THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

DEPARTMENT OF RESEARCH AND DEVELOPMENT

REPORT NO. 78-5-B

1975 ANNUAL SUMMARY REPORT

WATER QUALITY WITHIN THE WATERWAYS SYSTEM OF THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

VOLUME 2

BIOLOGICAL

May 1978

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WATER QUALITY WITHIN THE WATERWAYS SYSTEM OF THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

VOLUME II

BIOLOGICAL

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May 1978

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SUMMARY

The composition and distribution of phytoplankton, bacteria, bottom macroinvertebrates and fish near eighteen MSDGC R&D Research Stations, along the Chicago River and Calumet River Systems, were studied during 1975. Included with the benthic data were the oxygen demands of the sediment at 11 of the stations. This part of the long term MSDGC Water Pollution Control Study revealed that the areas of the waterways closest to the inlets of Lake Michigan have waters of better quality than the waters farther downstream. The data show the greatest number of fish individuals and species occur near the openings to Lake Michigan. Also, few fish or no fish were found farther downstream of these inlets. The phytoplankton species near the lake inlets are a reflection of the lake's flora while those farther downstream are representative of more polluted waters. In addition, the waters near the openings to Lake Michigan have much lower numbers of those bacteria considered to be of sanitary importance, including the indicators, TC, FC, and FS and pathogens, than the waters farther downstream. The greater variety of benthic macroinvertebrates were found near Lake Michigan inlets while only a few kinds were found downstream in the waterways. Noticeable effects of effluents and tributaries were mentioned. In general, Lake Michigan flora and fauna are present near the openings to Lake Michigan and are replaced by other types farther downstream. The small number of clean water organisms, including scuds and

rainbow trout, near the locks make it doubtful if they reproduce in the waterways. Those present in the waterways apparently are replenished by individuals carried through the locks from Lake Michigan.

I. INTRODUCTION

The Metropolitan Sanitary District of Greater Chicago (MSDGC) is responsible for the quality of the water in the streams and canals within its jurisdiction. To monitor this water quality the MSDGC has established a surveillance program. The biological research activities under this surveillance program are provided by the Research and Development Department's Biology Research Section. For 1975, the field monitoring studies were handled by the following biology teams within the Biology Research Section: Analytical Microbiology, Aquatic Ecology, Aquatic Biology, and Fisheries.

The effects of pollutants on a waterway are reflected in the population density, species composition, and species diversity of natural aquatic communities. Therefore, information on all types of aquatic organisms present in a waterway is important in evaluating water quality. The long term water quality monitoring methods conducted by the MSDGC biology teams, as described in this report, are directed primarily toward sample collection and processing, organism identification and enumeration, and data reporting. This report summarizes the data obtained on the bacteria, phytoplankton, benthic macroinvertebrate and fish communities. Included with the benthic data were the oxygen demand of the sediments. The eighteen research stations plus additional fish locations were selected to reflect general environmental conditions of the MSDGC main waterway systems.

II. WATER QUALITY SURVEILLANCE

Description of Waterways

Principal man-made water courses in the Metropolitan Sanitary District waterway system are the North Shore Channel connecting Lake Michigan at Wilmette to the North Branch of the Chicago River, the Sanitary and Ship Canal extending from the Chicago Avenue Controlling Works adjoining Lake Michigan to the Lockport Powerhouse, and the Cal-Sag Channel connecting Calumet Harbor and Lake Michigan via the Calumet River with the Main Channel (Figure 1). The functions of the canal system are to provide navigation facilities for boats and barges as well as to serve as receiving waters for conveying the flows from tributary streams and sewage treatment plant effluents, and storm water runoffs from the Lake Michigan watershed to the Des Plaines watershed through the terminus at the Lockport Powerhouse.

Eighteen (18) representative sampling stations covering approximately 78 miles of the waterways were selected for study (Figure 1). The fish collections were taken at 21 fish stations not far from the above 18 research stations. The simplest way of examining this waterway system is to start at Lincoln St. (Station #35) in the North Shore Channel below the Wilmette Lock, at the Outer Drive Bridge (#74) below the Chicago Harbor Lock, and at Ewing Ave. (Station #49) in the Calumet River above the O'Brien Lock.

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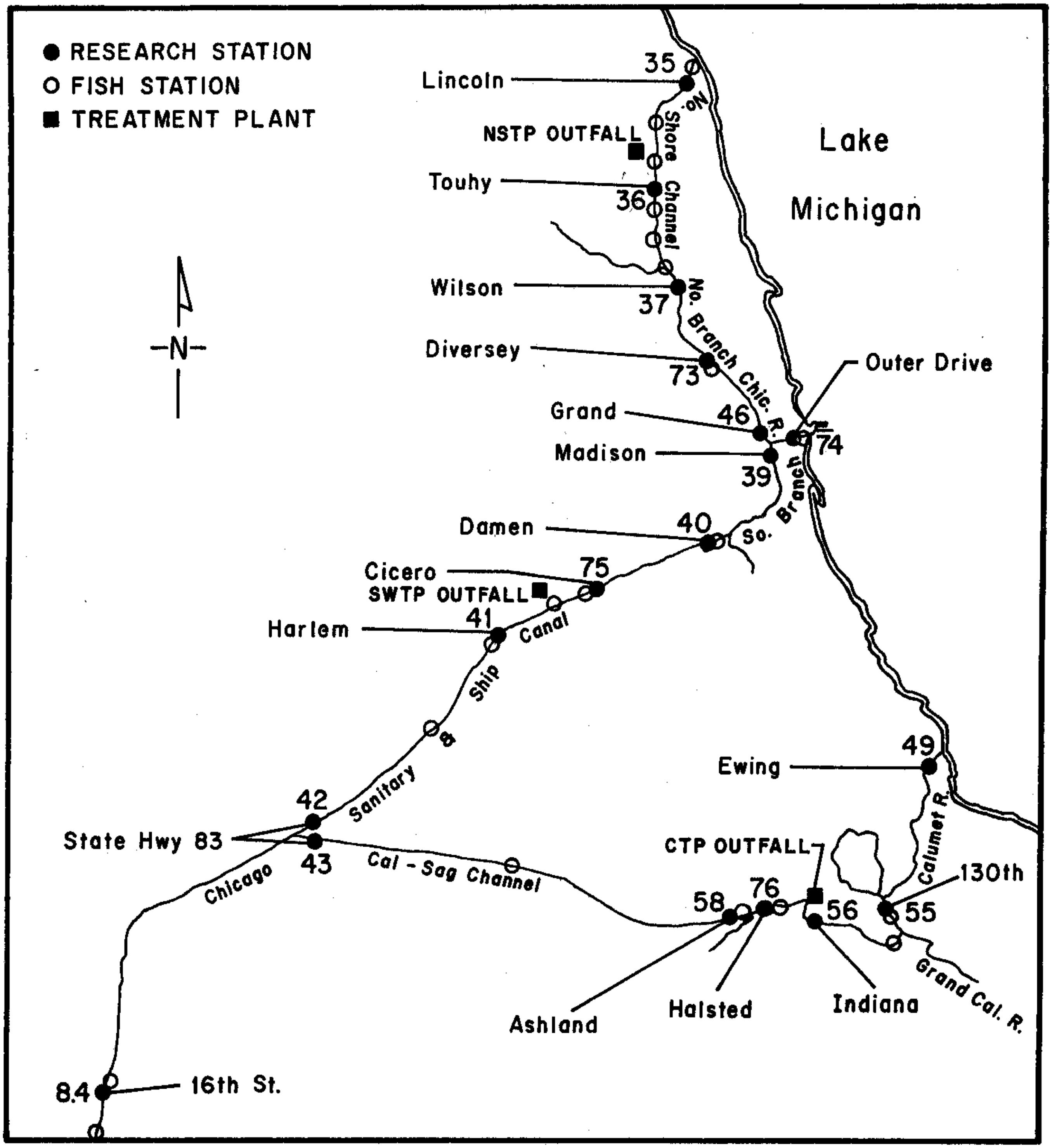
MAP OF THE BIOLOGY RESEARCH SAMPLING STATIONS ON MSDGC WATERWAYS

Figure 1



Types of Biological Samples

Four kinds of biological samples were collected in these waterways during the 1975 water quality monitoring program: (A) Bacteria, (B) Algae, (C) Benthos, and (D) Fish.

A. Bacteria

Bacterial analyses, which give an indication of the bacteriological or sanitary quality of the water, have been performed routinely on waterways samples for several years. Coliform, and the more specific fecal coliform and fecal streptococcus tests are used extensively by MSDGC to determine the bacteriological quality of the water. In addition to these routine parameters several other analyses will be included in this 1975 study:

1. Total Plate Count - This is a highly empirical procedure which gives an estimate of the total microbial populations.
2. *Salmonella* - The genus *Salmonella* contains a variety of species which are pathogenic for man or animals, and usually for both.
3. *Pseudomonas aeruginosa* - This organism is a causative agent of otitis media, otitis externa, chronic ulcerations of the skin and many wound and burn infections.

4. _Staphylococcus aureus_ - The most common infections caused by _Staph. aureus_ include pimples, boils, carbuncles, and food poisoning.

B. Algae

The objective of this part of the study was the identification and enumeration of that group of the biota collectively called the plankton, specifically the phytoplankton (the zooplankton have not been considered because of their low numbers and disproportionate biomass) in the major waterways of the District. The plankton may be defined as those microscopic organisms suspended in the water with little or no powers of locomotion subject to distribution primarily through the action of waves or currents. The phytoplankton, as the principal primary producers in the waterways can serve as indicators of water quality.

The phytoplankton studied belong to the following three groups:

1. The blue-green algae - These are primitive forms (single celled, with nuclear material scattered throughout the center of the cell while green chlorophyll is diffused throughout the peripheral portion of cell; has blue pigment and sometimes a red pigment) some of which produce "water blooms"; "pea soup" appearance; septic "pig-pen" odors; impart a "fish

taste"; and cover rocks with slimy gelatinous masses.

2. Green algae have pigments that are principally chlorophyll confined to chloroplasts or definite bodies. There is an organized nucleus, and the motile cells have flagelli.
3. Diatoms have a greater proportion of yellow or brown pigment than chlorophyll and the cell wall is composed of silica.

C. Benthos

Benthic macroinvertebrates, having limited mobility and relatively long life spans, are sensitive to even subtle changes in water quality and therefore can serve as excellent indicators of pollution in the waterways of MSDGC. A diverse bottom fauna with no overabundance of any one group in a waterway indicates water of good quality. Experience shows that organic pollution may restrict the variety of organisms while favoring the development of large numbers of organisms that tolerate these pollution conditions. Pollution by toxic substances, however, may eliminate almost all benthic macroinvertebrates. In the waterways for 1975, the bottom macroinvertebrate communities are sampled to determine the species composition and abundance of organisms. In addition to the benthos there was a need to quantify the oxygen demand characteristics of the bottom sediments.

D. Fish

Fish analyses, which gives the most meaningful index of water quality to the public, have been performed on the MSDGC waterways since 1974. Because fish occupy the upper levels of the aquatic food web, any water quality conditions that significantly affect the other kinds of organisms within the aquatic community will also affect the species composition, and abundance of the fish population. To measure the water quality of the environment for a community of fish species, diversity indices are useful. Their use is based on the generally observed phenomenon that relatively undisturbed environments support communities having large numbers of species with no individual species present in overwhelming abundance. If the species in such a community are ranked on the basis of their numerical abundance, there will be relatively few species, with large numbers of individuals and large numbers of species represented by only a few individuals. Many forms of stress tend to reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage. Ultimately, this part of the water pollution control program will lead to a qualitative description of which fish species inhabit which areas of each waterway as well as a quantitative enumeration of the relative abundance of each major species within selected areas of each waterway.

Methods of Biological Analysis of Waterways Samples

A. Bacteria

Water samples for total coliform, fecal coliform, fecal streptococcus and total plate counts are collected in sterile 4 ounce Reagent bottles containing enough sodium thiosulfate to neutralize 15 mg/l chlorine. *Salmonella sp.*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* samples are collected in sterile one gallon containers with enough sodium thiosulfate to neutralize 15 mg/l chlorine. All samples are taken one meter below the surface, in the center of the waterway, with a Kemmerer bottle, and are transported on ice to the R&D Laboratory. Analyses are usually begun within twenty-four hours of collection. Total coliforms (TC) are estimated and verified according to membrane filter (MF) procedures outlined in *Standard Methods for the Examination of Water and Wastewater*[1], fecal coliform (FC) determinations and verifications are carried out according to the MF technique described by Geldreich *et al*[2].

Fecal streptococci (FS) are determined and verified by a MF technique described by Kenner *et al*[3].

Total plate counts are performed utilizing a MF procedure and plate count agar. Plates are incubated for 48 $\pm$ 3 hours at 35^{o}C. *Salmonellae* are determined utilizing a MPN technique described by Kenner[4]. Five 200 ml, five 20 ml and five 2 ml portions of sample are filtered and the filters placed in dulcitol selenite enrichment broth (DSE). The containers of DSE are incubated at 40^{o} $\pm$ 5^{o}C for 48 hours and checked for selenite reduction. Positive tubes are streaked on xylose lysine desoxycholate agar (XLD) and incubated at 40^{o}C for a day. The selective agar plates are examined for possible *Salmonella*, indicated by black colonies. Suspect colonies are transferred to triple sugar iron agar (TSI). Those showing positive results on TSI (black butt, red slant) are transferred to phenylalanine deaminase (PD) agar, lysine decarboxylase broth, and malonate utilization broth. Isolates able to decarboxylate lysine and unable to deaminate phenylalanine or utilize malonate are considered presumptive *Salmonella* and are identified biochemically utilizing the API or R/B enteric systems. Confirmation of isolates is performed with polyvalent *Salmonella* "O" antisera. Agglutination of a suspension of the isolate in contact with antisera would be considered evidence of Salmonellae.

Verification and further serotyping of approximately 20% of the isolates will be performed by the Illinois Department of Public Health.

Pseudomonas aeruginosa analyses are performed according to a MPN procedure in Standard Methods[1]. Five 10 ml, five 1 ml and five 0.1 ml portions of sample are inoculated into tubes of asparagine enrichment broth. Tubes are incubated for 48 hours at 35°C. Upon subculture to acetamide broth, tubes showing acetamide utilization are considered positive for *Pseudomonas aeruginosa* and a MPN is calculated.

Staphylococcus aureus is quantified using a MF procedure in *Standard Methods*. Samples are filtered and placed on mannitol salt agar. Colonies which ferment mannitol are verified by gram staining and coagulase testing.

B. Algae

Six water samples for Aquatic Ecology are collected from each part of the waterways during each quarter, i.e., six from the northern region of the Chicago River System, six from the Chicago southern region, and six from the Calumet River System (Figure 1).

The water samples are received at the laboratory the day following their collection. The samples are preserved in 4% formalin and are analyzed by two methods. The first method is the Sedgewick-Rafter count in which 1 ml of sample is viewed at 160x magnification. The zooplankton are identified and enumerated along with the larger algae. The second method is conducted in two parts. In the first part, 200 ml of sample is digested with nitric acid (equal parts sample and acid) after centrifugation to reduce the volume to approximately 20 ml. After digestion, the sample is filtered through a 0.22 um membrane filter which is then air dried. A section to the center of the filter is removed, cleared with immersion oil and examined under an oil immersion objective (total magnification 1600x) for identification and enumeration of diatoms (silica covered algae). The second part of the analysis which is for the non-diatoms, involves the settling of the organisms from 875 ml sequentially until a final volume of 4.38 ml is achieved (200x concentration). A 0.1 ml sample is examined under the high dry objective (total magnification 688x) for the identification and enumeration of the green, blue-green, euglenoid, and other algae as well as members of the zooplankton. The latter method is preferred as the smaller organisms are more easily counted and identified. The former method is preferred for the larger organisms as it permits viewing the whole organisms within a field.

C. Benthos

Three replicate bottom grab samples are taken at each of the eighteen sites from the center of the waterway and are used to calculate organism numbers per square meter during each quarter. Bottom samples are collected with a 529 sq cm Ponar Grab and screened immediately with a U.S. STD No. 30 sieve. The screened residue is preserved in 10% formalin and taken to the laboratory where the organisms are removed, identified, and counted.

To measure the sediment oxygen demands *in situ* at 15 SOD Stations on the waterways, a bottom sampler, similar to the steel chamber--24" long, 14" wide, and 10" deep--designed by the Illinois State Water Survey, is used. This chamber has a volume of 30.27 liters and covers a bottom area of 0.22 square meters. With 100 feet of 1" rubber garden hose and five feet of clear plastic tubing attached, the total volume of water contained within the system is 47.39 liters. The oxygen demand of the sediments is computed using the procedures of the Illinois State Water Survey in Peoria, and reported in $gm^{-2}d^{-1}$.

D. Fish

All fish are collected with dip nets while electro-fishing with a 230 volt AC boom shocker-unit mounted on a flat bottom aluminum boat. These collections are carried out for approximately one hour at each site within a 400 meter length of channel. Both sides of the channel are sampled whenever possible.

All large fish (greater than four inches) were identified, weighed to the nearest gram, measured for total length to the nearest millimeter, fin-clipped and released in the area of capture. Small forage fish were preserved in 10% formalin, identified, and weighed and measured as soon as possible at the laboratory.

The diversity index, $\bar{d}$, used in this report is a modification of one originally proposed by Shannon and Wiener.[5]

The machine formula presented by Lloyd, Zar, and Karr[6] is:

$$\bar{d} = \frac{C}{N} (N \log_{10} N - ni \log_{10} ni)$$

where C = 3.321928 (converts base 10 log to base 2); N = total number of individuals; and ni = total number of individuals in the i^{th} species.

III. RESULTS AND DISCUSSION OF WATERWAYS QUALITY CONDITIONS

Bacteria

Waterways bacterial analyses for May through December, 1975 show that the various indicators, TC, FC, and FS, are generally lowest at stations near Lake Michigan (Tables 1 - 3). In addition, the results from the new analyses added to the study are as follows: *Staphylococcus aureus* was detected in 3 of 48 samples (Tables 1 - 3). *Salmonella* was recovered from 20 of 48 samples but never exceeded 10 per 100 ml and *Pseudomonas aeruginosa* was recovered in 46 of 48 samples in numbers that on occasion exceeded 24,000/100 ml (Tables 1 - 3). Seven *Salmonella* isolates were sent to the Illinois Public Health Department for confirmation and serotyping. All were common serotypes (Table 4). The confirmation results of total coliform, fecal coliform and fecal streptococcus serotyping (Table 5) in general coincide with those found by other investigators.

Algae

Chicago River, northern portion, including North Shore Channel.

In both May and August the initial plankton concentration is diluted by the effluent from the NS-STW by 50% (Station 36, Figure 2). Sufficient organisms are introduced by the NBCR (Station 37, Figure 2), however, to negate this dilution effect. The concentration of organisms are greater at this point and so remain to the confluence with the CR-SSC except for August where

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TABLE 1

BACTERIAL COUNTS PER 100ML GEOMETRIC AVERAGE OF 5/13/75, 8/12/75 and 11/4/75
SAMPLING RUNS CHICAGO RIVER

Station[1]	TC	FC	FS	*S.*[2] *aureus*	*P.*[3] *aeruginosa*	*Salmonella*	TPC[4]
35	6.1×10^{4}	1.6×10^{3}	5.7×10^{2}	$<2.2 \times 10^{1}$	2.8×10^{2}	1.0×10^{-1}	9.5×10^{8}
36	1.7×10^{4}	2.5×10^{2}	5.9×10^{1}	$<2.2 \times 10^{1}$	1.5×10^{2}	$<1.0 \times 10^{-1}$	5.5×10^{8}
37	6.6×10^{3}	9.1×10^{2}	2.4×10^{2}	$<1.3 \times 10^{1}$	6.6×10^{2}	1.6×10^{-1}	1.0×10^{9}
73	2.5×10^{4}	1.4×10^{3}	5.1×10^{3}	$<2.2 \times 10^{1}$	3.8×10^{2}	8.4×10^{-1}	1.2×10^{9}
46	6.6×10^{6}	6.9×10^{3}	1.1×10^{4}	$<2.2 \times 10^{1}$	6.0×10^{2}	1.8×10^{-1}	1.7×10^{9}

1. See Figure 1.
2. S = *Staphylococcus*
3. P = *Pseudomonas*
4. TPC = Total Plate Count

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TABLE 2

BACTERIAL COUNTS PER 100ML GEOMETRIC AVERAGE OF 6/17/75, 9/17/75 and 12/9/75
SAMPLING RUNS CHICAGO RIVER AND SANITARY AND SHIP CANAL

Station[1]	TC	FC	FS	*S.*[2] *aureus*	*P.*[3] *aeruginosa*	*Salmonella*	TPC[4]
74	2.9×10^{2}	1.6×10^{1}	3.9×10^{1}	$<4.3 \times 10^{1}$	6.5×10^{1}	$<1.0 \times 10^{-1}$	2.9×10^{7}
39	1.6×10^{5}	5.3×10^{3}	5.3×10^{2}	$<2.2 \times 10^{1}$	8.3×10^{2}	1.0×10^{-1}	1.7×10^{9}
40	2.8×10^{5}	5.6×10^{3}	5.9×10^{2}	$<6.4 \times 10^{1}$	4.9×10^{2}	$<1.0 \times 10^{-1}$	2.1×10^{8}
75	2.2×10^{5}	6.3×10^{3}	9.5×10^{2}	$<2.2 \times 10^{1}$	6.9×10^{2}	$<1.0 \times 10^{-1}$	1.9×10^{8}
41	3.9×10^{4}	1.3×10^{3}	3.0×10^{2}	$<7.1 \times 10^{1}$	2.8×10^{2}	$<1.0 \times 10^{-1}$	1.9×10^{8}
42	2.3×10^{5}	5.4×10^{3}	$<1.8 \times 10^{3}$	$<6.2 \times 10^{1}$	$>1.9 \times 10^{3}$	$<1.3 \times 10^{-1}$	1.5×10^{8}
8.4	7.7×10^{4}	1.7×10^{3}	1.6×10^{2}	2.4×10^{2}	7.6×10^{2}	$<1.5 \times 10^{-1}$	5.2×10^{7}

1. See Figure 1.
2. S = *Staphylococcus*
3. P = *Pseudomonas*
4. TPC = Total Plate Count

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TABLE 3

BACTERIAL COUNTS PER 100ML GEOMETRIC AVERAGE OF 7/15/75 and 10/21/75 SAMPLING RUNS CALUMET RIVER SYSTEM

Station[1]	TC	FC	FS	*S.*[2] *aureus*	*P.*[3] *aeruginosa*	*Salmonella*	TPC[4]
49	1.4×10^{3}	$<1.0 \times 10^{2}$	$<1.0 \times 10^{2}$	$<3.2 \times 10^{1}$	1.7×10^{1}	$<1.5 \times 10^{-1}$	2.2×10^{6}
55	1.4×10^{3}	4.9×10^{2}	$<1.0 \times 10^{2}$	$<3.2 \times 10^{1}$	1.6×10^{2}	$<1.0 \times 10^{-1}$	4.2×10^{6}
56	2.6×10^{4}	7.2×10^{2}	1.4×10^{2}	$<3.2 \times 10^{1}$	1.0×10^{1}	$<1.0 \times 10^{-1}$	1.9×10^{7}
76	$<9.5 \times 10^{3}$	$<4.1 \times 10^{2}$	3.2×10^{2}	$<3.2 \times 10^{1}$	7.1×10^{1}	$<1.6 \times 10^{-1}$	1.7×10^{7}
58	5.9×10^{4}	3.9×10^{3}	1.4×10^{2}	$<3.2 \times 10^{1}$	1.8×10^{2}	$<1.0 \times 10^{-1}$	3.4×10^{7}
43	1.3×10^{4}	1.6×10^{3}	1.4×10^{2}	$<3.2 \times 10^{1}$	1.7×10^{2}	$<1.0 \times 10^{-1}$	7.1×10^{6}

1. See Figure 1.
2. S = *Staphylococcus*
3. P = *Pseudomonas*
4. TPC = Total Plate Count

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TABLE 4

SALMONELLA SEROTYPES ISOLATED FROM WATERWAYS 1975

Date	Station*	Serotype
7/15/75	58	Infantis
7/15/75	39	Heidelberg
7/15/75	43	Typhimurium
8/12/75	37	Anatum
8/12/75	73	San Diego
10/21/75	49	Typhimurium
10/21/75	58	Agona

*See Figure 1.

TABLE 5

TOTAL COLIFORM, FECAL COLIFORM AND FECAL STREPTOCOCCUS COLONY CONFIRMATIONS ON ECOSYSTEMATIC STATIONS DURING 1975

	TC	FC	FS
Number Confirmed / Confirmations attempted	90/136	118/129	51/59
Percent confirmed	66	91	86

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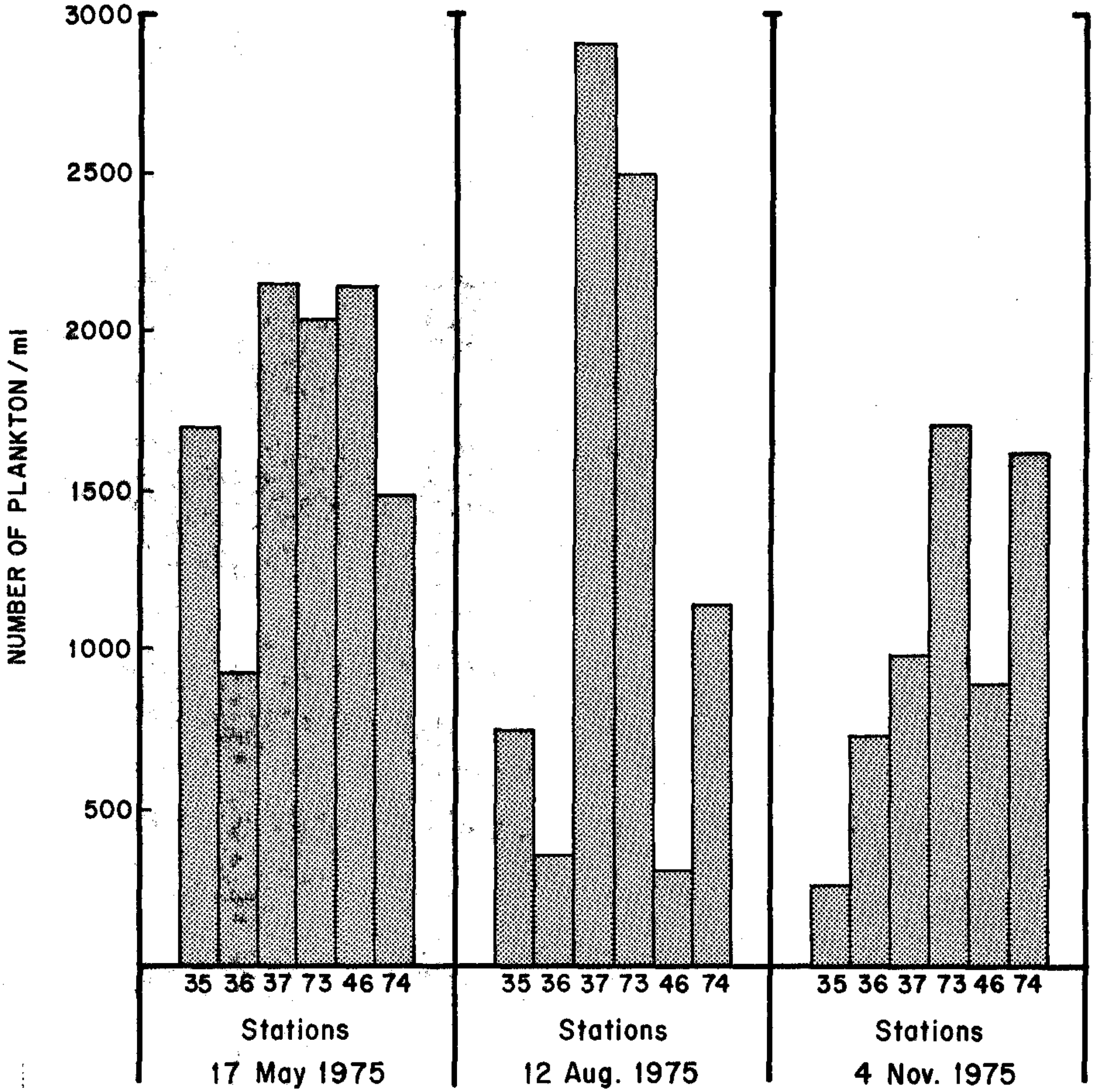
NUMBER OF PLANKTON, AT EACH STATION SAMPLED, ALONG THE NORTH SHORE CHANNEL - NORTH BRANCH CHICAGO RIVER

Figure 2



the high plankton counts are reduced downstream from Goose Island (Station 46, Figure 2) to the same population density occurring after introduction of the NS-STW effluent. In November, the initial plankton count is low and increases at each station sampled until Grand Avenue (Station 46) where a 50% reduction occurs after passage past Goose Island (Figure 2).

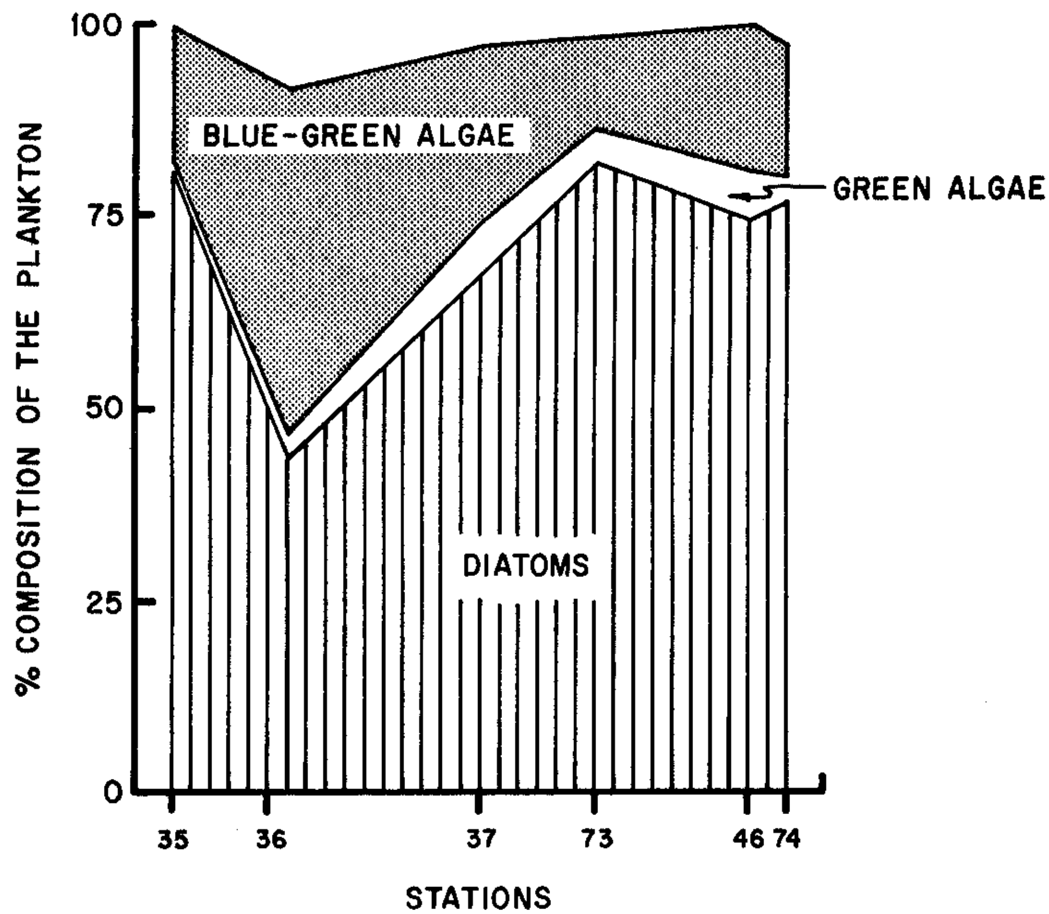
The dominant organisms present in the NSC-NBCR are the blue-green algae and diatoms (Figures 3 - 5). The green algae are also found in the system throughout the year. The blue-greens present are predominantly of the filamentous types - Oscillatoria sp., occurring most often in the greatest number followed by Anabaena sp. The high concentrations of diatoms at Stations #35 and #74 are a reflection of Lake Michigan flora. At its peak, the green algae never exceeded 7-1/2% of the total population and the Chrysophyte - Dinobryon sertularia (Lake Michigan flora), was prevalent only at Stations #35 and 74 (Figures 3 - 5).

Chicago River - Southern portion, including the Sanitary Ship Canal.

In June, in this part of the waterway system, there is a steady decline in plankton populations until we arrive downstream from the WSWSTP where the plankton counts more than double (Station 41, Figure 6). It is likely that this increase is due to a continuation of an established trend in the composition of the plankton. The diatoms received a nutritional boost greater

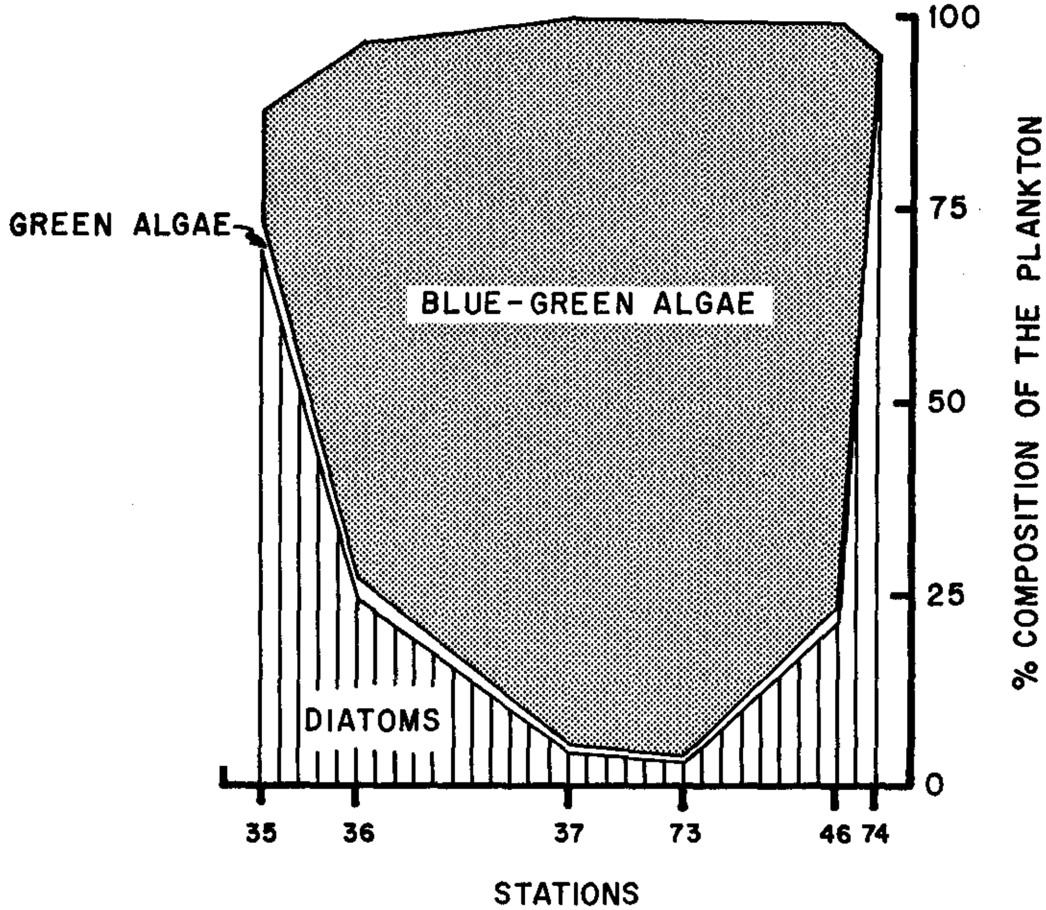
PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON
AT EACH STATION SAMPLED 17 MAY 1975
ALONG THE NORTH SHORE CHANNEL - NORTH BRANCH CHICAGO RIVER

Figure 3



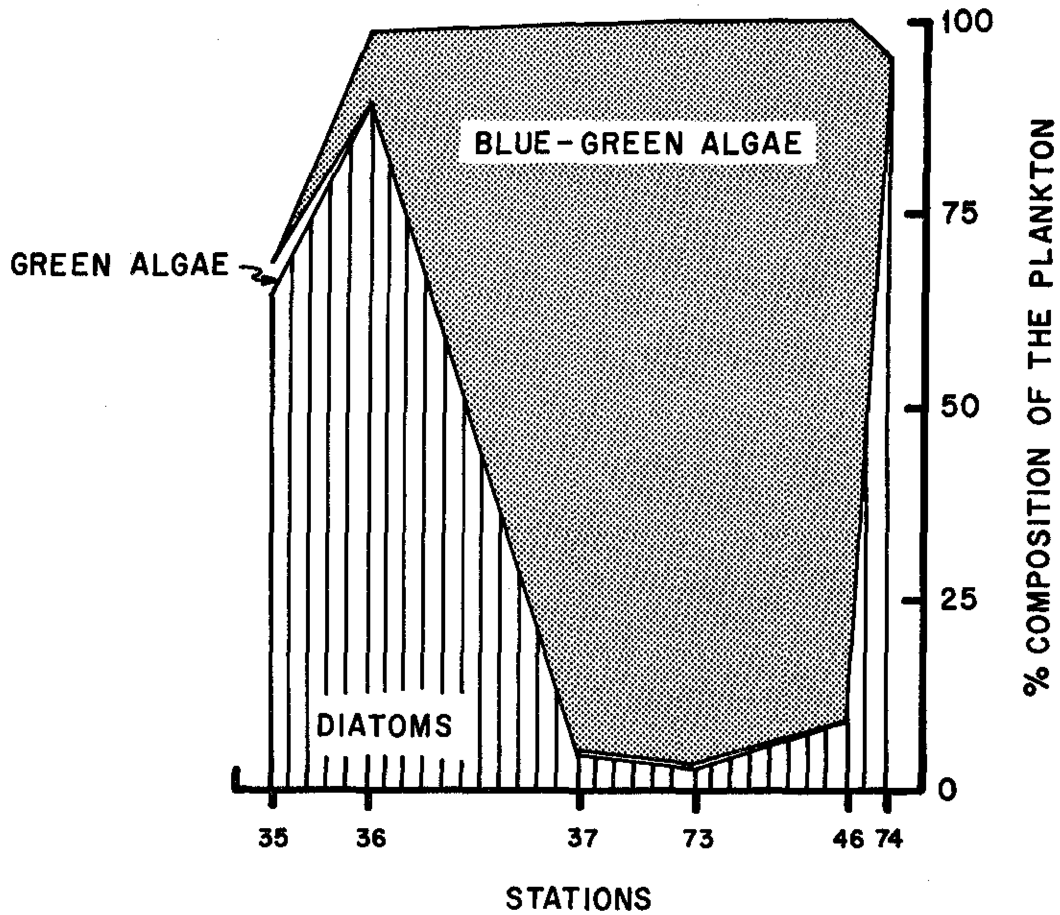
PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON
AT EACH STATION SAMPLED 12 AUGUST 1975
ALONG THE NORTH SHORE CHANNEL - NORTH BRANCH CHICAGO RIVER

Figure 4



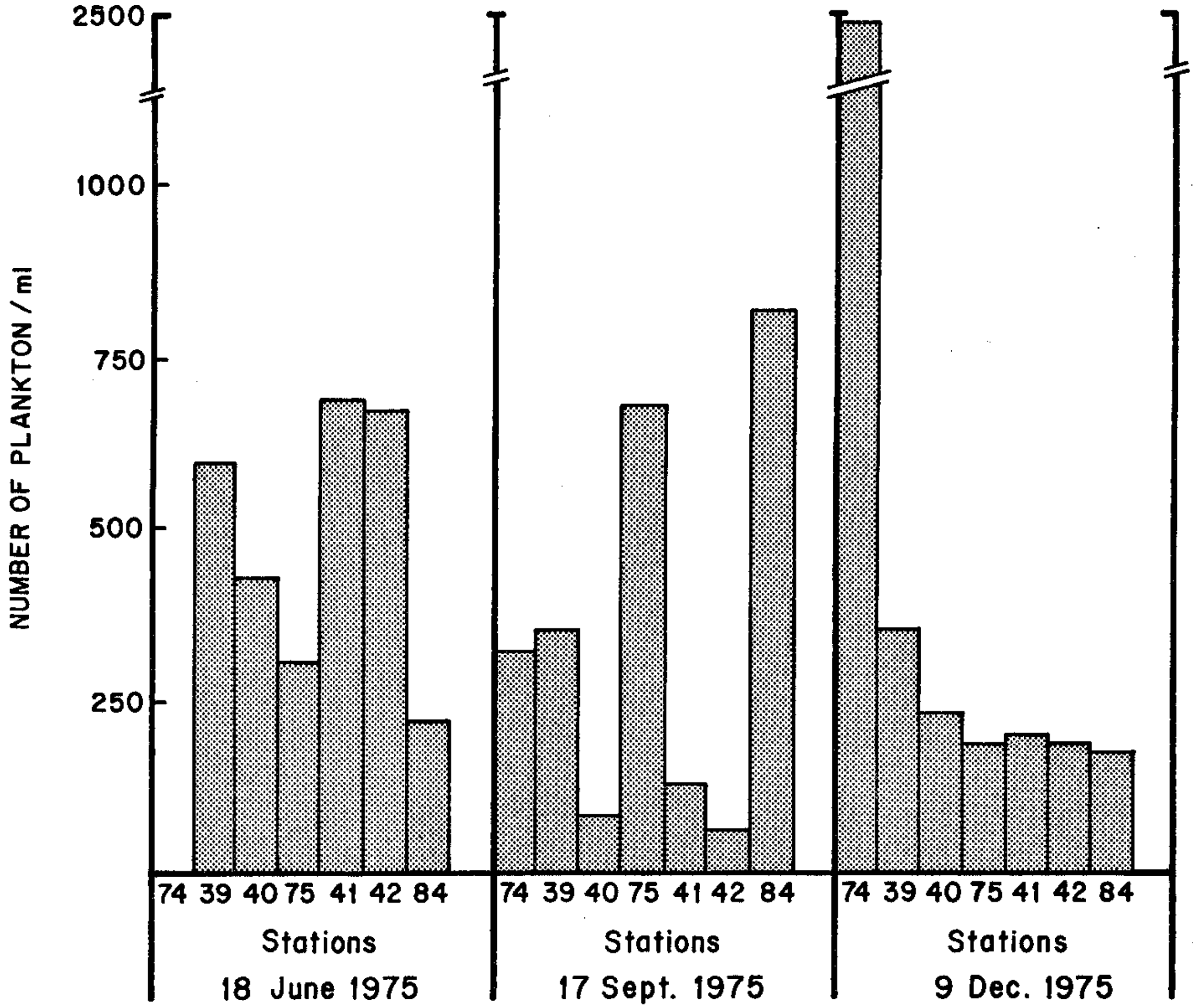
PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON
AT EACH STATION SAMPLED 4 NOVEMBER 1975
ALONG THE NORTH SHORE CHANNEL - NORTH BRANCH CHICAGO RIVER

Figure 5



NUMBER OF PLANKTON, AT EACH STATION SAMPLED, ALONG THE CHICAGO RIVER-SANITARY SHIP CANAL

Figure 6



than the green and blue-green algae or at the very least were able to respond quicker to the added nutrients supplied by this effluent (Figure 7). Their proportion of the total population had been increasing since Station #40 (Damen Avenue). This advantage continued to Station #42 (St. Hwy. #83). Confluence with the Cal-Sag Channel, however, severely reduced the plankton population and the diatom contribution (Figures 6-7).

In September, the data trends are completely anomalous to that found in June, and later in December (Figures 6-9). Complete elimination of the blue-green algae after confluence with the SBCR at Station #40 (Damen Avenue) occurs. With no intervening major discharges, a peak blue-green population (Figure 8) occurs at the next downstream station, Station #75 (Cicero Avenue) located just upstream from the WSWSTP. The high green algal population (greater than 40%) found at the two previous stations upstream has been decimated (to approximately 7%). The influence of the WSWSTP effluent in September appears to be a decimation of the total population from 675 org/ml to 125 org/ml at Harlem Avenue (Station #41, Figure 6). The effect is primarily in reducing the numbers of blue-green algae (Figure 8). Apparently, this effect established by the WSWSTP effluent continues to Station #42 (St. Hwy. #83) where the blue-green population is reduced to 2% from the 88% found at Station #75 (Cicero Avenue). The green algae have again assumed a greater contribution to the total population (38%) (Figure 8).

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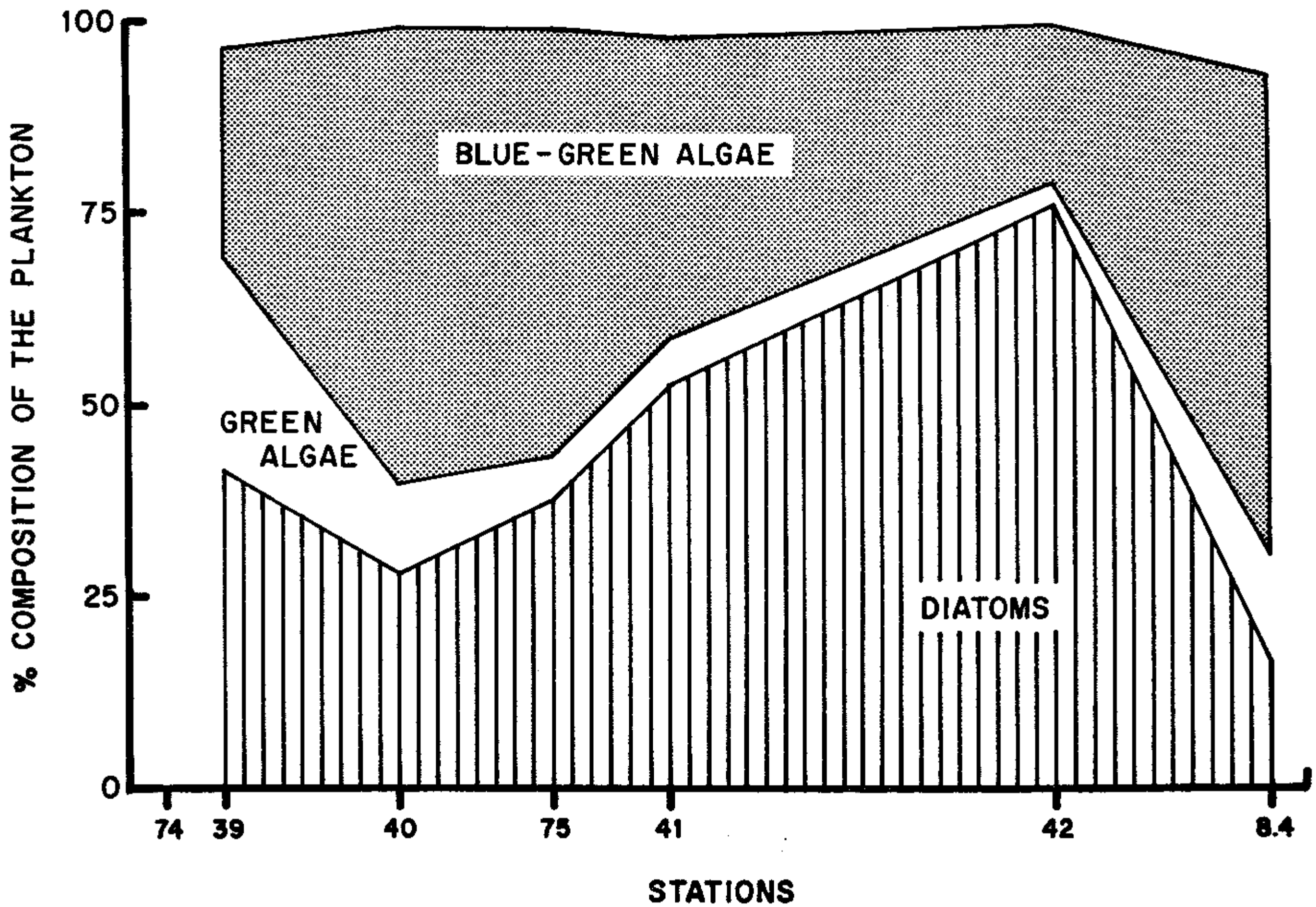
PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON AT EACH STATION SAMPLED 18 JUNE 1975 ALONG THE CHICAGO RIVER - SANITARY SHIP CANAL

Figure 7



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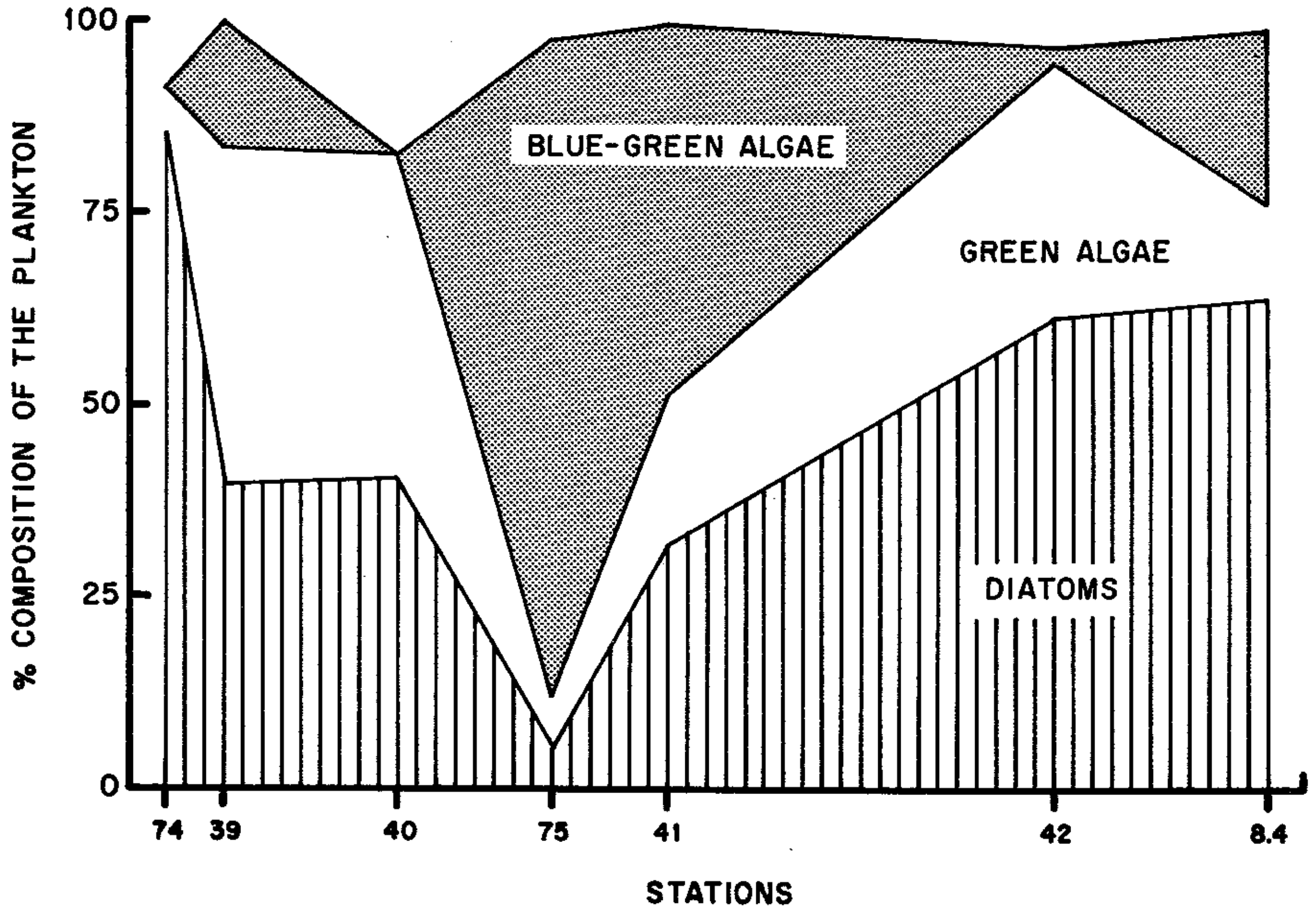
PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON AT EACH STATION SAMPLED
17 SEPTEMBER 1975 ALONG THE CHICAGO RIVER - SANITARY SHIP CANAL

Figure 8



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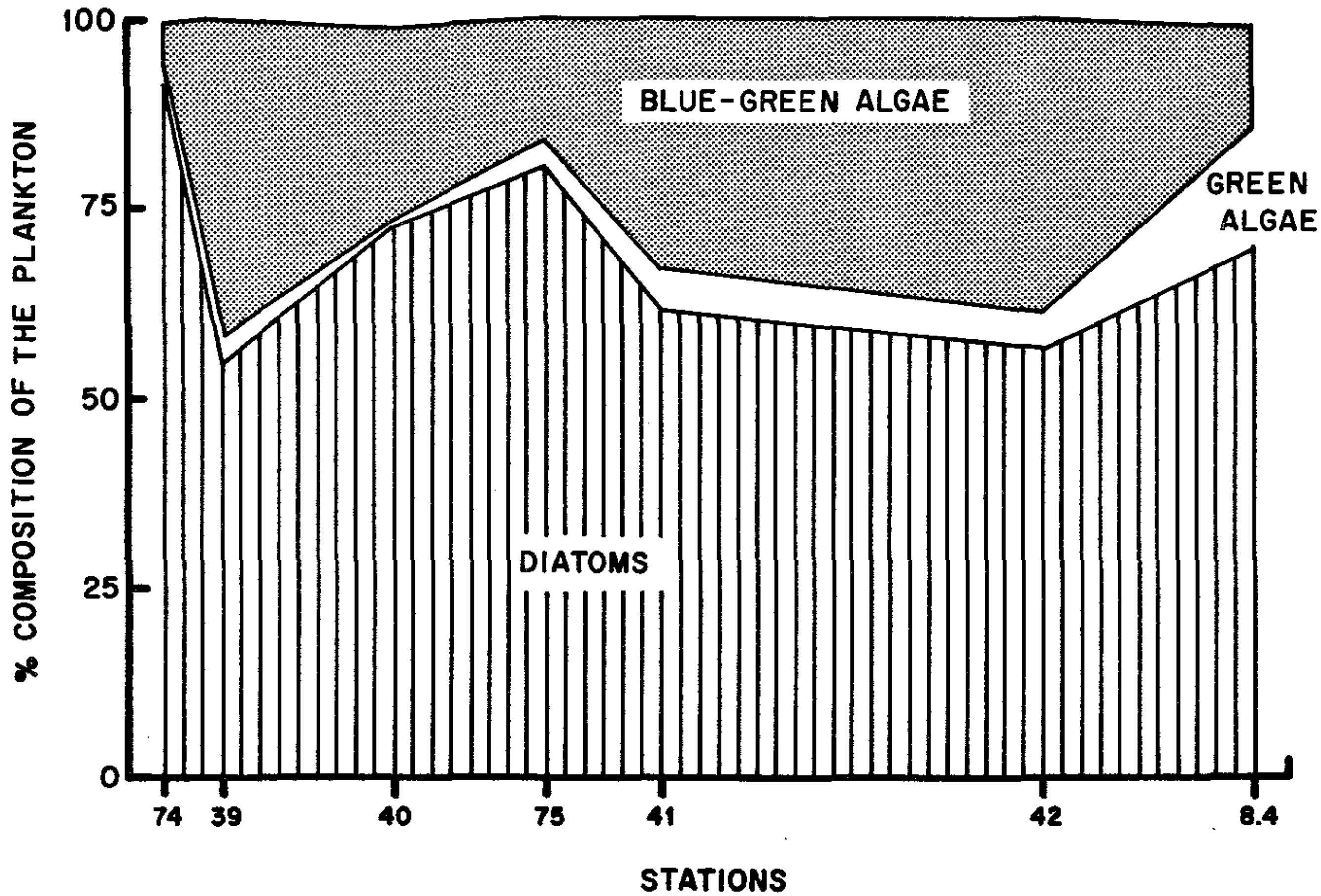
PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON AT EACH STATION SAMPLED 9 DECEMBER 1975 ALONG THE CHICAGO RIVER-SANITARY SHIP CANAL

Figure 9



Apparently, the fall bloom of Lake Michigan survived to Station #74 but not the confluence with the NSC-NBCR (Station 39, Figures 6 - 9). The population continued to decline and then leveled off for the remainder of the waterway with little, if any, effects noted for the entry of tributaries or effluent discharges. Ordinarily, one could assume that the coldness of the climate effected the organisms to slow down metabolism such as to inhibit growth and reproduction. However, the beginning of December was extraordinarily mild in 1975 thus negating this mechanism as a factor.

The blue-green, green algae and diatoms played significant roles in the composition of the flora for this part of the waterway. As in NSC-NBCR, the blue-greens were represented by the filamentous type - Oscillatoria. In addition, during September, it was joined by the single celled mucilaginous colonial form of Chroococcus. The green algae, were primarily represented by Chlamydomonas (flagellated), Crucigenia (flagellated, colonial), and Scenedesmus (colonial). The diatoms were more representative of Lake Michigan flora at those stations closest to openings to Lake Michigan. In addition, it should be noted that two species of a marine diatom, Raphoneis, were found present, but not necessarily viable, at Stations #39 (Madison Avenue) and #75 (Cicero Avenue).

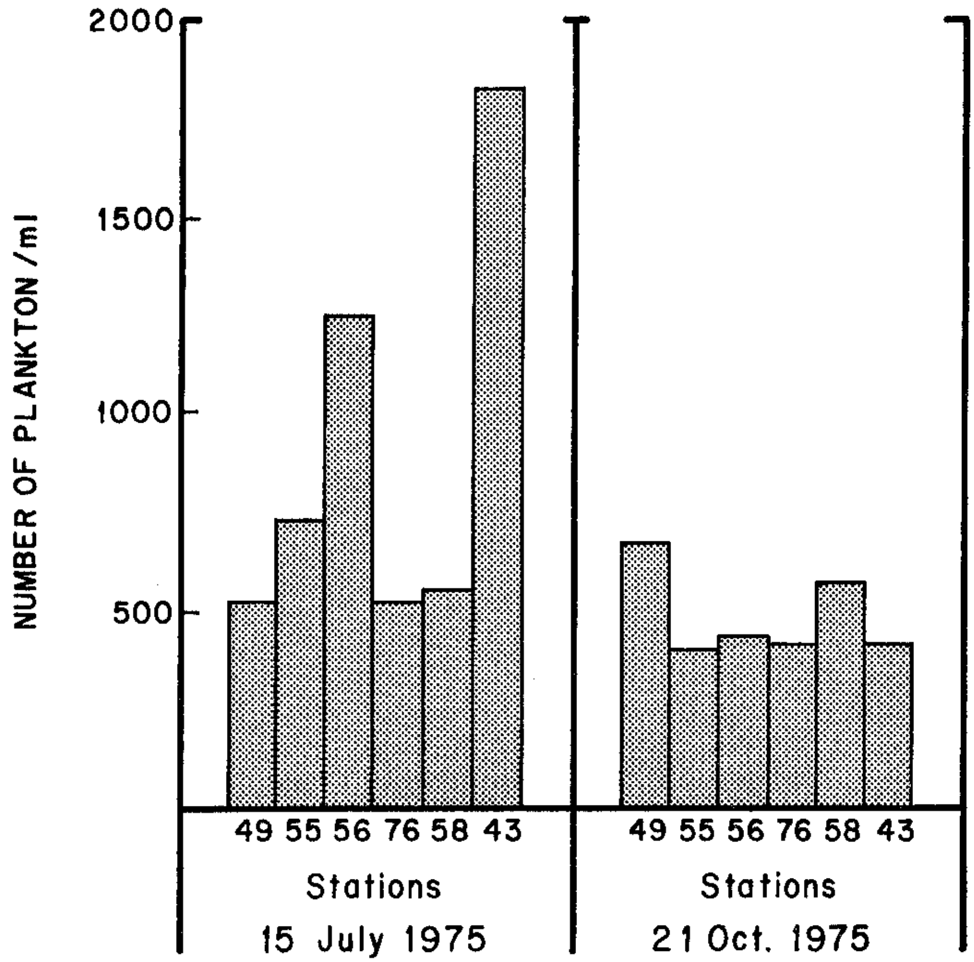
Calumet River - Cal-Sag Channel (CR-CSC)

In July, the total plankton counts increased from the source (Ewing Avenue) to Indiana Avenue (Station #56, Figure 10). Then, apparently influenced by the discharge from CSTP, the plankton population downstream is more than halved. The confluence with the Little Calumet River has little effect upon the total population as recorded at Ashland Avenue (Station #58). The passage through the long stretch of waterway between Station #58 (Ashland Avenue) and Station #43 (St. Hwy. #83), where no major discharges occur, results in a threefold increase in the population density (Figure 10).

The percentage composition of the plankton for July shows that while the total numbers increased for the first three stations, the diatoms decreased and then increased their contribution to the population (Figure 11). Both the green and blue-green algae increased and then decreased in their percentage of the composition. Lake Calumet waters introduced the blue-green algae, encouraged the growth of the green algae and inhibited the growth of the diatoms (Station #55, Figure 11). The waters from the Grand Calumet River, on the other hand, had an opposite effect (Station #56, Figure 11). For the remaining stretch of the waterway sampled, the diatom contribution was gradually reduced, the green algae were correspondingly increased, and the blue-green contribution remained the same (Figure 11).

NUMBER OF PLANKTON, AT EACH STATION SAMPLED, ALONG THE CALUMET RIVER-CAL-SAG CHANNEL

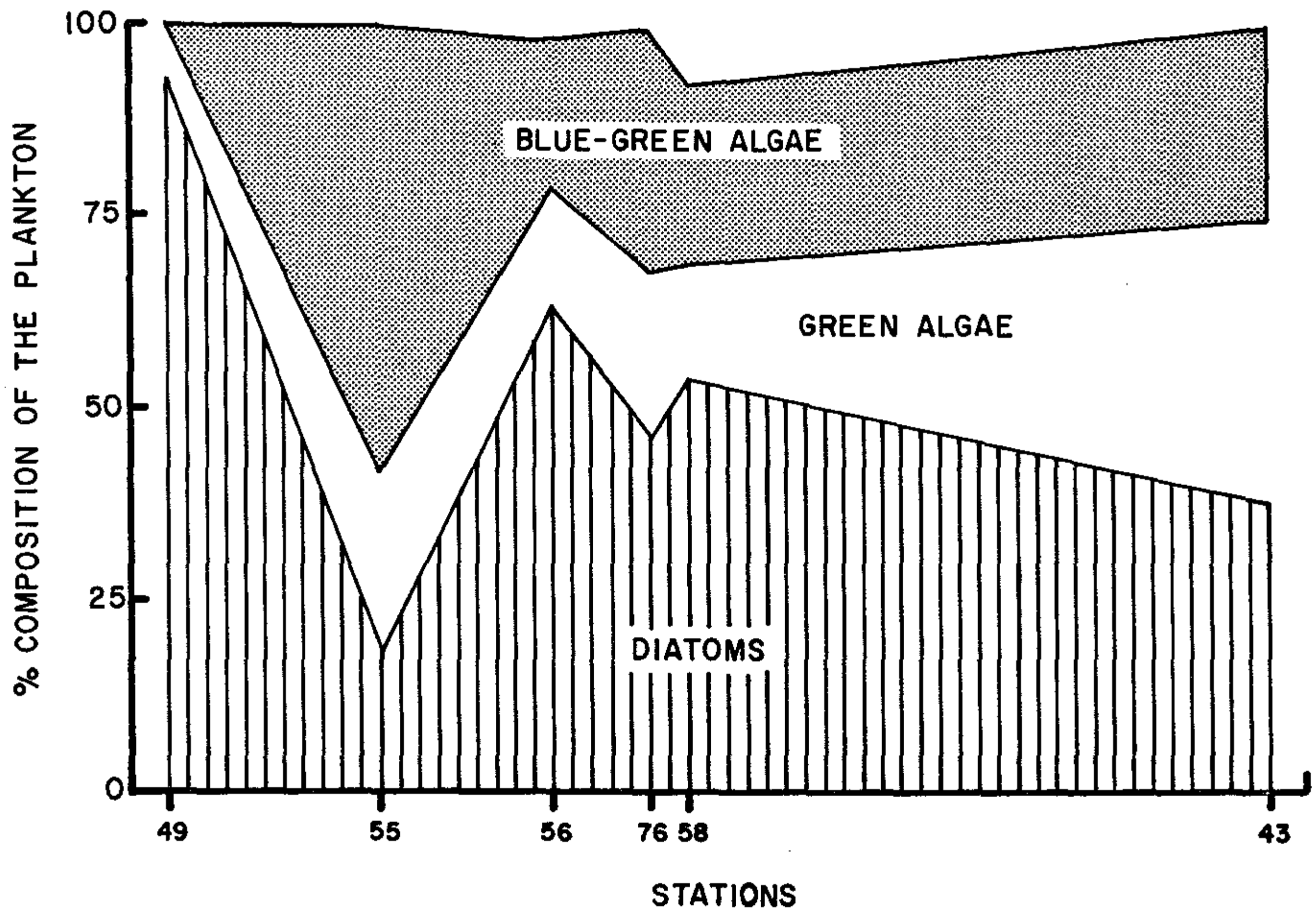
Figure 10



THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON AT EACH STATION SAMPLED 15 JULY 1975 ALONG THE CALUMET RIVER-CAL-SAG CHANNEL

Figure 11



The percentage compositions of the phytoplankton in October generally show that Lake Calumet eliminated the blue-green algae and introduced green algae to the system (Station #55, Figure 12). The Chrysophyte, Dinobryon sertularia, was also not found. The data indicate that the diatoms played an increasing role in the population until Station #56 (Indiana Avenue). The Grand Calumet River, again supporting and/or contributing the diatoms, did not introduce blue-greens and did reduce the number of green algae. Then, the diatoms were drastically reduced in percentage, the green algae increased and blue-green algae introduced to the same approximate proportion as the green algae. The influence of CSTP effluent is seen here, providing the same trends as seen in July.

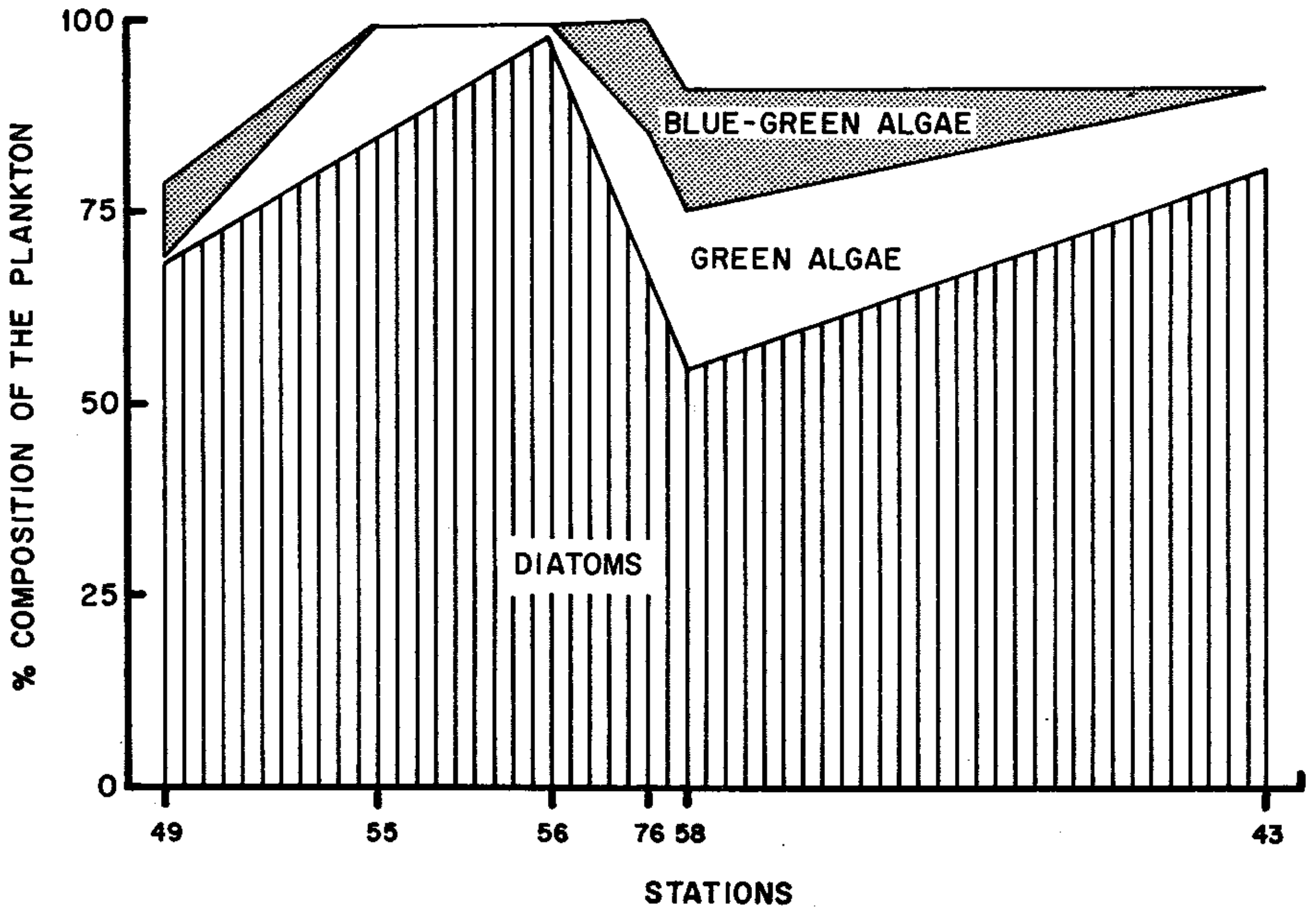
Entry of the Little Calumet River seems to have no effect on the continuing rate of decline in the diatom contribution. The green and blue-green algae continue their equality of contribution. Euglenoids are introduced at this point and maintain their percentage of the composition for the remainder of this waterway while the blue-greens are eliminated. The green algae are reduced somewhat in their contribution while the diatoms increase.

In July, the only blue-greens found were Oscillatoria and Chroococcus while in October Anabaena was found at the first station but not thereafter, Chroococcus was found in the beginning of the system, Oscillatoria was found at the end of the

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

PERCENTAGE COMPOSITION OF THE PHYTOPLANKTON AT EACH STATION SAMPLED
21 OCTOBER 1975 ALONG THE CALUMET RIVER - CAL-SAG CHANNEL

Figure 12



system and Merismopedia was found throughout. Amongst the green algae, Ankistrodesmus and Scenedesmus were cosmopolitan. Frequently reported were Chlamydomonas, Crucigenia and Kirchuriella. Only two filamentous green algae were reported: Ulothrix in July and Spirogyra in October, and at only one station. The diatoms here, as with the other waterways, go from a Lake Michigan flora to a water flora representative of polluted waters.

In summary, the generalization that most adequately describes the Chicago waterways is that Lake Michigan flora are swept into a lotic environment for which they are unsuited and the composition rapidly changes to a pollution tolerant flora consisting of primarily filamentous, free-floating blue-green algae. The influence of sewage treatment plant effluent and tributaries is indeterminant as it varies with the seasons and the particular waterway.

Benthos

The quality of the water passing a given point depends upon the conditions in the watershed upstream. In each of the major three MSDGC waterways there are numerous combined overflows, one or more tributaries, and one sewage plant outfall, all effecting the quality of the water. The pollutants entering the waterways from the above sources, the occasional backflows through the locks, the various kinds and methods of river traffic, and many other factors, apparently, affect the kinds of aquatic organisms able to live in certain sections of these waterways. The bottom organism data herein indicate that while all areas of the study are degraded, those stations closest to the lake inlets are less so.

Chicago River - northern portion

The following analyses were made on the pooled samples collected at each station on the northern portion of the Chicago River System in 1975: (1) community composition by percent and (2) taxonomic density (Table 6). Results of these analyses on a station-by-station basis are considered in the following discussion. Although the number of samples is small, certain generalizations can be made of the benthic macroinvertebrates over the period from May to November, 1975 (Table 6).

Station 35, Lincoln Street

Lincoln Street is located in the North Shore Channel 0.88 miles downstream of the sluice gate at Wilmette. Four taxa were found at this station, oligochaetes, leeches, isopods, and midges. However, 92% of these organisms were oligochaetes. This poor balance among the macrobenthic community indicates a poor water quality. The mean total density of macroinvertebrates from the three sampling dates was 15,000 organisms per square meter found at any station upstream of the South Branch.

Station 36, Touhy Avenue

Touhy is located 0.56 miles downstream from the discharge from the Northside Sewage Treatment Plant and four miles downstream of Lincoln Street. Two taxa were collected at this station, oligochaetes, and midges. Ninety-one percent of the specimens collected were sludgeworms (oligochaetes). This community domination by sludgeworms indicates a response to moderate organic enrichment.

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TABLE 6

MEAN DENSITY OF BENTHIC MACROINVERTEBRATES OF THE NORTH SHORE CHANNEL, CHICAGO RIVER AND LOWER PORTION OF THE NORTH BRANCH OF THE CHICAGO RIVER IN 1975*

Station		River System	Benthic Macroinvertebrates (Per Square Meter)								
Name	Number		Oligochaeta (sludgeworms)	Hirudinea (leeches)	Isopoda (sow bugs)	Amphipoda (scuds)	Chroborinae (phantom midges)	Chronomidae (non-biting midges)	Pelecypoda (clams)	Gastropoda (snails)	% Oligochaeta
Lincoln Street	35	Channel	14,000	4	17	0	0	1,200	0	0	92
Touhy Avenue	36	Channel	74,000	0	0	0	0	7,300	0	0	91
Wilson Avenue	37	North Branch	170,000	8	0	0	0	3,100	0	8	>99
Diversey Avenue	73	North Branch	120,000	19	2	0	0	250	0	0	>99
Grand Avenue	46	North Branch	65,000	0	0	0	8	0	0	0	>99
Outer Drive	74	Chicago	2,500	8	13	21	0	38	180	120	87

*Average of three sampling dates (May, August, October)

At Station 36, the mean total density of organisms for the three sampling dates was 81,000 per square meter.

Station 37, Wilson Avenue

This station, located four miles below the Northside outfall and 0.7 miles downstream from the junction of the channel and North Branch, also supported a depressed macrobenthic invertebrate community. The four taxa collected at this station, oligochaetes, leeches, midges, and snails (*Physa integra*) are considered to be highly tolerant of organic enrichment. More than 99% of these specimens were sludgeworms. The mean total density of these macroinvertebrates from the three sampling dates amounted to 170,000 per square meter, the largest number present in any of these areas.

Station 73, Diversey Avenue

Diversey is located 3.3 miles downstream of the Junction. Four kinds of benthic macroinvertebrates were collected at this point; sludgeworms, leeches, isopods, and midges. More than 99% of these organisms were pollution-tolerant sludgeworms. The total mean density of organisms for the three sampling periods was 120,000 per square meter. The high number of oligochaetes and the low number of taxa suggest a highly stressed community.

Station 46, Grand Avenue

The benthic macroinvertebrate community at this station was the most uniformly disturbed of the "northern" six stations examined. Only sludgeworms and phantom midges (*Chaoborus* sp.)

were present, indicating an area under severe stress. The oligochaetes, commonly associated with organic enrichment, for the three sampling dates had a mean total of 65,000 per square meter.

Station 74, Outer Drive

The "Outer Drive" is located near the MSDGC Lock 0.2 miles from Lake Michigan. Seven taxa of macroinvertebrates were present here: Worms, leeches, midges, isopods, amphipods, snails, and clams, indicating an acceptable water quality. This was the only station of the six sampled in which amphipods and clams were present. The total mean density for the three sampling dates was 3,000 organisms per square meter, 87% of which were sludgeworms.

Chicago River - southern portion

As this waterway proceeds downstream, the influence of the cleaner water from the Chicago Lock (Lake Michigan water) is rapidly nullified by the junction with the North Branch and the wastewaters from tributaries and combined sewer overflows (in the vicinity of Stations 56, 76, and 58). The variety of benthic macroinvertebrates previously found at the upstream stations are eliminated until only oligochaetes, mainly tubificids, are present. When these pollution tolerant organisms are present in large numbers and/or make up more than 80 percent of the total population, heavy pollution is indicated. The 1975 seasonal data are reported herein on a station-by-station basis (Tables 7-9). Included are the temperature and other important data (Table 10).

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 7

BENTHIC MACROINVERTEBRATE ABUNDANCE (AVERAGE NUMBER PER m^2) AT STATIONS SHOWN IN FIGURE 1 ON JUNE 17 (CHICAGO RIVER) AND JULY 15, 1975 (CALUMET RIVER). (THE ABUNDANCE OF OLIGOCHAETA IS ALSO EXPRESSED AS A PERCENTAGE OF THE TOTAL MACROINVERTEBRATE BOTTOM FAUNA)

Station		River System	Benthic Macroinvertebrates (Number/m^2)				
Name	Number		Oligochaeta (Aquatic worms)	Hirudinea (leeches)	Chronomidae (midges)	Pelecypoda (clams)	% Oligochaeta
Madison	39	Chicago-S.B.	20,000	--	--	480	98
Damen	40	Chicago-S.B.	5,800	--	--	25	>99
Cicero	75	Chicago-CS&SC	12,000	--	--	--	100
-----	-----	-----	SWTP Outfall	-----	-----	-----	-----
Harlem	41	Chicago-CS&SC	32,000	--	--	--	100
Route 83	42	Chicago-CS&SC	95,000	--	--	--	100
16th St.	8.4	Chicago-CS&SC	340	--	--	--	100
Ewing[1]	49	Calumet-Cal.	4,600	25	--	--	>99
130th St.	55	Calumet-Cal	4,300	6	160	19	97
Indiana	56	Calumet-L.Cal.	2,300	--	500	130	81
-----	-----	-----	CTP Outfall	-----	-----	-----	-----
Halsted	76	Calumet-L.Cal.	12,000	--	--	--	100
Ashland	58	Calumet-Cal-Sag C.	140,000	--	25	--	>99
Route 83	43	Calumet-Cal-Sag C.	27,000	--	13[2]	--	>99

1. Six (6) crayfish were also present. 2. Chaoboridae only.

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 8

BENTHIC MACROINVERTEBRATE ABUNDANCE (AVERAGE NUMBER PER m^2) AT STATIONS SHOWN IN FIGURE 1 ON SEPTEMBER 17 (CHICAGO RIVER) AND OCTOBER 21, 1975 (CALUMET RIVER). (THE ABUNDANCE OF OLIGOCHAETA IS ALSO EXPRESSED AS A PERCENTAGE OF THE TOTAL MACROINVERTEBRATE BOTTOM FAUNA)

Station		River System	Benthic Macroinvertebrates (Number/m^2)				
Name	Number		Oligochaeta (Aquatic worms)	Hirudinea (leeches)	Chronomidae (midges)	Pelecypoda (clams)	% Oligochaeta
Madison	39	Chicago-SB	130,000	--	6	860	> 99
Damen	40	Chicago-SB	1,500	--	--	--	100
Cicero	75	Chicago-CS&SC	400	--	--	--	100
SWTP Outfall							
Harlem	41	Chicago-CS&SC	140,000	--	--	--	100
Route 83	42	Chicago-CS&SC	1,900	--	--	--	100
16th St.	8.4	Chicago-CS&SC	4,000	--	--	--	100
Ewing	49	Calumet-Cal.	44	76	--	--	37
130th St.	55	Calumet-Cal.	1,900	--	6	--	>99
Indiana	56	Calumet-L.Cal.	5,100	--	1,700	190	73
CTP Outfall							
Halsted	76	Calumet-L.Cal.	130,000	--	--	--	100
Ashland	58	Calumet-Cal.Sag C.	190,000	--	--	--	100
Route 83	43	Calumet-Cal Sag C.	56,000	--	--	--	100

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 9

BENTHIC MACROINVERTEBRATE ABUNDANCE (AVERAGE NUMBER PER m^2) AT STATIONS SHOWN IN FIGURE 1 ON DECEMBER 9, 1975 (CHICAGO RIVER). (THE ABUNDANCE OF OLIGOCHAETA IS ALSO EXPRESSED AS A PERCENTAGE OF THE TOTAL MACROINVERTEBRATE BOTTOM FAUNA)

Station		River System	Benthic Macroinvertebrates (Number/m^2)				
Name	Number		Oligochaeta (Aquatic worms)	Hirudinea (leeches)	Chronomidae (midges)	Pelecypoda (clams)	% Oligochaeta
Madison	39	Chicago-SB	190,000	--	95	400	98
Damen	40	Chicago-SB	21,000	--	25	76	>99
Cicero	75	Chicago-CS&SC	56,000	--	--	--	100
			SWTP Outfall				
Harlem	41	Chicago-CS&SC	280,000	--	--	--	100
Route 83	42	Chicago-CS&SC	38,000	--	--	--	100
16th St.	8.4	Chicago-CS&SC	2,500	--	--	--	100
Ewing	49	Calumet-Cal.	Not Sampled				
130th St.	55	Calumet-Cal.	" "				
Indiana	56	Calumet-L.Cal.	" "				
			CTP Outfall				
Halsted	76	Calumet-L. Cal.	Not Sampled				
Ashland	58	Calumet-Cal-Sag C.	" "				
Route 83	43	Calumet-Cal-Sag C.	" "				

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 10

DESCRIPTION OF SAMPLING STATIONS DURING 1975

Station	Sediment Temperature (°C)			No. of Species			Total Number Organisms (in Thousands) per m^2		
	June /	Sept./	Dec.	June /	Sept. /	Dec.	June /	Sept. /	Dec.
Chicago River System									
Madison (39) NBCR	19.0	22.0	12.0	5	5	6	20.5	131.0	190.0
Damen (40) NBCR	21.5	25.0	13.5	4	3	6	5.8	1.5	21.0
Cicero (75) CS&SC	24.0	30.0	17.0	3	4	3	12.0	0.4	56.0
Harlem (41) CS&SC	24.0	28.0	15.5	3	3	3	32.0	140.0	280.0
Route 83 (42) CS&SC	24.0	24.5	16.0	2	2	3	95.0	1.9	38.0
16th St. (84) CS&SC	22.0	----	16.0	3	3	3	0.34	4.0	2.5
	July /	Oct.		July /	Oct.		July /	Oct.	
Calumet River System									
Ewing (49) CR	25.0	15.0		7	2		4.6	0.1	
130th (55) CR	25.0	17.0		8	7		4.4	1.9	
Indiana (56) LCR	24.0	14.0		7	6		2.9	7.0	
Halsted (76) LCR	23.0	15.5		3	1		12.0	130.0	
Ashland (58) CSC	23.0	16.5		4	3		140.0	190.0	
Rt. 83 (43) CSC	23.0	16.5		4	3		27.0	56.0	

Station 39 - Madison

Madison is located on the South Branch of the Chicago River near the Chicago downtown area. The bottom is composed of mostly black, oily sludge with some sand and pieces of metal and paper debris. Numerous fingernail clam shells (empty) were noticeable in the area, in addition to the live fingernail clams. Midges, small in number (Tables 7-9) were present only in September and December. The oligochaetes (aquatic worms), however, make-up 98 percent or more of the benthic macroinvertebrate community during all times of the year studied. They increased in numbers from June to December, from 20,000 to more than 180,000 per square meter. Other tubificid worms present throughout the year in a decreasing order of magnitude were *Limnodrilus hoffmeisteri*, *L. cervix*, *L. udekemianus* and *Peloscolex multisetosus*.

Station 40 - Damen

Damen is about four miles downstream from Station 39 (Madison) on the South Branch of the Chicago River. The bottom is mostly black sludge and clay with some vegetative debris. The benthic macroinvertebrate community is greatly reduced from the previous station. The clams are present in smaller numbers and were not found during the summer run. Midges were present only during the December run. The oligochaetes varied from 1,500 to less than 22,000 per square meter, but made-up more than 99 percent of the community (Tables 7-9). The dominant tubificid

(Oligochaeta) was Limnodrilus hoffmeisteri. L. cervix, Tubifex tubifex, and Peloscolex multisetosus were present, but in very small numbers - less than 1,000 per square meter.

Station 75 - Cicero

Cicero is located four miles downstream of Station 40 (Damen) on the Chicago Sanitary and Ship Canal. The bottom is composed of black sludge with some sand, charcoal and much vegetative debris. Anaerobic conditions are especially noticeable because of the extensive bubbling action present. Only tubificids were found present here. Changes in the sediment temperatures (Table 10) apparently affect the worm populations, because there were 12,000 worms per square meter when the sediment temperature was 24°C. Then, when the temperature increased to 30°C the worms decreased in numbers to 400 per square meter. The cooler temperatures later in the year enabled the worm numbers to jump to 56,000 per square meter. Limnidrilus hoffmeisteri, the dominant species of worm out-numbered the L. cervix, L. udekemianus, and the few Tubifex tubifex.

Station 41 - Harlem

This station, Harlem, is located on the Chicago Sanitary and Ship Canal about 1.5 miles downstream of the West-Southwest Treatment Plant outfall. The addition of this treatment plant effluent represents a very sizeable amount of water entering the system. Organic material present creates extensive black sludge beds, apparently providing enough food to support a large standing crop of worms. The worms number 32,000 per square meter in June, increase to 140,000 and later in the year to 280,000 per square meter (Tables 7-9). Here, *Limnodrilus cervix* dominates *L. hoffmeisteri* with *L. udekemianus* also being present.

Station 42 - Route 83

Route 83 is about 10 miles downstream of Station 41 (Harlem) on the Chicago Sanitary and Ship Canal. The bottom is composed of mostly rock, gravel, and sand darkened by oily material. Because of the hard bottom material some difficulty in collecting samples exists. The tubificids are the only benthic macroinvertebrates present. Their numbers were highest in June (95,000) and lowest in September (1,900) (Tables 7-9). During this time there was barely a change in sediment temperature (Table 10) except for December. At this location, far removed from the WSW STP outfall, *Limnodrilus hoffmeisteri* was the dominant tubificid. *L. cervix* was also present with a few *Tubifex tubifex*.

Station 8.4 - 16th Street

This station, 16th Street, is approximately 11 miles downstream of Sag Junction, the confluence of the Chicago and Calumet River Systems, and one mile upstream of the locks at Lockport on the Chicago Sanitary and Ship Canal. The bottom is composed of black sludge with clay. Very little residue remains from the sample being screened through a U.S. Number 30 sieve. The numbers of aquatic worms ranged from 340 to 4,000 per square meter. *Limnodrilus hoffmeisteri*, *L. cervix*, and *L. udekemianus* were the tubificid species present.

Calumet River System

This waterway starts near the mouth of the Calumet Harbor and flows past numerous steel, oil, and other large industrial concerns before meeting at Sag Junction with the Chicago Sanitary and Ship Canal. The flow in the Calumet River System, however, is low in both volume and velocity. Tubificids are the most abundant macroinvertebrates throughout the system. They comprised 73 - 100% of the invertebrates (Tables 7-9). Also present, although in small numbers, are the midges, fingernail clams, leeches, Naididae worms, and crayfish.

Station 49 - Ewing

Ewing is located near the mouth of Calumet Harbor on the Calumet River. The bottom is composed of mostly clay with some gravel and rocks, making sampling difficult. The number of organisms present in the area during the two sampling runs was extremely low (Tables 7-9). In July when the temperature of the sediment was high (Table 10) the variety of aquatic worms was high. *Peloscolex multisetosus* was the dominant worm. Next were *Limnodrilus hoffmeisteri*, *L. cervix* and *Tubifex tubifex*. Other macroinvertebrates present were the leeches.

Station 55 - 130th Street

This station, 130th Street, is located about one-half mile upstream of the O'Brien Lock on the Calumet River. The bottom consists of mostly clay. The oligochaetes make-up 97 percent or more of the benthic macroinvertebrate community during the times sampled (Tables 7-9). Limnodrilus hoffmeisteri was the dominant worm. Other worm species were L. cervix, L. udekemianus, and Tubifex tubifex. Leeches, midges, and clams were also present.

Station 56 - Indiana

Indiana Station is located on the Little Calumet River about 4 miles downstream of the O'Brien Lock. The bottom is composed of mostly gray clay. The oligochaetes made up 73 - 81 percent of the benthic macroinvertebrate community in this area at the times sampled (Tables 7-9). Limnodrilus hoffmeisteri was the dominant worm. Next were L. cervix, Peloscolex multisetosus, Tubifex tubifex, and L. udekemianus. Also present were the midges and the clams.

Station 76 - Halsted

This station, Halsted, is located 1-1/2 miles downstream of the Calumet Treatment Plant outfall on the Little Calumet River. The bottom here consists of mostly black sludge and clay. The numbers of aquatic worms present here ranged from 12,000 - 130,000 per square meter (Tables 7-9). Limnodrilus hoffmeisteri was the dominant species present. Very few other worms were present and no other kindsof macroinvertebrates were found in the area.

Station 58 - Ashland

Ashland Station is located one mile downstream of Station 76 (Halsted) at the Junction on the Cal-Sag Channel. The bottom is composed of mostly sludge and debris (coal, etc.). The numbers of aquatic worms ranged from 140,000 - 190,000 per square meter (Tables 7 - 9). Limnodrilus hoffmeisteri was the dominant worm in the sediment at this site. Tubifex tubifex, not collected since the station at 130th Street, is present in rather large numbers here (21,000 - 44,000). L. cervix was also collected here. A few midges were present in July, but not in October (Tables 7 - 9).

Station 43 - Route 83

This station, Route 83, is located near Sag Junction, the confluence with the Chicago Sanitary and Ship Canal (Station 42). The bottom consists mostly of mud. The numbers of worms present in this location are much lower from the previous site. The worms ranged from 27,000 - 56,000 per square meter (Tables 7 - 9). Limnodrilus cervix was the dominant worm present in the sediment at this site. L. hoffmeisteri, and Tubifex tubifex were the other species present. The phantom midge, Chaoborus sp., was collected in July from this area.

Sediment Oxygen Demand Characteristics

During late fall 1975, the oxygen demands of the sediments (SOD) in the waterways were measured at five stations in the North Shore Channel - North Branch of the Chicago River, five stations in the South Branch of the Chicago River - Chicago Sanitary and Ship Canal, and one station on the Calumet River System (Table 11).

The substrate at the two stations with the greatest depths, Diversey (#73) and Grand (#46), consisted of thick deposits of

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 11

SUMMARY OF DISTRICT WATERWAYS SOD CHARACTERISTICS FOR 1975

Station (No.)[1]	Corps of Engineers Mile point[2]	Date	DO (mg/l)	Water Temp (^{o}C)	SOD ($g/m^2/day$)
(North Shore Channel - North Branch of Chicago River)					
Lincoln (#35)	(L)	Dec. 8, 1975	12.5	3.0	1.66[3]
Touhy (#36)	(L)	Dec. 2, 1975	8.5	14.5	1.44
Wilson (#37)	(L)	Dec. 4, 1975	8.0	11.5	3.83
Diversey (#73)	(L)	Dec. 5, 1975	6.4	12.0	5.50
Grand (#46)	(R)	Dec. 5, 1975	5.1	11.0	6.78
(South Branch of Chicago River - Chicago Sanitary and Ship Canal)					
Madison (#39)	325.3 (R)	Nov. 7, 1975	2.8	18.0	4.55
Cicero (#75)	317.6 (L)	Nov. 14, 1975	1.3	21.0	1.70[4]
Harlem (#41)	314.0 (L)	Nov. 20, 1975	5.7	20.0	3.61
Route 83 (#42)	305.8 (R)	Nov. 19, 1975	1.7	20.0	3.48
16th St. (#8.4)	292.3 (L)	Nov. 18, 1975	2.5	20.0	2.39
(Calumet River System)					
Route 83 (#43)	304.1 (L)	Nov. 19, 1975	1.8	11.0	1.54

1. Station Numbers as used in this study.
2. Mile point includes side of channel, looking upstream, with L=left side and R=right side.
3. North Side Treatment Plant effluent outfall point.
4. W-SWTP effluent outfall point.

sludge. The sediment oxygen demand rates obtained at these stations were the highest, 5.50-6.78g $O_2m^{-2}day^{-1}$ respectively (Table 11). The other three stations in this northern portion of the Chicago River had SOD rates ranging from 1.44-3.83g O_2m^{-2} day^{-1} with substrates consisting of mud, sand, and clay. The DO at all five of these stations was high, ranging from 5.1-12.5 mg/l (Table 11).

The stations on the southern portion of the Chicago River system, except for Harlem (DO=5.7 mg/l), had very low DO's ranging from 1.3-2.8 mg/l. Madison, with thick deposits of sludge, had the highest SOD rate, 4.55g $O_2m^{-2}day^{-1}$. The other SOD rates ranged from 1.70-3.61g $O_2m^{-2}day^{-1}$ (Table 11).

The oxygen demand of the sediment at Route 83 on the Cal Sag was measured at 1.54g $O_2m^{-2}day^{-1}$ at a temperature of 11.0°C with a DO of only 1.8 mg/l (Table 11).

D. Fish

The greatest number of fish individuals and species occurred at Wilmette, Outer Drive, O'Brien Lock and the Calumet Expressway (Table 12), most probably due to their proximity to the cleaner waters of Lake Michigan. There was a great increase in both number of species and number of individuals in the Wilmette catch from 1974 to 1975. This may be due to the greatly increased water flow through the lock gate during 1975, allowing entrance of individuals from the lake (especially alewife and yellow perch).

Results of the channel fish collections in terms of species diversity at each station are listed in Table 13. When Wilhm[7] evaluated values calculated from benthic macroinvertebrate data that numerous authors had collected from a variety of polluted and unpolluted waters, he found that in unpolluted waters $\bar{d}$ was generally between 3 and 4, whereas in polluted water, $\bar{d}$ was generally less than 1. The higher values for $\bar{d}$ (Outer Drive-Chicago River, O'Brien Lock-Calumet River, Wilmette-North Shore Channel) occur as expected in areas close to Lake Michigan and represent relatively clean water conditions. Lower values occur in the Little Calumet River/Cal Sag Channel and the Sanitary and Ship Canal. The estimate of $\bar{d}$ improves with increased sample size, and samples containing less than 100 specimens should be evaluated with caution, if at all.[5] This was particularly noted when the $\bar{d}$ values were applied to the North Shore Channel/North Branch Chicago River. Here, except near Wilmette, the $\bar{d}$ values indicated a uniform water quality which would normally suggest that the water quality both above (Dempster Avenue) and below (Pratt Avenue) the North Side Treatment Plant Outfall is similar when in fact, this was not the case. Thus, while these $\bar{d}$ values may be helpful in an overall assessment program, they are not by themselves reliable water quality indicators.

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 12

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL,
THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL
(INCLUDING THE CALUMET RIVER)
DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
Wilmette-NSC (340.8)[1]	1974	1975	1974	1975
Alewife	0	323	0	29.58
Bluntnose minnow	23	321	29.88	29.40
Goldfish	266	180	62.59	16.48
Yellow perch	1	116	0.24	10.62
Carp	127	50	29.88	4.58
Carp x goldfish hybrid	N.I.[2]	43	--	3.94
Spottail shiner	0	27	0	2.47
Bluegill	0	17	0	1.56
Green sunfish	5	6	1.18	0.55
Gizzard shad	0	2	0	0.18
Largemouth bass	0	2	0	0.18
Golden shiner	0	~~2~~	0	0.18
Rock bass	0	1	0	0.09
White crappie	0	1	0	0.09
Rainbow trout	0	1	0	0.09
Pumpkinseed sunfish	1	0	0.24	0

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL, THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL (INCLUDING THE CALUMET RIVER) DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
Wilmette-NSC (340.8)[1] (Cont'd.)	1974	1975	1974	1975
Coho salmon	1	0	0.24	0
White sucker	1	0	0.24	0
Total:	425	1092		
Dempster Ave.-NSC (337.6)				
Goldfish	--[3]	37	--	59.7
Carp x goldfish hybrid	--	20	--	32.3
Carp	--	4	--	6.5
Green sunfish	--	1	--	1.6
Total:		62		
Howard St.-NSC (336.5)	No fish	--	No fish	--
Pratt Ave.-NSC (335.5)				
Green sunfish	--	4	--	57.1
Goldfish	--	1	--	14.3
Goldfish x carp hybrid	--	1	--	14.3
Bluegill sunfish	--	1	--	14.3
Total:		7		
Peterson Ave.-NSC (334.5)	No fish	--	No fish	--

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL,
THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL
(INCLUDING THE CALUMET RIVER)
DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
NBCR Junction/NSC (333.3)[1]	1974	1975	1974	1975
Goldfish	--[3]	21	--	50.0
Carp	--	12	--	28.6
Green sunfish	--	6	--	14.3
Carp x goldfish hybrid	--	1	--	2.4
Gizzard shad	--	1	--	2.4
Largemouth bass	--	1	--	2.4
Total:		42		
Diversey-NBCR (330)				
Goldfish	--	6	--	54.5
Green sunfish	--	2	--	18.2
Bigmouth shiner	--	2	--	18.2
Yellow perch	--	1	--	9.1
Total:		11		

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL,
THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL
(INCLUDING THE CALUMET RIVER)
DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
Outer Drive-Chicago R. (326.9)[1]	1974	1975	1974	1975
Gizzard shad	--[3]	15	--	38.5
Bluntnose minnow	--	7	--	17.9
Largemouth bass	--	6	--	15.4
Bluegill sunfish	--	3	--	7.7
Carp	--	3	--	7.7
Alewife	--	2	--	5.1
Goldfish	--	1	--	2.6
White bass	--	1	--	2.6
Mottled sculpin	--	1	--	2.6
Total:		39		
Damen Ave.-SSC (321.1)	--	No fish	--	No fish
Cicero Ave.-SSC (317.3)	--	No fish	--	No fish
Laramie Ave.-SSC (316.8)	No fish	--	No fish	--
Harlem Ave.-SSC (314)	No fish	2	No fish	100
Willow Springs Rd-SSC (308)	No fish	No fish	No fish	No fish

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL, THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL (INCLUDING THE CALUMET RIVER) DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
	1974	1975	1974	1975
16th St. (Joliet)-SSC (292.1)[1]	--[3]	No Fish	--	No fish
Lockport Lock-SSC (291)				
Carp	3	--[3]	50.0	--
Goldfish	2	--	33.3	--
Green sunfish	1	--	16.7	--
Total:	6			
Desplaines River near Junction with SSC- (290)				
Goldfish	26	--	42.6	--
Carp	17	--	27.9	--
Emerald shiner	8	--	13.1	--
Gizzard shad	5	--	8.2	--
Bluntnose minnow	2	--	3.3	--
Yellow bass	2	--	3.3	--
Black bullhead	1	--	1.6	--
Total:	61			

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL,
THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL
(INCLUDING THE CALUMET RIVER)
DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
	1974	1975	1974	1975
O'Brien Lock and Dam (326.5)[1] Calumet River				
Gizzard shad	32	176	23.02	29.68
Bluntnose minnow	19	166	13.67	27.99
Emerald shiner	37	130	26.62	21.92
Carp	29	42	20.86	7.08
Yellow perch	18	37	12.95	6.24
Largemouth bass	1	17	0.72	2.87
Goldfish	2	9	1.44	1.52
Golden shiner	0	5	0	0.84
Green sunfish	0	3	0	0.51
Carp x goldfish hybrid	N.I.[2]	3	--	0.51
Bluegill sunfish	0	2	0	0.34
Common shiner	0	1	0	0.17
Alewife	1	1	0.72	0.17
Pumpkinseed sunfish	0	1	0	0.17
Total:	139	593		

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL,
THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL
(INCLUDING THE CALUMET RIVER)
DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
	1974	1975	1974	1975
Calumet Expressway (324.6)[1] Little Calumet River				
Gizzard shad	--[3]	220	--	41.98
Emerald shiner	--	207	--	39.50
Goldfish	--	60	--	11.45
Carp	--	19	--	3.63
Largemouth bass	--	11	--	2.10
Bluegill sunfish	--	3	--	0.57
Carp x goldfish hybrid	--	2	--	0.38
Golden shiner	--	1	--	0.19
Fathead minnow	--	1	--	0.19
Total:		524		
Halsted St. (320.1) Little Calumet River				
Gizzard shad	0	26	0	86.67
Carp	0	2	0	6.67
Carp x goldfish hybrid	0	2	0	6.67
Bluegill sunfish	1	0	100	0
Total:	1	30		

TABLE 12 (Cont'd.)

FISH COLLECTIONS FROM THE NORTH SHORE CHANNEL,
THE SANITARY AND SHIP CANAL AND CAL-SAG CHANNEL
(INCLUDING THE CALUMET RIVER)
DURING SEPTEMBER - NOVEMBER, 1974 - 1975

Species Collected	Number Collected		% Occurrence In Total Catch	
	1974	1975	1974	1975
Ashland Ave.-CSC (319)				
Goldfish	1	0	100	0
Gizzard shad	0	31	0	100
Total:	1	31		
86th Ave.-(Palos Hills) (309.7) Cal-Sag Channel				
Goldfish	--[3]	16	--	88.89
Carp	--	1	--	5.56
Black crappie	--	1	--	5.56
Total:		18		

1. Corps of Engineers mile point.

2. During 1974, any carp x goldfish hybrid would have been identified as a carp.

3. - Not sampled.

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 13

MEAN SPECIES DIVERSITY, $\bar{d}$, FOR THE CHANNEL FISH COLLECTIONS DURING THE FALL OF 1974 AND 1975

Location	$\bar{d}$ 1974	$\bar{d}$ 1975
North Shore Channel		
Wilmette (340.8)[1]	1.3	2.5
Dempster Avenue (337.63)	--[2]	1.3 (62)[3]
Howard Street (336.48)	0.0	--
Pratt Avenue (335.48)	--	1.7 (7)
Peterson Avenue (334.48)	0.0	--
Branch Junction (333.3)	--	1.8 (42)
Diversey Avenue (330)	--	1.7 (11)
Outer Drive-Chicago River (326.9)	--	2.6 (39)
Sanitary and Ship Canal		
Damen Avenue (321.1)	--	0.0
Cicero Avenue (317.3)	--	0.0
Laramie Avenue (316.8)	0.0	--
Harlem Avenue (314)	0.0	0.0
Willow Springs Road (308)	0.0	0.0
16th Street (Joliet) (292.1)	--	0.0
Lockport Lock (291)	1.5 (6)	--

METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

TABLE 13 (Cont'd.)

MEAN SPECIES DIVERSITY, $\bar{d}$, FOR THE CHANNEL FISH COLLECTIONS DURING THE FALL OF 1974 AND 1975

Location	$\bar{d}$ 1974	$\bar{d}$ 1975
Sanitary and Ship Canal (Cont'd.)		
Desplaines River near San-Ship Canal Junction (290)	2.1 (61)	--
Calumet River/Cal-Sag Channel		
O'Brien Lock and Dam (326.5)[1]	2.4	2.5
Calumet Expressway (324.6)	--[2]	2.0
Halsted Street (320)	0.0	0.7 (30)
Ashland Avenue (319)	0.0	0.0
86th Avenue (309.7)	--	0.6 (18)

1. - Corps of Engineers mile point.

2. - Not sampled.

3. - Those $\bar{d}$ values based on total catch (in parentheses) of fish less than 100 are less sensitive as indicators of water quality for fish life and should be used with caution.

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