mile 7.80, freshwater populations of midgefly larvae and sludgeworms markedly declined in number. Neither group existed at the end of the section.

Several factors led to the demise of the freshwater fauna and the absence of saltwater fauna. Although organic matter of sewage origin was especially noticeable in the silty bottom sediments upstream of river mile 7.80, bottom sediments at downstream locations were composed of relatively clean sand with enough organic matter to support anaerobic bacterial decomposition. Availability of food for life support[8] apparently was not a limiting factor in this area. The unstable stream bed brought about by tidal action was the more probable cause for the decline in fresh and saltwater benthic fauna. Only a small number of marine scuds and sowbugs penetrated the polluted waters in this section.

Section 2 of this reach encompasses the estuarine portion of the Merrimack River. The partially treated sewage from the towns of Salisbury and Newburyport, as well as wastes carried to this area by the

Merrimack River, nourish an abundant benthic fauna and flora. At river mile 1.73, about one-half mile downstream of the Newburyport sewage outfall, marine worms numbered 6,399 per square meter. Even freshwater sludgeworms in sediments dredged at this location numbered 2,459 per square meter. Large numbers of clams, mussels, scuds and sowbugs were also found in the sediments. Sea lettuce flourished in the estuary, especially just west of Woodbridge Island and Black Rock Creek. A summary of total tolerant and total organisms found in the estuary is shown in Figure 5.

FIGURE 5



BENTHIC ORGANISMS IN MERRIMACK RIVER ESTUARY- 1964

BOTTOM ORGANISMS OF SOUHEGAN RIVER

In late May and early June, 1965, a biological survey was carried out on the lower Souhegan River, a tributary which discharges into the Merrimack River 12.5 miles upstream of the New Hampshire-Massachusetts state line. The section studied extended from just upstream of Wilton, New Hampshire, to the mouth of the Souhegan. A list of the sampling stations and reference points is presented in Table 4.

Three locations were sampled upstream of Wilton—two in the Souhegan River and one in Stony Brook. The only known source of pollution occurs at Greenville, New Hampshire, about 8.4 miles upstream of Wilton, where raw sewage from approximately 500 persons is discharged. In each of these three locations, pollution sensitive organisms were found to be predominant both in total numbers and in their diversity of species (Table 5 and Figure 6). The river at mile 21.46 was cool ($T = 15^{\circ}C$) and shallow, with a rocky bed and fast current. The water was soft (Hardness = 12 mg/l as $CaCO_3$), low in alkalinity (5 mg/l as $CaCO_3$) and well oxygenated (Dissolved Oxygen = 10.8 mg/l).

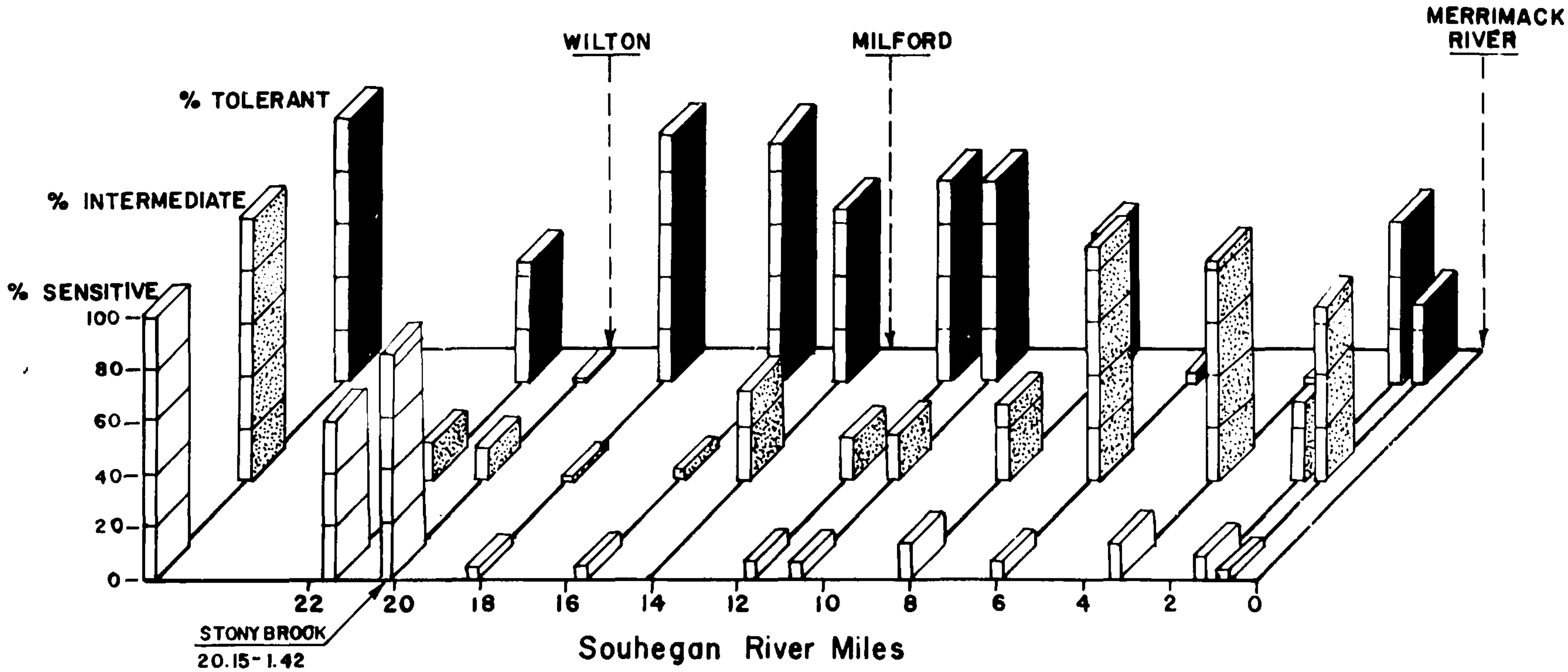
The Souhegan River between Wilton and Milford, New Hampshire, deteriorated considerably, with pollution tolerant leeches and sludgeworms making up most of the benthic fauna found. Textile operations and raw sewage from Wilton accounted for the polluted condition in the river. The dissolved oxygen dropped to 7.1 mg/l but there was little change in hardness, alkalinity and temperature from upstream. Throughout most of this reach, the stream bed was rocky and the current moderate.

Moderately polluted conditions continued to exist in the stream for several miles downstream of Milford, which discharges the raw sewage of approximately 3,000 persons. Gases from decomposition of sludge deposits were noted at river mile 8.42. The stream meandered throughout this section and had a moderate current and shallow depth. The stream bed was mostly sandy with some gravel and loam. Dissolved oxygen continued high.

By the time the Souhegan River reached the Amherst-Merrimack town line, the river showed signs of recovery from a biological standpoint. Bottom organisms generally found in moderately polluted environments, such as certain midgeflies and snails, assumed dominance both in species diversity and in percentage of total organisms. There was a marked decline in the percentage of pollution tolerant individuals compared to the section just downstream of Milford (Figure 6). The stream bed was sandy with some sandy loam. The shallow depth and moderate current continued. Dissolved oxygen increased from 7.3 mg/l at river mile 6.51 to 9.0 mg/l at river mile 3.12 at a temperature of 15°C.

Sampling of the river in a riffle area just upstream of Wildcat Falls, river mile 1.15, showed the continued dominance of benthic fauna generally found in moderately polluted streams. However, there was an increase in the proportion of tolerant forms. Similar conditions were found in the sample taken just downstream of the Everett Turnpike and upstream of the waste discharges of Merrimack, New Hampshire.

Bottom organisms that were sensitive to pollution were found at all sampling sites except at river mile 14.49 at Milford. Where



DISTRIBUTION OF BENTHIC ORGANISMS IN SOUHEGAN RIVER

FIGURE 6

these organisms were found, those occurring most frequently were the caddisflies, mayflies and riffle beetles.

The greatest numbers of tolerant organisms were found between river miles 18.17 and 8.42, forty-seven per cent of the length of stream studied. Sludge worms were the tolerant kind most frequently found.

From a biological standpoint, the river was moderately polluted from Wilton, New Hampshire, to the confluence with the Merrimack River, a distance of twenty miles.

PRODUCTIVITY OF THE MERRIMACK RIVER

A productivity study of short duration of the Merrimack River between Manchester, New Hampshire and Lowell, Massachusetts, was initiated in August 1965. Three sampling stations were selected at river miles 65.11, 48.76 and 43.47. The data were plotted downstream of the Queen City Bridge in Manchester, New Hampshire, (river mile 71.07) to indicate the productivity of the stream after passing through the major cities of Manchester and Nashua in New Hampshire.

Algae are reported(9) (10) to be adversely affected in culture media when the concentration of inorganic nitrogen falls below 0.2 mg/l and that of phosphorus below 0.05 mg/l. Sawyer reported in the Madison Lakes survey(11) that nuisance algae conditions were expected when inorganic phosphorus was found in excess of 0.01 mg/l and an inorganic nitrogen level of 0.30 mg/l. Recently, Maloney(12) reported that algal growth was exponential in concentrations of detergent phosphorus above 0.1 mg/l as phosphorus. Reference to Table 6 indicates that the nitrogen and phosphorus levels found in the Merrimack River were obviously not limiting to potentially abundant growths of phytoplankton at any of the stations.

As indicated in Figure 7, photosynthetic oxygen production, concentration of chlorophyll a, and the total number of phytoplankton increased downstream of the Queen City Bridge. The inflow of nutrient phosphorus and nitrogen was potentially capable of supporting an abundant

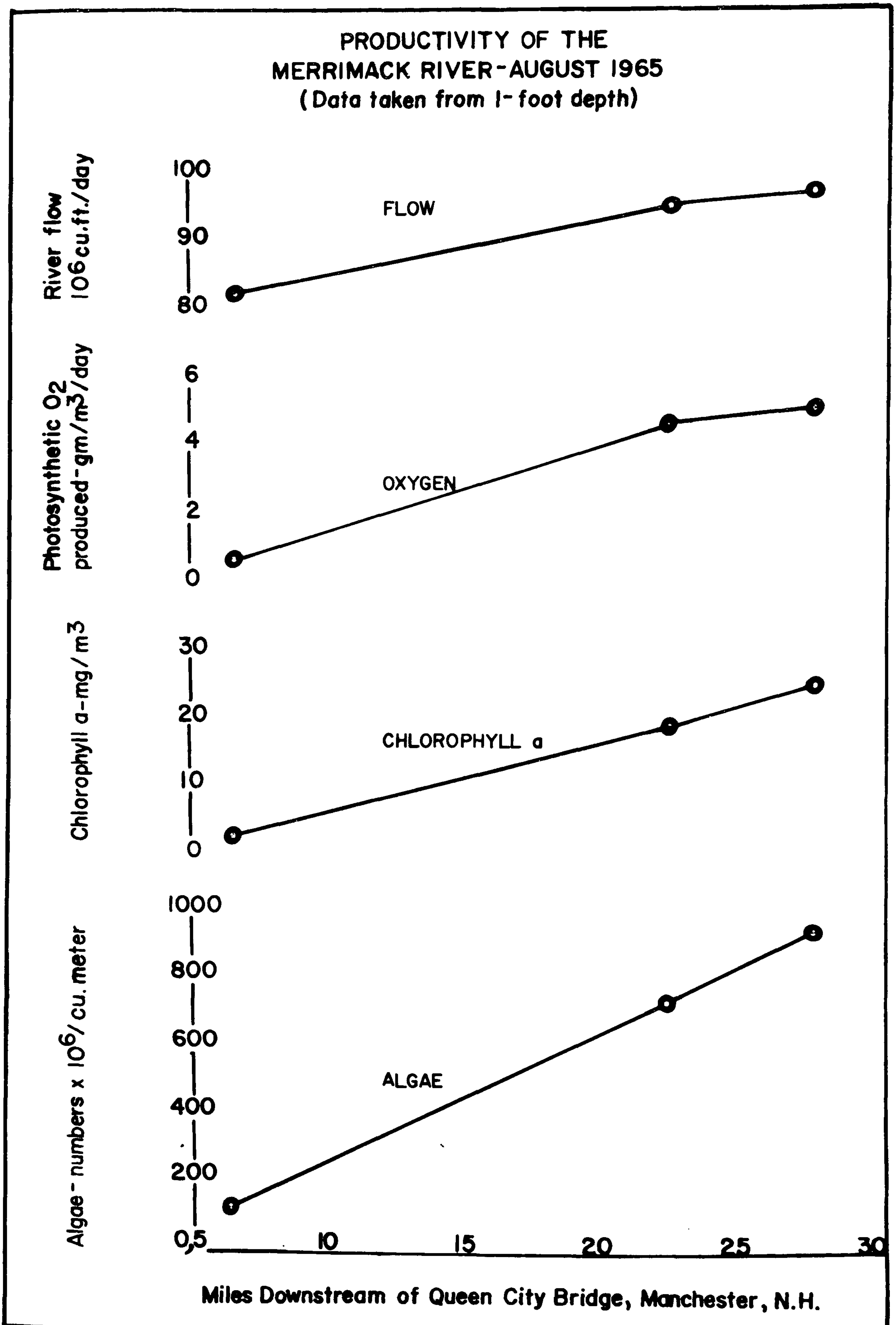

PRODUCTIVITY OF THE
MERRIMACK RIVER-AUGUST 1965
(Data taken from 1-foot depth)
River flow
106 cu.ft./day
100
90
80
FLOW
Photosynthetic O2
produced-gm/m3/day
6
4
2
0
OXYGEN
Chlorophyll a-mg/m3
30
20
10
0
CHLOROPHYLL a
Algae-numbers x 106/cu.meter
1000
800
600
400
200
0,5
ALGAE
10
15
20
25
30
Miles Downstream of Queen City Bridge, Manchester, N.H.

FIGURE 7

growth of phytoplankton in any of the three reaches. The backwater effect of the dam at Lowell, Massachusetts, caused an environment in the two downstream stations more favorable to the growth of algae. Chlorophyll a was measured in accordance with the procedure outlined by Creitz & Richards[13] and proved to be a less time-consuming method for the estimation of standing crop than that of the identification and enumeration of algae. Photosynthetic oxygen production was measured by the light and dark bottle technique.

In this study, the use of several tools--photosynthetic oxygen production, measurement of chlorophyll a, enumeration of algae—appear necessary to fully interpret productivity especially where nutrient levels were sufficient to cause an abundant growth in any of the stations studied. These tools adequately reflected a relative increase in productivity in the Merrimack River downstream of the Queen City Bridge to the City of Lowell, Massachusetts.

MICROSCOPIC PLANKTON IN MERRIMACK RIVER

The surface water of the Merrimack River at the entrance to the Essex Canal in Lawrence was monitored periodically for phyto- and zooplankton during April through October 1965. Samples were hand dipped and then brought to the laboratory where the microscopic plankton were concentrated by the Sedgewick-Rafter method. The algae were identified as to genera and the concentration reported in areal standard units per ml of the sample (ASU/ml). The data are shown in Figure 8 and Tables 7 and 8.

The diatoms gradually increased from a low average of 348 ASU/ml in April to a maximum of 931 ASU/ml in July. In order of decreasing occurrence, those genera of diatoms found were Melosira, Synedra, Asterionella, Navicula and Fragilaria. Except for Asterionella, all of the other four most abundant diatoms were listed by Palmer(14) as most tolerant of pollution.

The green algae rapidly increased from a low average of twenty ASU/ml in April to a maximum of 3,285 ASU/ml in July, after which the average count fell to 1,289 ASU/ml in October. Again, of the five most abundant genera found, four of the five genera were included(14) among the fifty-two most tolerant genera of algae. These were, in order of decreasing occurrence: Scenedesmus, Eudorina, Pediastrum and Pandorina.

The blue-green algae were not found to any significant extent except in July, when the average count was 1,210 ASU/ml. Only species of Coelosphaerium, Anabaena, Oscillatoria and Polycystis were found.

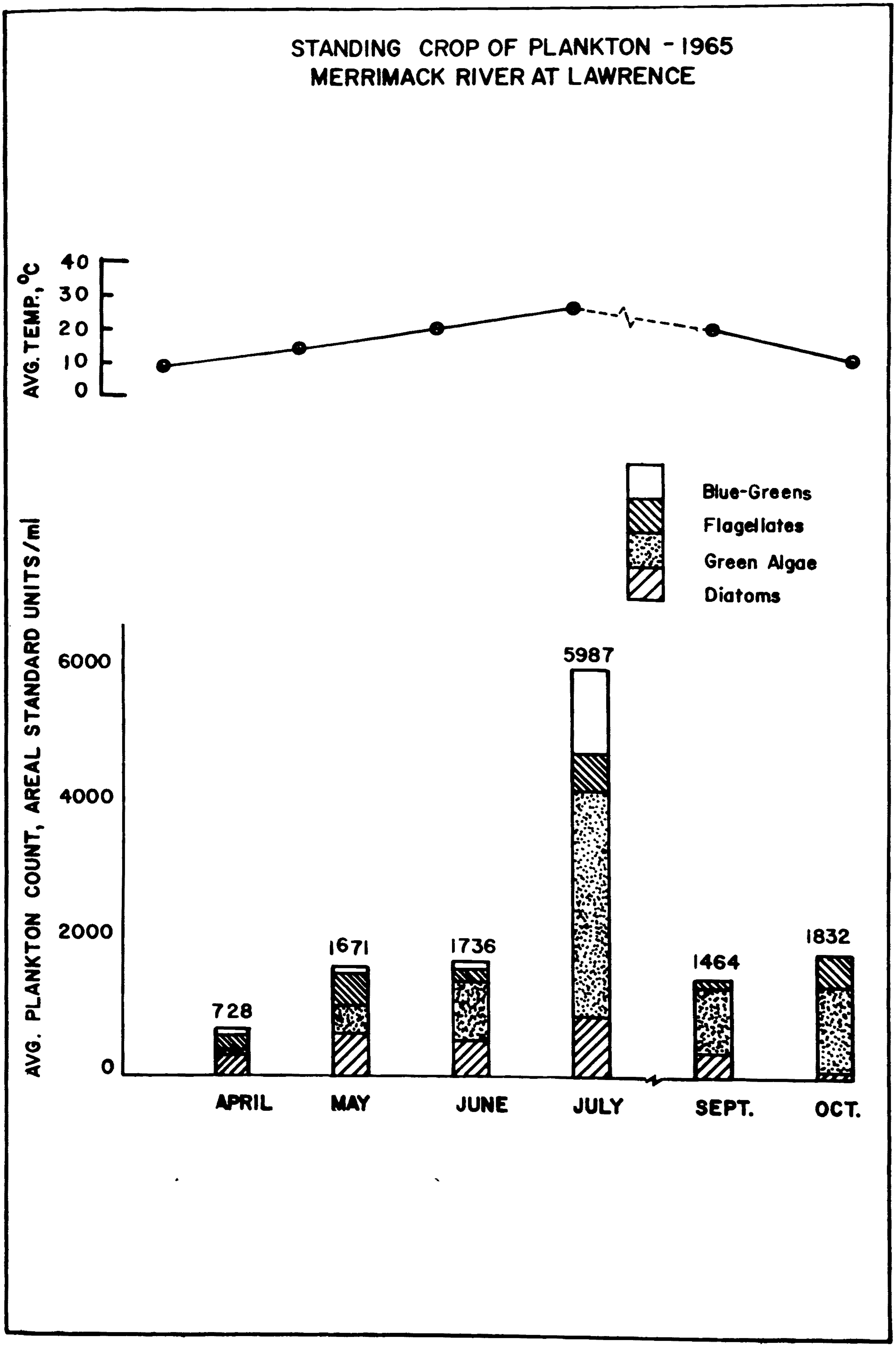

STANDING CROP OF PLANKTON - 1965
MERRIMACK RIVER AT LAWRENCE
AVG. TEMP., °C
40
30
20
10
0
Blue-Greens
Flagellates
Green Algae
Diatoms
AVG. PLANKTON COUNT, AREAL STANDARD UNITS/ml
6000
4000
2000
0
728
1671
1736
5987
1464
1832
APRIL
MAY
JUNE
JULY
SEPT.
OCT.

FIGURE 8

Of these four genera, Oscillatoria and Anabaena are most tolerant of pollution. Blue-greens were not found in September and October.

The flagellated protozoa found most frequently were Chlamydomonas, Dinobryon, Synura, Mallomonas and Euglena. Both Euglena and Chlamydomonas are considered the genera most tolerant of pollution.

Early summer showed a marked rise of the zooplankton. Codonella and Vorticella species were the most common ciliates found. The genera of rotifers which were found most frequently were Anuraea, Synchaeta, Polyarthra and Triarthra. Daphnia, Cyclops and Bosmina were the most common crustacea found. Both the rotifers and crustacea appeared to be more abundant during the summer and autumn than in the spring period.

SUMMARY AND CONCLUSIONS

The biological conditions, with few exceptions, show that the Merrimack River is grossly polluted from Franklin, New Hampshire, to its mouth at Newburyport, Massachusetts.

Benthic organisms sensitive to pollution were absent from the samples taken in the lower fifty-seven miles of the Merrimack River. In only four extremely short portions of the river, consisting of less than fifteen miles out of the total river mileage of 116, did the river recover enough from its despoiled condition to permit a small number of sensitive organisms to exist before additional wastes reduced the quality of the river. These four areas were: four miles below the confluence of the Pemigewasset and Winnipesaukee Rivers; above Concord, New Hampshire, in the reservoir behind Amoskeag Dam; and just above the Nashua River confluence.

Organisms intermediate in their response to pollution were predominant from Franklin, New Hampshire, to the confluence of the Contoocook River. Additional waste discharges between the Contoocook River and the Suncook River resulted in an increase in the proportion of pollution tolerant forms. Between Hooksett and Manchester, New Hampshire, the majority of bottom organisms again were of the types intermediate in their resistance to pollution. From Manchester to Amesbury, Massachusetts, a distance of sixty-six miles, pollution tolerant organisms constituted the entire benthic population or the majority of the forms found.

The number of species found in the Merrimack River was far below the levels desired in a benthic community. Pollution sensitive benthic fauna, such as mayflies, stoneflies and certain beetles, were not found in the river from Manchester, New Hampshire, to the Atlantic Ocean.

A number of tributaries were sampled near their confluences with the Merrimack River. Results show that all of the sampled areas were polluted. In most cases, wastes were discharged into the lower part of the tributary and affected the bottom fauna.

A biological survey was carried out on the lower Souhegan River, a tributary which discharges into the Merrimack River 12.5 miles upstream of the New Hampshire-Massachusetts state line. Between Wilton and Milford, New Hampshire, the Souhegan deteriorated considerably, with pollution tolerant leeches and sludgeworms making up most of the benthic fauna. This polluted condition of the river continued for several miles downstream of Milford. From a biological standpoint, the river was moderately polluted from Wilton, New Hampshire, to its confluence with the Merrimack River, a distance of twenty miles.

A productivity study of the Merrimack River was conducted between Manchester, New Hampshire, and Lowell, Massachusetts, that reflected a relative increase in productivity as the river flowed downstream.

The surface water of the Merrimack River at the entrance to the Essex Canal in Lawrence was monitored periodically for phyto- and zooplankton from April through October 1965. Most of the kinds of phytoplankton found were tolerant of pollution.

REFERENCES

1. Report on Pollution of the Merrimack River and Certain Tributaries - Part V - Nashua River, U. S. Department of the Interior, Merrimack River Project, Lawrence, Massachusetts, August 1966.

2. Gaufin, A. R., Environmental Requirements of Plecoptera, Third Seminar, 1962 - Biological Problems in Water Pollution, USDHEW, Cincinnati, Ohio.

3. Ibid., Leonard, J. W., Environmental Requirements of Ephemoptera.

4. Ibid., Roback, S. S., Environmental Requirements of Trichoptera.

5. Macan, T. T., Freshwater Ecology, John Wiley and Sons, Inc., pp. 213 and 255, 1964.

6. Jones, J. R. E., Fish and River Pollution, Butterworths, London, pp. 144-151, 1964.

7. Pennak, Robert W., Fresh Water Invertebrates of the United States, Ronald Press Company, New York, 1953.

8. Brinkhurst, R. O., The Biology of the Tubificidea with Special Reference to Pollution, Third Seminar 1962 - Biological Problems in Water Pollution, USDHEW, Cincinnati, Ohio.

9. Chu, S. P., The Influence of the Mineral Composition of the Medium on the Growth of Planktonic Algae, Part I. Methods and Culture Media, Journal of Ecology, Vol. 30, No. 2, pp. 284-325, 1942.

10. Ibid., Part II. The Influence of the Concentration of Inorganic Nitrogen and Phosphate Phosphorus, Vol. 31, pp. 109-148, 1943.

11. Sawyer, C. N., Some New Aspects of Phosphates in Relation to Lake Fertilization, Sewage and Industrial Wastes, Vol. 24, No. 6, pp. 768-776, 1952.

12. Maloney, T. E., Detergent Phosphorus Effect on Algae, Journal Water Pollution Control Federation, Vol. 38, No. 1, pp. 38-45, January 1966.

13. Creitz, G. I., and Richards, F. A., The Estimation and Characterization of Plankton Populations by Pigment Analysis. III. A Note on the Use of Millipore Membrane Filters in the Estimation of Plankton Pigments, Journal of Marine Research, Vol. 14, No. 3, pp. 211-216, 1965.

14. Palmer, C. M., The Effect of Pollution on River Algae, New York Academy of Sciences, Vol. 108, Article 2, pp. 389-395, June 29, 1963.

APPENDIX

TABLE 1

BIOLOGICAL SAMPLING STATIONS AND REFERENCE POINTS

MERRIMACK RIVER AND TRIBUTARIES

STATION	RIVER MILE	DESCRIPTION
1	115.70-0.46	Pemigewasset River, 4 ft. depth off east bank-1000 ft. upstream of large rock near confluence with Winnepesaukee River.
2	115.70-0.19	Winnepesaukee River, 3 ft. depth off south bank-1000 ft. upstream of big rock near confluence with Pemigewasset River.
-	115.70	Confluence of Pemigewasset and Winnepesaukee Rivers.
3	115.53	Merrimack River, 3 ft. depth off east bank- 1000 ft. downstream of confluence of Pemigewasset and Winnepesaukee Rivers.
4	114.04	1 ft. depth off west bank downstream of Franklin, N.H.
5	113.53	4 ft. depth in midstream channel at Daniel Webster Island.
6	112.60	3 ft. depth off west bank 1 mile downstream of Daniel Webster Island.
7	111.18	4 ft. depth off west bank under high tension wires.
8	102.84	1 ft. depth off east bank 1000 ft. upstream of White Tower.
9	100.71-0.5	Contoocook River, 6 ft. depth, off south bank 500 ft. downstream of R.R. bridge below tannery.
-	100.71	Confluence with Contoocook River.
-	97.83	Sewells Falls Dam.
10	95.30	4 ft. depth off north bank 1 mile upstream of Iron bridge above Concord.
11	93.38	2 ft. depth, 1 mile downstream Rt. 3B bridge.

TABLE 1 (Continued)

STATION	RIVER MILE	DESCRIPTION
-	91.60	U. S. Route 4 & 202 Bridge, Concord, N. H.
12	91.51	10 ft. depth off west bank, 100 ft. downstream 4 ft. diameter outfall.
-	87.61	Confluence with Turkey River.
-	86.80	Garvins Falls Dam.
13	86.60	8 ft. depth, 1/5 mile downstream from Garvins Falls Dam.
14	86.30	1 ft. depth in midstream, off sandbar 1/2 mile downstream of Garvins Falls Dam.
15	85.80-0.04	Soucook River, 2 ft. depth off north bank 200 ft. upstream of confluence with Merrimack River.
-	85.80	Confluence with Soucook River.
16	84.80	10 ft. depth off east bank, 1 mile downstream of Soucook River.
17	83.68	4 ft. depth off west bank near Bow Bog Brook.
18	82.90-0.2	Suncook River, 3 ft. depth, midstream, 100 ft. downstream of 5 ft. cement outfall.
-	82.90	Confluence with Suncook River.
19	81.24	4 ft. depth off east bank, 1000 ft. upstream of Hooksett Dam.
-	81.05	Hooksett Dam.
20	80.55	10 ft. depth off west bank, 100 ft. downstream of R.R. bridge.
21	77.60	8 ft. depth off east bank, 3 miles downstream of Hooksett, N. H.
22	76.79	8 ft. depth under 1st high tension wires downstream of Hookset Dam.
23	74.17	8 ft. depth off east bank, 20 ft. downstream of outfall opposite 4 radio towers.

TABLE 1 (Continued)

STATION	RIVER MILE	DESCRIPTION
-	73.14	Amoskeag Dam, Manchester, N. H.
-	71.30	Confluence with Piscataquog River.
24	68.05	1 ft. depth off east bank, 200 ft. upstream of R.R. bridge.
25	65.11	1 ft. depth off east bank under high tension wires, about 3 miles downstream of Goffs Falls.
-	62.35	Confluence with Souhegan River.
26	59.28	4 ft. depth off west bank, 1 mile below Nesenkeag Brook.
27	58.29	5 ft. depth off east bank, 0.36 mile below Little Nesenkeag Brook.
28	58.10	6 ft. depth in midstream at Rodonis' Farm.
29	57.91	6 ft. depth, 1000 feet below Rodonis' Farm.
30	57.10	4 ft. depth, midstream, 0.65 mile below Pennichuck Brook.
31	55.75	4 ft. depth off east bank at high tension wires about 1 mile upstream of Hudson Bridge.
32	54.80-0.01	Nashua River, 1 ft. depth, midstream, 50 feet upstream of confluence with Merrimack River.
33	54.80-4.0	Nashua River, 4 ft. depth off south bank of canal, 10 ft. upstream of Rt. 3 bridge.
-	54.80	Confluence with Nashua River.
34	54.25	5 ft. depth off east bank, 100 ft. downstream of Twin Piers below Hudson.
35	52.81	7 ft. depth, midstream 500 ft. upstream of high tension wires.
36	52.72	Under high tension wires.
37	52.53	5 ft. depth, 1000 feet downstream of high tension wires.

TABLE 1 (Continued)

STATION	RIVER MILE	DESCRIPTION
-	49.82	New Hampshire-Massachusetts state line.
38	48.95	7 ft. depth, 1000 ft. upstream of Lakeview Avenue.
39	48.76	7 ft. depth, at Lakeview Avenue.
40	48.57	8 ft. depth, 1000 ft. downstream of Lakeview Avenue.
41	47.54	10 ft. depth, 1000 ft. upstream of Tyngsboro Bridge.
42	47.35	10 ft. depth, Tyngsboro Bridge.
43	47.16	10 ft. depth, 1000 feet downstream of Tyngsboro Bridge.
44	46.82	10 ft. depth, below power lines.
45	44.69	9 ft. depth, 200 feet downstream of Tyngsboro Island and small channel.
-	43.47	Lowell Water Intake.
46	43.47	4 ft. depth, 50 feet downstream of Deep Brook.
47	42.52	10 ft. depth, 50 feet downstream of power line.
48	42.22	10 ft. depth, off north bank, near Lowell Drive-In.
-	40.60	Pawtucketville Dam, Lowell, Mass.
-	38.75	Confluence with Concord River.
49	37.45	Below Duck Island.
50	36.89	4 ft. depth, off south bank 100 ft. downstream of gas line crossing.
51	36.36	7 ft. depth, off north bank-15 ft. downstream of Richardson Creek culvert.
52	36.30	9 ft. depth, at midstream 300 ft. downstream of culvert-Richardson Creek-near golf course.
53	35.11	200 yards upstream of power lines.
54	34.48	150 yards upstream of Dracut-Methuen line.

TABLE 1 (Continued)

STATION	RIVER MILE	DESCRIPTION
55	34.39	Dracut-Methuen line.
56	33.93	100 yards upstream of used car lot near Wheeler St.
-	33.03	Confluence with Fish Brook.
57	32.37	Drive-In Theater, Methuen.
58	31.92	At Mill Pond Brook (Bartlett Brook) off north bank.
59	31.74	Upstream end of Pine Island.
60	31.66	100 yards upstream of Interstate 93 bridge.
-	29.81	Lawrence Water Intake.
-	28.99	Essex Dam, Lawrence, Mass.
61	28.50	3 ft. depth, off east bank, 1/2 mile downstream of Essex Dam.
-	27.85	Confluence with Spickett River.
-	27.45	Confluence with Shawsheen River.
62	25.35	4 ft. depth, off north bank, opposite Western Electric outfall.
63	23.43	4 ft. depth, off east bank, upstream of Kimball Island.
64	21.85	4 ft. depth, off south bank, opposite Creek Brook.
65	21.15	4 ft. depth, off south bank, opposite Stanley Island.
66	19.62	4 ft. depth, off south bank, opposite Moody School.
67	19.35	5 ft. depth, off north bank, 1000 ft. upstream of Washington St. and Rt. 113 bridge.
-	18.85	Confluence with Little River.
68	17.75	5 ft. depth, off north bank, 200 ft. below outfall of Hale Hospital.

TABLE 1 (Continued)

STATION	RIVER MILE	DESCRIPTION
69	17.30	3 ft. depth, off upstream end of Porter Island.
70	16.56	8 ft. depth, midway between buoys 60 & 61.
71	16.51	5 ft. depth, off south bank, opposite downstream tip of Porter Island.
72	16.17	6 ft. depth, line between Johnson's Creek & Buoy #60-upstream.
73	16.14	5 ft. depth, line between Johnson's Creek & Buoy #60-downstream.
74	16.03	3 ft. depth, on line between dry creek and Buoy #58.
75	15.87	10 ft. depth, midway between Groveland Bridge & Buoy #57.
76	15.68	300 yards downstream of Groveland Bridge.
77	14.00	5 ft. depth, off south bank, about 2 1/4 miles upstream of Rocks Village Bridge.
78	12.50	4 ft. depth, off south bank, 3/4 mile upstream of Rocks Village Bridge.
79	8.81	5 ft. depth, off south bank, 500 ft. upstream of confluence with Indian River.
80	7.80	6 ft. depth, off south bank, 200 ft. upstream of confluence with Artichoke River.
81	7.28	5 ft. depth, off south bank, 2000 ft. upstream of Bailey Pond.
82	5.00	Off west bank Eagle Island.
83	4.10	4 ft. depth, off north bank, opposite mid-point Carr Island.
84	3.40	6 ft. depth, off east bank 1/2 mile upstream of R.R. bridge.
85	2.28	2 ft. depth, off north bank 100 yards downstream of power lines.

TABLE 1 (Continued)

STATION	RIVER MILE	DESCRIPTION
86	2.20	10 ft. depth, 50 yards downstream of Newburyport sewage outfall.
87	2.17	10 ft. depth, in channel, on line between Buoys 13A and 14.
88	2.15	5 ft. depth, off south bank, 500 ft. downstream of Newburyport sewage outfall.
89	1.84	3 ft. depth, off south bank, 700 yards downstream of Newburyport sewage outfall.
90	1.73	6 ft. depth, 1/2 mile downstream of Newburyport sewage outfall.
91	0.98	5 ft. depth, 100 feet offshore, opposite Shad Creek.
92	0.90	5 ft. depth, just west of Woodbridge Island.
93	0.46-0.5	3 ft. depth in Black Rock Creek.
-	0.46	Confluence with Black Rock Creek.
94	0.15-1.15	Plum Island River, 5 ft. depth, off east bank of little island between Woodbridge and Seal Island.
-	0.15	Confluence with Plum Island River and the Basin.
95	0.15-0.53	In Basin, 5 ft. depth, 200 ft. from south bank.

TABLE 2

NUMBER OF BOTTOM ORGANISMS PER SQUARE METER

WHITMAN RIVER
(June 1964)

KINDS	SENSITIVE ORGANISMS
Beetles	
Elmidae	
Stenelmis sp.	129
Promoresia sp.	11
Psephenidae	
Psephenus herricki	11
Caddis flies	
Leptoceridae	
Leptocerus sp.	32
Limnephilidae	
Limnephilus sp.	11
Neophylax sp.	54
Hydropsychidae	
Macronemum sp.	43
Smicridea sp.	11
Rhyacophilidae	
Rhyacophila sp.	516
Stone flies - Taeniopteryginae	
Brachyptera sp.	172
May flies - Heptageniidae	
Iron sp.	65
Stenonema sp.	22
SUBTOTAL ORGANISMS	1077
SUBTOTAL KINDS	12

KINDS	INTERMEDIATE ORGANISMS
Beetles - Haliplidae	
Haliplus sp.	11
Moth flies - Psychodidae	
Pericoma sp.	850
Midge flies - Tendipedidae	
Pentaneura sp.	850
Procladius sp.	161
Cryptochironomus sp.	11
Clams - Sphaeriidae	
Pisidium sp.	65
SUBTOTAL ORGANISMS	1948
SUBTOTAL KINDS	6
	TOLERANT ORGANISMS
Sludge worms - Tubificidae	
tubificids without gills	22
SUBTOTAL ORGANISMS	22
SUBTOTAL KINDS	1
GRAND TOTAL ORGANISMS	3047
GRAND TOTAL KINDS	19

TABLE 3

KINDS OF BOTTOM ORGANISMS IN MERRIMACK RIVER

AND NUMBERS PER SQUARE METER

STATION NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
SENSITIVE ORGANISMS																																															
Caddisflies - Trichoptera																																															
Helicopsychidae sp.	--	--	--	--	--	--	79	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Leptoceridae sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Limnephilidae sp.	--	--	--	--	--	16	16	--	--	--	8	--	--	--	--	--	--	--	--	--	--	47	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Riffle beetles - Elmidae																																															
Stenelmis sp.	--	--	--	--	--	--	--	--	--	--	24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Subtotal Organisms	0	0	0	0	0	16	95	0	0	0	32	0	0	0	0	0	0	0	0	0	16	47	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal Kinds	0	0	0	0	0	1	2	0	0	0	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INTERMEDIATE ORGANISMS																																															
Biting midges - Heleinae																																															
Bezzia sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5
Clams - Sphaeriidae																																															
Pisidium sp.	--	--	--	--	--	--	--	22	--	--	--	16	--	--	--	--	--	16	--	16	--	16	16	--	--	--	--	--	--	--	--	--	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Craneflies - Tipulidae																																															
Pseudolimnophila sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dragon flies - Anisoptera																																															
Cordulegaster sp.	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Epicordulia sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Midge flies - Tendipedidae																																															
Anatopynia dyari	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--
Brillia sp.	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	79	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Calopsectra sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--
Cryptochironomus sp.	--	--	--	--	--	--	--	--	--	16	8	--	--	47	--	--	16	--	8	--	--	--	--	--	--	47	63	63	16	--	--	--	--	--	16	--	32	16	16	16	--	--	--	--	--	--	--
Glyptotendipes senilis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	16	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Glyptotendipes sp.	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydrobaeninae sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metriocnemus fuscipes	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metriocnemus lundbecki	--	--	--	--	--	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	126	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Metriocnemus sp.	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pentaneura melanops	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	126	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polypedilum convictum	--	583	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polypedilum fallax	47	--	--	194	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polypedilum sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--
Procladius sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pseudochironomus sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	142	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tanytarsus nigricans	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tanytarsus subtendens	--	--	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mussels - Unionidae																																															
Elliptio sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	120	--	16	--	32	22	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--
Uniomerus sp.	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scavenger Beetles - Hydrophilidae																																															
Helophorus sp.	63	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scuds - Amphipoda																																															
Hyalella azteca	16	--	--	--	--	--	--	--	--	--	8	--	--	--	--	--	--	--	--	--	--	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sow Bugs - Isopoda																																															
Asellus militaris	16	--	--	--	158	47	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Snails																																															
Bulimidae																																															
Amnicola sp.	16	110	16	--	315	615	1135	764	--	32	24	158	--	63	--	--	32	32	168	205	426	126	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Physidae																																															
Physa sp.	--	110	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Planorbidae																																															
Helisoma sp.	--	16	--	--	--	16	--	--	--	--	--	47	--	--	--	16	32	47	88	--	--	32	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gyraulus sp.	--	--	--	--	--	--	--	140	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Viviparidae																																															
Campeloma sp.	--	--	--	--	--	--	--	--	--	--	16	268	16	--	--	32	284	142	96	32	473	520	788	--	--	--	--	--	--	32	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	16	--
Subtotal Organisms	238	835	48	194	489	710	1167	926	0	48	56	505	16	110	32	64	364	237	488	300	1089	1136	915	119	0	63	63	63	16	48	0	0	64	0	16	0	32	16	16	48	16	16	0	0	0	16	5
Subtotal Kinds	8	5	2	1	3	4	3	3	0	2	4	5	1	2	1	3	4	4	6	4	6	10	6	5	0	2	1	1	1	2	0	0	3	0	1	0	1	1	1	3	1	1	0	0	0	1	1
TOLERANT ORGANISMS																																															
Leeches - Glossiphoniidae																																															
Glossiphonia heteroclita	--	--	32	--	47	32	63	22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Helobdella elongata	--	--	--	--	--	--	32	--	--	16	8	--	--	--	--	16	16	95	33	--	47	79	110	11	--	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Helobdella fusca	--	662	142	11	--	95	79	--	47	--	--	32	--	--	--	--	--	--	7	--	16	110	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Helobdella lineata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Helobdella punctata - lineata	--	--	--	--	--	32	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Helobdella stagnalis	16	536	930	--	--	142	--	11	47	--	16	--	--	--	--	--	--	32	--	32	16	221	158	75	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Placobdella parasitica	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Midge flies - Tendipedidae																																															
Glyptotendipes lobiferus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	63	--	--	--	--	--	--	--	--	--	--	946	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tendipes anthracinus	--	--	126	--	--	--	--	--	--	--	--	63	--	95	--	--	--	--	--	32	--	--	16	172	430	--	16	--	--	--	79	32	5910	--	--	32	--	--	--	--	16	--	--	--	--	--	--
Sludgeworms - Tubificidae																																															
Tubificids without gills	--	--	173	11	79	126	236	11	--	63	61	756	315	95	110	189	126	32	7	16	47	189	--	65	86	158	7092	189	16	16	--	32	1292	--	189	977	315	946	867	599	756	1261	236	599	24	1340	630
Subtotal Organisms	16	1198	1419	22	126	427	457	44	94	79	85	851	315	190	110	205	142	159	47	80	126	662	300	334	516	206	7108	189	16	16	79	64	8148	0	189	1009	315	946	867	599	772	1261	236	599	24	1340	630
Subtotal Kinds	1	2	6	2	2	5	5	3	2	2	3	3	1	2	1	2	2	3	3	3	4	5	4	5	2	3	2	1	1	1	1	2	3	0	1	2	1	1	1	1	2	1	1	1	1	1	1
Grand Total Organisms	254	2033	1467	216	615	1153	1719	970	94	127	173	1356	331	300	142	269	506	396	535	380	1231	1845	1215	453	516	269	7171	252	32	80	79	64	8212	0	205	1009	347	962	883	647	788	1277	236	599	24	1356	635
Grand Total Kinds	9	7	8	3	5	10	10	6	2	4	9	8	2	4	2	5	6	7	9	7	11	16	10	10	2	5	3	2	2	4	1	2	6	0	2	2	2	2	2	4	3	2	1	1	1	2	2

TABLE 3 (Continued)

KINDS OF BOTTOM ORGANISMS IN MERRIMACK RIVER

AND NUMBERS PER SQUARE METER

STATION NO.	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
SENSITIVE ORGANISMS																								
None																								
INTERMEDIATE ORGANISMS																								
Barnacles - Balanomorpha																								
balanomorphs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clams																								
Myacidae																								
Mya arenaria	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	--	--	--	79	--
Sphaeriidae																								
Pisidium sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--
Midge flies - Tendipedidae																								
Cryptochironomus sp.	--	--	8	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--
Endochironomus subtendens	--	--	--	--	--	--	--	--	--	--	--	--	--	77	--	--	--	--	61	--	--	--	--	--
Glyptotendipes senilis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	--
Polypedilum sp.	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Procladius sp.	--	--	8	--	--	--	--	--	--	--	32	--	--	31	--	--	--	--	15	--	--	--	--	--
Mudcrabs - Pilumnidae																								
Rhithropanopeus harrisi	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mussels - Mytilidae																								
Mytilus edulis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Scuds																								
Gammaridae																								
Gammarus fasciatus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gammarus locusta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pontogeneiidae																								
Pontogeneia inermis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrimp-like animals - Callianassidae																								
Callianassa atlantica	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sow Bugs																								
Anthuridae																								
Cyathura carinata	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Janiridae																								
Jaera marina	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Snails																								
Bulimidae																								
Amnicola sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	31	--	--	--	--	--
Rissoidae																								
Hydrobia minuta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Subtotal Organisms	0	0	24	16	0	0	0	0	0	0	32	0	0	108	0	0	0	0	122	0	0	0	143	0
Subtotal Kinds	0	0	3	1	0	0	0	0	0	0	1	0	0	2	0	0	0	0	4	0	0	0	4	0
TOLERANT ORGANISMS																								
Leeches - Glossiphoniidae																								
Helobdella fusca	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	61	--	--	--	47	--
Helobdella stagnalis	--	--	34	--	--	--	--	--	--	--	--	--	--	215	--	--	--	--	--	--	--	--	--	--
Marine Worms - Nereidae																								
Nereis sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Midge flies - Tendipedidae																								
Glyptotendipes lobiferus	--	--	--	--	--	--	--	--	--	--	--	--	--	1813	--	--	--	--	--	--	--	--	--	--
Tendipes anthracinus	6	8	16	347	32	8	24	--	--	--	47	47	--	--	--	31	92	61	353	--	--	15	189	230
Sludgeworms - Tubificidae																								
Tubificids without gills	2104	71	115	299	47	47	94	134	16	47	55	284	8	414	--	15	614	15	307	--	--	46	1261	--
Subtotal Organisms	2110	79	173	646	79	55	118	134	16	47	102	331	8	2442	0	46	706	76	721	0	0	61	1497	230
Subtotal Kinds	2	2	4	2	2	2	2	1	1	1	2	2	1	3	0	2	2	2	3	0	0	2	3	1
Grand Total Organisms	2110	79	197	662	79	55	118	134	16	47	134	331	8	2550	0	46	706	76	843	0	0	61	1640	230
Grand Total Kinds	2	2	7	3	2	2	2	1	1	1	3	2	1	5	0	2	2	2	7	0	0	2	7	1

STATION NO.	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
SENSITIVE ORGANISMS																								
None																								
INTERMEDIATE ORGANISMS																								
Barnacles - Balanomorpha																								
balanomorphs	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2837	--	--	--	63	--
Clams																								
Myacidae																								
Mya arenaria	16	--	134	79	173	--	--	--	--	--	--	--	--	--	--	--	--	--	--	441	230	441	16	504
Sphaeriidae																								
Pisidium sp.	--	--	16	16	47	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Midge flies - Tendipedidae																								
Cryptochironomus sp.	16	--	16	--	47	61	61	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Endochironomus subtendens	--	--	--	--	32	107	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Glyptotendipes senilis	8	32	40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Polypedilum sp.	--	--	--	--	630	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Procladius sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mudcrabs - Pilumnidae																								
Rhithropanopeus harrisi	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	--
Mussels - Mytilidae																								
Mytilus edulis	--	--	--	--	--	--	--	--	--	--	--	--	--	32	--	--	--	--	1150	--	--	205	16	--
Scuds																								
Gammaridae																								
Gammarus fasciatus	16	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gammarus locusta	--	--	--	--	--	--	--	31	--	--	46	169	693	1403	362	1907	3089	63	3688	--	--	2364	--	--
Pontogeneiidae																								
Pontogeneia inermis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	110	--	--	--	32	--
Shrimp-like animals - Callianassidae																								
Callianassa atlantica	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--
Sow Bugs																								
Anthuridae																								
Cyathura carinata	--	--	--	--	--	--	--	15	--	31	138	61	--	--	--	--	--	--	--	--	--	--	--	--
Janiridae																								
Jaera marina	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2049	--	--	--	--	--
Snails																								
Bulimidae																								
Amnicola sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rissoidae																								
Hydrobia minuta	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16
Subtotal Organisms	56	32	206	95	945	168	61	46	0	31	184	230	693	1435	362	1907	3089	63	9834	441	236	3010	175	520
Subtotal Kinds	4	1	4	2	6	2	1	2	0	1	2	2	1	2	1	1	1	1	5	1	1	3	6	2
TOLERANT ORGANISMS																								
Leeches - Glossiphoniidae																								
Helobdella fusca	23	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Helobdella stagnalis	16	--	--	16	32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Marine Worms - Nereidae																								
Nereis sp.	--	--	--	--	--	--	--	--	--	--	--	107	--	5548	3641	410	5106	1150	6399	1135	1340	5957	189	536
Midge flies - Tendipedidae																								
Glyptotendipes lobiferus	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tendipes anthracinus	39	331	134	599	504	384	--	--	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sludgeworms - Tubificidae																								
Tubificids without gills	78	1576	1182	1340	14972	123	31	92	430	--	16	--	--	79	32	--	--	2459	473	63	--	--	--	95
Subtotal Organisms	164	1907	1332	1955	15508	507	31	92	445	0	16	107	0	5627	3673	410	5106	3609	6872	1198	1340	5957	189	631
Subtotal Kinds	5	2	3	3	3	2	1	1	2	0	1	1	0	2	2	1	1	2	2	2	1	1	1	2
Grand Total Organisms	220	1939	1538	2050	16453	675	92	138	445	31	200	337	693	7062	4035	2317	8195	3672	16706	1639	1576	8967	364	1151
Grand Total Kinds	9	3	7	5	9	4	2	3	2	1	3	3	1	4	3	2	2	3	7	3	2	4	7	4

TABLE 4

SOUHEGAN RIVER MILES

BIOLOGICAL SAMPLE NUMBER	RIVER MILE	LOCATION
	28.58	Rte. 31 Bridge, Greenville
S-1	21.46	
S-2	21.44	
	21.42	Rte. 31-101 Bridge, Wilton
S-3	20.15-1.42	Stony Brook
	20.15	Confluence with Stony Brook, Wilton
S-4	18.17	North Purgatory Road Bridge, Milford
S-5	15.58	Confluence with Tucker Brook, Milford
S-6	14.55	
S-7	14.49	
	13.31	Rte. 13-101 Bridge, Milford
S-8	11.82	Riverside Cemetery, Milford
S-9	10.60	Ponemah Bridge, Amherst
S-10	8.42	
	8.40	Honey Pot Pond Bridge, Amherst
	6.80	Amherst-Merrimack Town line
	6.53	Severns Bridge, Merrimack
S-11	6.51	
	3.14	Turkey Hill Bridge, Merrimack
S-12	3.12	
	1.34	USCG Gaging Station, Merrimack
S-13	1.15	
	0.73	Everett Turnpike Bridge, Merrimack
S-14	0.70	
	0.34	U. S. Route 3 Bridge, Merrimack
	0.00	Confluence with Merrimack River (mile 62.35)

TABLE 5

KINDS OF BOTTOM ORGANISMS IN SOUHEGAN RIVER AND NUMBERS PER SQUARE METER

STATION NO.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14
SENSITIVE ORGANISMS														
Beetles														
Elmidae														
Promoresia sp.	--	--	11	--	--	--	--	--	--	11	--	--	--	--
Psephenus herricki	183	64	--	22	--	--	--	--	--	22	--	--	--	--
Stenelmis sp.	97	172	75	--	--	11	--	--	--	11	--	11	--	--
Psephenidae														
Psephenus herricki	--	--	140	--	--	--	--	--	--	--	--	--	--	--
Caddis flies - Trichoptera														
Glossosoma sp.	64	--	43	--	--	--	--	--	--	--	--	--	--	--
Helicopsyche sp.	11	97	54	--	--	--	--	--	--	11	--	--	--	--
Hydropsyche sp.	118	--	237	--	--	--	--	--	--	--	--	--	--	--
Hydroptilidae	--	--	--	43	--	--	--	--	--	--	--	--	--	--
Leptoceridae	--	--	--	--	--	--	--	--	--	--	--	--	--	43
Limnephilidae	54	129	54	--	--	--	--	32	108	32	54	--	32	--
Limnephilus sp.	--	11	97	--	--	--	--	--	--	--	--	--	--	--
Molanna sp.	22	--	--	--	--	--	--	--	--	11	--	32	--	--
Fish flies - Megaloptera														
Chauliodes sp.	--	--	11	--	--	--	--	--	--	--	--	--	--	--
May flies - Ephemoptera														
Ameletus sp.	--	43	--	--	--	--	--	--	--	--	--	--	--	--
Caenis sp.	--	129	--	--	--	--	--	--	--	--	--	--	32	11
Ephemerella sp.	108	194	226	32	172	--	--	11	11	86	11	22	11	--
Iron sp.	--	--	183	--	--	--	--	--	--	--	--	--	--	--
Isonychia sp.	--	--	22	--	--	--	--	--	--	--	--	--	--	--
Paraleptophlebia sp.	54	--	850	--	--	--	--	--	--	--	--	--	--	--
Potamanthus sp.	--	--	11	--	--	--	--	--	--	--	--	--	--	--
Siphlonurus sp.	--	--	--	--	11	--	--	--	--	--	--	--	--	--
Stenonema sp.	--	--	11	--	--	--	--	--	--	--	--	--	--	--
Stoneflies - Plecoptera														
Isoperla sp.	--	--	11	--	--	--	--	--	--	--	--	--	--	--
Subtotal Organisms	711	839	2036	97	183	11	0	43	119	184	65	65	75	54
Subtotal Kinds	9	8	16	3	2	1	0	2	2	7	2	3	3	2
INTERMEDIATE ORGANISMS														
Beetles														
Haliplidae														
Brychius sp.	--	--	32	--	--	--	--	--	--	--	--	--	--	--
Hydrophilidae														
Hydrochus sp.	--	--	22	--	--	--	--	--	--	--	--	--	--	--
Clams - Sphaeriidae														
Musculium sp.	--	--	--	--	--	--	--	--	--	--	--	22	11	75
Pisidium sp.	--	97	97	--	--	--	32	--	--	--	140	11	--	22
Crane flies - Tipulidae														
Antocha sp.	22	--	54	--	--	--	--	--	--	--	--	--	--	--
Damsel flies - Zygoptera														
Ischnura sp.	--	--	--	--	11	--	--	--	--	11	--	--	--	--
Dragon flies - Anisoptera														
Gomphus sp.	--	--	--	--	--	--	--	--	--	--	--	11	--	--
Neurocordulia sp.	--	--	22	--	--	--	--	--	--	--	--	--	--	--
Ophiogomphus sp.	--	--	--	--	--	--	--	--	--	11	--	--	--	--
Midge flies - Tendipedidae														
Anatopynia dyari	--	--	--	--	--	--	--	--	--	--	--	--	--	22
Brillia sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	32
Calopsectra sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	194
Cricotopus sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	32
Cryptochironomus sp.	--	--	32	--	--	--	--	--	--	--	--	129	--	376
Endochironomus subtendens	--	--	--	--	--	--	--	--	--	54	--	--	--	--
Endochironomus sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	43
Glyptotendipes lobiferus	--	--	--	--	--	--	--	--	--	--	11	--	--	--
Hydrobaenus sp.	43	--	--	--	--	--	54	22	--	--	--	--	11	43
Metriocnemus fuscipes	--	--	--	--	11	--	--	--	--	--	--	--	--	--
Metriocnemus lundbecki	--	--	--	--	--	--	--	--	--	--	--	--	11	--
Microtendipes sp.	--	--	--	--	--	--	--	--	--	--	--	--	22	--
Polypedilum convictum	22	--	22	--	--	--	--	43	--	--	--	--	11	--
Polypedilum fallax	--	64	--	--	--	--	--	--	--	--	--	--	--	--
Procladius sp.	--	43	--	--	--	--	--	--	--	11	--	--	--	22
Pseudochironomus sp.	--	--	--	--	--	--	--	--	--	--	--	--	75	75
Mussels - Unionidae														
Lampsilis sp.	--	--	--	--	--	--	--	--	--	--	11	--	22	11
Scuds - Amphipoda														
Hyallela azteca	--	--	--	11	43	--	--	11	--	--	--	--	--	--
Snails														
Bulimidae														
Amnicola sp.	--	--	--	--	11	--	118	--	75	--	--	215	54	86
Planorbidae														
Helisoma sp.	11	--	--	32	22	--	22	32	--	--	140	--	--	--
Viviparidae														
Campeloma sp.	--	--	--	--	--	--	--	--	183	301	542	--	11	--
Sow Bugs - Isopoda														
Asellus militaris	--	--	--	--	32	--	366	--	11	--	--	--	--	--
Water Boatmen - Corixidae														
Sigora sp.	--	--	--	--	--	--	--	--	--	--	--	--	22	--
Subtotal Organisms	98	204	281	43	130	0	592	108	269	388	894	388	250	1033
Subtotal Kinds	4	3	7	2	6	0	5	4	3	5	5	5	10	13
TOLERANT ORGANISMS														
Leeches - Glossiphoniidae														
Glossiphonia heteroclita	--	--	--	--	--	--	--	108	64	43	--	--	--	--
Helobdella punctata-lineata	--	--	--	11	--	--	--	--	--	--	--	--	--	--
Helobdella stagnalis	--	--	--	2190	2280	118	--	247	730	--	--	--	--	32
Placobdella rugosa	--	--	--	--	--	--	--	--	--	--	--	11	--	--
Midge flies - Tendipedidae														
Tendipes anthracinus	--	--	--	--	--	--	--	--	32	323	--	--	150	75
Sludgeworms - Tubificidae														
Tubificids	75	366	43	333	881	--	1140	151	387	387	43	--	366	365
Subtotal Organisms	75	366	43	2534	3161	118	1140	506	1213	753	43	11	516	472
Subtotal Kinds	1	1	1	3	2	1	1	3	4	3	1	1	2	3
Grand Total Organisms	884	1409	2360	2674	3474	129	1732	657	1601	1325	1002	464	841	1559
Grand Total Kinds	14	12	24	8	10	2	6	9	9	15	8	9	15	18

TABLE 6

PRODUCTIVITY OF MERRIMACK RIVER - AUGUST 1965

Date Aug. 1965	O_2 Produced gm/m^3/day	Chlorophyll a mg/m^3	Algae No. x 10^6/m^3	River Flow 10^6 CF/day	NH_3-N mg/l	NO_3 + NO_2 Nitrogen mg/l	Total N mg/l	Ortho-PO_4 mg/l	Total PO_4 mg/l	Turbidity mg/l	Solar Radiation gm cal/cm^2
RIVER MILE 65.11											
18	0.576	7.30	233.4	87.3	0.51	0.60	1.55	0.36	0.77	6.0	314
19	0.0	3.65	241.2	78.6	0.49	0.50	1.41	0.42	0.53	1.8	220
20	1.140	3.05	206.8	72.6	0.30	0.55	1.46	0.32	0.37	2.0	338
24	0.979	1.00	109.5	82.9	0.53	0.80	2.13	0.30	0.46	2.5	464
25	0.450	0.70	116.4	88.1	0.53	0.80	1.92	0.29	0.39	2.3	488
26	--	1.20	60.2	86.4	0.49	0.60	1.58	0.25	0.34	1.6	298
AVERAGE	0.629	2.82	161.2	82.7	0.48	0.64	1.67	0.32	0.48	2.7	354
RIVER MILE 48.76											
18	5.33	40.8	1230	95.0	0.44	0.40	1.35	0.61	0.74	4.3	314
19	3.72	21.4	938	103.7	0.66	0.50	1.69	0.63	0.73	3.9	220
20	3.55	12.1	507	99.4	0.61	0.50	1.45	0.64	0.78	2.5	338
24	6.53	15.6	1252	96.8	0.66	0.60	1.86	0.54	0.72	3.0	464
25	7.82	11.2	475	93.3	0.86	0.80	2.20	0.64	0.77	2.8	488
26	2.18	14.6	186	86.4	0.82	0.70	2.10	0.51	0.52	2.6	298
27	1.25										
AVERAGE	4.34	19.3	765	95.8	0.67	0.58	1.77	0.60	0.71	3.2	354
RIVER MILE 43.47											
18	2.83	32.7	731	99.3	0.36	0.50	1.37	0.44	0.58	4.5	314
19	3.16	32.0	494	108.9	0.49	0.40	1.17	0.55	0.73	3.6	220
20	4.34	17.3	555	106.3	0.49	0.45	1.95	0.53	0.69	2.7	338
24	6.05	17.8	1488	95.9	0.69	0.60	--	0.49	0.59	3.5	464
25	7.57	25.2	1815	86.4	0.74	0.80	1.90	0.50	0.59	6.0	488
26	4.52	23.9	779	86.4	0.66	0.60	1.86	0.50	0.64	2.0	298
27	4.15										
AVERAGE	4.66	24.8	977	97.2	0.57	0.56	1.65	0.50	0.64	3.7	354

NOTES: Nitrogen and phosphorus represent soluble forms.
All samples taken at one foot depth.

TABLE 7

MOST ABUNDANT GENERA OF ALGAE IN MERRIMACK RIVER

APRIL-OCTOBER, 1965

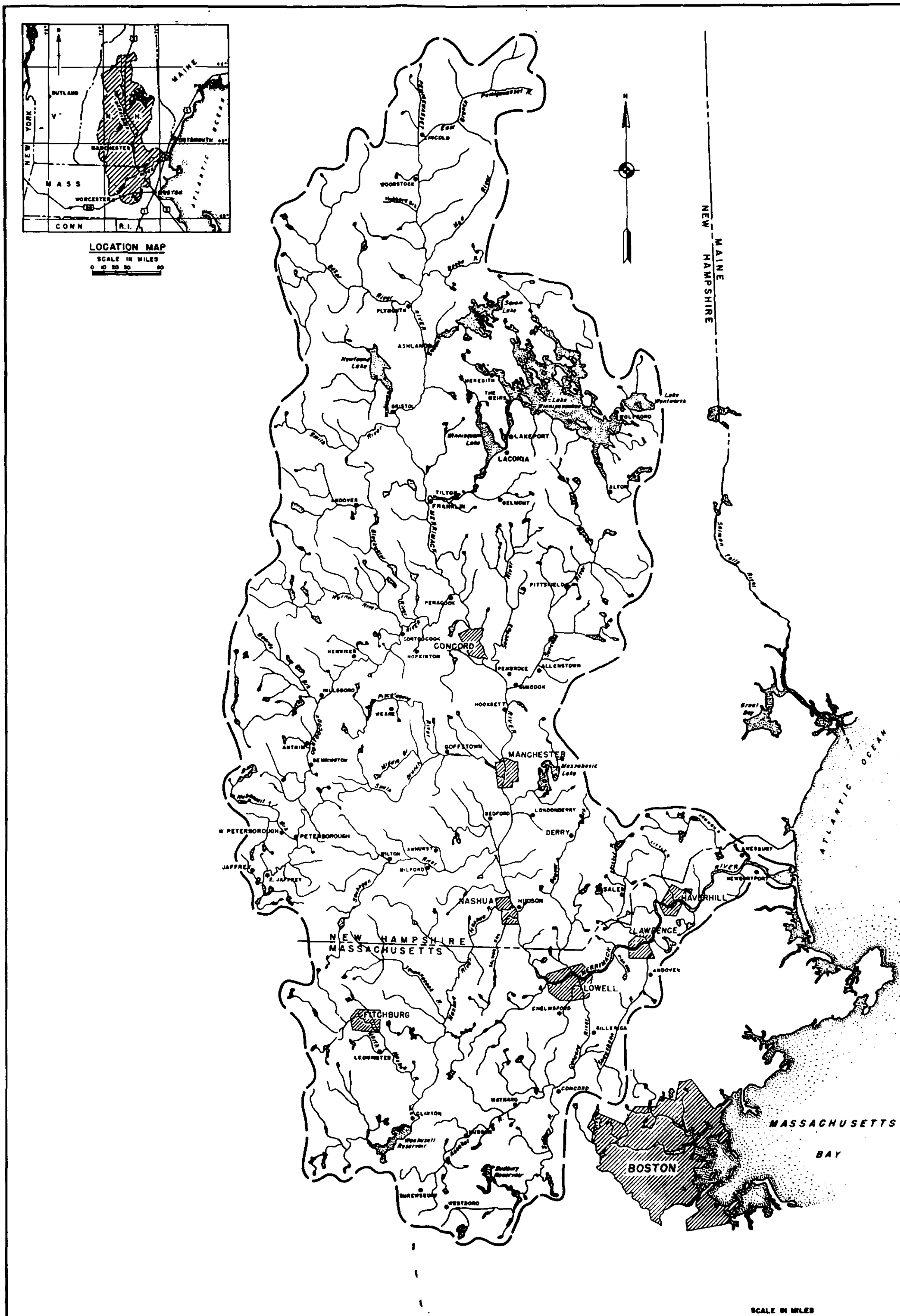
	APRIL			MAY			JUNE			JULY				SEP	OCT
	9	16	23	14	21	28	7	11	18	6	12	14	23	29	29
DIATOMS															
Asterionella	455	100	130	240	50	160	40	150	90	46	--	40	--	--	58
Melosira	--	40	70	20	90	325	130	260	40	--	700	630	870	97	--
Synedra	40	30	10	395	310	250	210	90	190	1277	40	--	100	--	19
Navicula	--	50	30	60	30	20	--	10	40	--	--	--	--	281	19
Fragilaria	50	--	30	--	--	--	120	100	140	--	--	--	--	--	--
Other	--	10	--	90	10	--	30	30	--	--	--	20	--	19	--
TOTAL ASU/ml	545	230	270	805	490	755	530	640	500	1323	740	690	970	397	96
BLUE-GREEN															
Anabaena	--	--	--	--	--	--	--	250	--	--	800	--	--	--	--
Polycystis	--	--	--	--	--	--	--	--	50	--	--	--	--	--	--
Coelosphaeium	--	--	20	--	--	20	--	--	--	342	3400	--	--	--	--
Oscillatoria	--	--	--	--	--	50	--	--	--	--	300	--	--	--	--
Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL ASU/ml	0	0	20	0	0	70	0	250	50	342	4500		0	0	0
GREEN															
Protococcus	--	--	--	--	--	550	360	820	325	--	--	--	1280	194	--
Pediastrum	--	--	--	--	--	--	30	90	120	114	400	640	720	--	--
Scenedesmus	20	30	10	40	50	60	40	30	140	410	1370	570	490	272	281
Eudorina	--	--	--	100	--	--	--	--	--	1300	300	--	100	291	97
Pandorina	--	--	--	100	--	--	20	--	--	--	1000	300	--	--	--
Other	--	--	--	20	80	130	170	360	80	1915	340	1100	790	174	911
TOTAL ASU/ml	20	30	10	260	130	740	620	1300	665	3739	3410	2610	3380	931	1289
FLAGELLATES															
Dinobryon	375	30	20	400	285	200	80	--	250	--	--	--	--	--	78
Chlamydomonas	145	20	60	145	50	150	55	80	75	548	260	40	340	97	39
Synura	200	30	50	150	225	140	50	30	--	342	--	200	--	--	194
Mallomonas	--	10	--	--	--	--	--	--	--	114	--	20	80	--	136
Euglena	60	20	40	--	--	20	20	10	--	--	--	--	40	--	--
Other	--	--	--	--	--	--	--	--	--	--	260	--	--	39	--
TOTAL ASU/ml	780	110	170	695	560	510	205	120	325	1004	520	260	460	136	447
GRAND TOTAL ASU/ml	1345	370	470	1760	1180	2075	1355	2310	1540	6408	9170	3560	4810	1464	1832

TABLE 8

MOST ABUNDANT GENERA OF ZOOPLANKTON IN MERRIMACK RIVER

APRIL-OCTOBER, 1965

	APRIL			MAY			JUNE			JULY				SEP	OCT
	9	16	23	14	21	28	7	11	18	6	12	14	23	29	29
CILIATES															
Codonella	--	--	--	--	--	--	20	2	--	--	--	--	--	--	--
Vorticella	--	--	--	--	100	--	5	--	2	--	--	--	--	1	4008
Other	--	--	--	--	--	--	--	--	--	--	--	--	--	9	--
TOTAL #/20 ml	0	0	0	0	100	0	25	2	2	0	0	0	0	10	4008
ROTIFERS															
Polyarthra	--	--	--	--	--	--	--	--	1	4	--	--	--	8	--
Anuraea	--	--	--	--	1	6	10	10	25	--	10	--	40	13	2
Synchaeta	--	--	--	--	--	1	--	--	--	--	12	--	1	3	--
Triarthra	--	--	--	--	--	1	--	--	2	1	4	--	2	--	--
Other	--	--	--	--	--	--	--	--	--	13	1	12	--	9	1
TOTAL #/20 ml	0	0	0	0	1	8	10	10	28	18	27	12	43	33	3
CRUSTACEA															
Bosmina	--	--	--	--	--	--	--	--	--	--	7	--	--	--	--
Cyclops	--	--	--	--	1	--	--	--	--	1	--	5	--	1	--
Daphnia	--	--	--	--	--	--	--	--	--	--	--	--	12	--	--
Nauplius	--	--	--	--	--	--	--	4	--	--	2	--	--	2	--
Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL #/20 ml	0	0	0	0	1	0	0	4	0	1	9	5	12	3	0
GRAND TOTAL, #/20 ml ZOOPLANKTON	0	0	0	0	102	8	35	16	30	19	36	17	55	46	4011
AMORPHOUS MATTER, ASU/ml x 10^3	1.2	1	2.25	10	10	1.5	3	5	2	2.85	2	2	1.25	7.8	3.49
WATER TEMP. °C	--	--	9.5	9.2	17.2	20.4	20	23.3	20.2	24.2	28	25	24	19	9.7



MERRIMACK RIVER BASIN

FIGURE I